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# Motorcycles — Measurement method for gaseous exhaust emissions and fuel consumption —

## Part 1:
## General test requirements

*Motocycles — Méthode de mesure des émissions de gaz d'échappement et de la consommation de carburant —*

*Partie 1: Exigences générales d'essai*

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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 32, *Road vehicles*, Subcommittee SC 38, *Motorcycles and mopeds*.

This second edition cancels and replaces the first edition (ISO 6460-1:2007), which has been technically revised. It also incorporates the Amendment ISO 6460-1:2007/Amd.1:2015.

The main changes are as follows:

- addition of a detailed description of a critical flow venturi (CFV) as a flow measurement principle to the CVS system;
- permission to use of the subsonic venturi (SSV) as a flow measurement principle to the CVS system;
- addition for the measurement of methane ($CH_4$) concentration, either a GC-FID (flame ionization detector with gas chromatograph) or an NMC-FID (flame ionization detector with non-methane cutter);
- addition of a calculation method for non-methane hydrocarbons (NMHC);
- permission to determine the ratio of hydrogen and carbon ($R_{HC}$) and the ratio of oxygen and carbon ($R_{OC}$) by the content analysis of fuel;
- addition of calculation methods for the mass of the gaseous exhaust emissions and the fuel consumption when using oxygenated fuels;
- deletion of descriptions related two-stroke engines and diesel fuel.

A list of all parts in the ISO 6460 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Introduction

For the measurement of motorcycle fuel consumption, the carbon balance method, where the fuel consumption is calculated from analysis of the carbon quantity in the exhaust emissions, is now widely used in addition to the conventional fuel flow measurement. Therefore, the measurement of exhaust emissions pollutants and fuel consumption are inseparably related to each other.

This document defines the fundamental elements such as the measurement accuracy, test motorcycle conditions and the details of the carbon balance method. The measurement of gaseous exhaust emissions and fuel consumption during test cycles can be conducted by means of this document and ISO 6460-2. Additionally with ISO 6460-3, these three documents provide details of those measurements at a constant speed.

The following revisions are mainly made in this document.

— The detailed description of a critical flow venturi (CFV), adopted by most of the manufacturers as well as a positive displacement pump (PDP), is added as a flow measurement principle to the CVS system. Also, the use of the subsonic venturi (SSV) is also permitted as a CVS flow measurement principle.

— For measurement of methane ($CH_4$) concentration in the diluted exhaust mixture, either a GC-FID (flame ionization detector with gas chromatograph) or an NMC-FID (flame ionization detector with non-methane cutter) shall be used as the analytical instrument. The formula for calculating non-methane hydrocarbons (NMHC) is also defined.

— Instead of obtaining the ratio of hydrogen and carbon ($R_{\mathrm{HC}}$) and the ratio of oxygen and carbon ($R_{\mathrm{OC}}$) from the exhaust emissions analysis, $R_{\mathrm{HC}}$ and $R_{\mathrm{OC}}$ shall be determined by the fuel analysis. In addition, when using the oxygenated fuels such as gasoline (E5) and gasoline (E10), the mass of the gaseous exhaust emissions and the fuel consumption also can be calculated.

— As there has been no need for newly development of two-stroke engines and compression ignition engines in recent years, the description regarding two-stroke engines and diesel fuel is to be deleted. If these are required, see ISO 6460-1:2007.

# Motorcycles — Measurement method for gaseous exhaust emissions and fuel consumption —

# Part 1:
# General test requirements

## 1 Scope

This document specifies the general test requirements for measurement of the gaseous exhaust emissions from motorcycles, and for determining the fuel consumption of motorcycles as defined in ISO 3833. It is applicable to motorcycles equipped with a spark ignition engine (four-stroke engine or rotary piston engine).

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3833, *Road vehicles — Types — Terms and definitions*

ISO 6460-2:2014, *Motorcycles — Measurement method for gaseous exhaust emissions and fuel consumption — Part 2: Test cycles and specific test conditions*

ISO 6460-3:2007, *Motorcycles — Measurement method for gaseous exhaust emissions and fuel consumption — Part 3: Fuel consumption measurement at a constant speed*

ISO 11486:2006, *Motorcycles — Methods for setting running resistance on a chassis dynamometer*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3833 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at https://www.electropedia.org/

**3.1**
**equivalent inertia**
total inertia of the rotating masses of the chassis dynamometer, determined with respect to the reference mass of the test motorcycle, which is total unladen mass of the test motorcycle increased by a uniform figure of 75 kg, which represents the mass of a rider

Note 1 to entry: Total unladen mass of the test motorcycle includes mass of the vehicle with bodywork and all fitted equipment, electrical and auxiliary equipment for normal operation of vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks and spare wheel, if fitted.

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

### 3.2
### gaseous exhaust emissions

emissions of gaseous pollutants from the tailpipe of test motorcycles, such as carbon monoxide (CO), total hydrocarbons (THC), non-methane hydrocarbons (NMHC), nitrogen oxides (NOx) as gaseous pollutants and carbon dioxide ($CO_2$)

## 4 Symbols

**Table 1 — Symbols**

| Symbols | Definition | Unit [a] |
|---|---|---|
| $c_{\mathrm{CH4,d}}$ | methane concentration in the dilution air, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{CH4,e}}$ | methane concentration in the diluted exhaust mixture, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{CH4,ec}}$ | volumetric concentration of methane in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of methane in the dilution air | ppmC |
| $c_{\mathrm{CO,d}}$ | carbon monoxide concentration in the dilution air | ppm |
| $c_{\mathrm{CO,dm}}$ | carbon monoxide concentration in the dilution air with the water vapour and carbon dioxide absorbent | ppm |
| $c_{\mathrm{CO,e}}$ | carbon monoxide concentration in the diluted exhaust mixture | ppm |
| $c_{\mathrm{CO,ec}}$ | volumetric concentration of carbon monoxide in the diluted exhaust mixture, corrected to take account of carbon monoxide in the dilution air | ppm |
| $c_{\mathrm{CO,em}}$ | carbon monoxide concentration in the diluted exhaust mixture with the water vapour and carbon dioxide absorbent | ppm |
| $c_{\mathrm{CO2,d}}$ | carbon dioxide concentration in the dilution air | % |
| $c_{\mathrm{CO2,e}}$ | carbon dioxide concentration in the diluted exhaust mixture | % |
| $c_{\mathrm{CO2,ec}}$ | volumetric concentration of carbon dioxide in the diluted exhaust mixture, corrected to take account of carbon dioxide in the dilution air | % |
| $c_{\mathrm{HC(w/\ NMC)}}$ | hydrocarbon concentration measured by the NMC-FID with sample gas flowing through the NMC, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{HC(w/\ NMC),d}}$ | hydrocarbon concentration in the dilution air with sample gas flowing through the NMC, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{HC(w/\ NMC),e}}$ | hydrocarbon concentration in the diluted exhaust mixture with sample gas flowing through the NMC, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{HC(w/\ NMC),ec}}$ | volumetric concentration of hydrocarbon in the diluted exhaust mixture with sample gas flowing through the NMC, expressed in ppm carbon equivalent, corrected to take account of hydrocarbon in the dilution air | ppmC |
| $c_{\mathrm{HC(w/o\ NMC)}}$ | hydrocarbon concentration measured by the NMC-FID with sample gas bypassing the NMC, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{HC(w/o\ NMC),d}}$ | hydrocarbon concentration in the dilution air with sample gas bypassing the NMC, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{HC(w/o\ NMC),e}}$ | hydrocarbon concentration in the diluted exhaust mixture with sample gas bypassing the NMC, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{HC(w/o\ NMC),ec}}$ | volumetric concentration of hydrocarbon in the diluted exhaust mixture with sample gas bypassing the NMC, ppm C, expressed in ppm carbon equivalent, corrected to take account of hydrocarbon in the dilution air | ppmC |
| $c_{\mathrm{NMHC,ec}}$ | volumetric concentration of non-methane hydrocarbon in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of non-methane hydrocarbon in the dilution air | ppmC |
| $c_{\mathrm{NOx,d}}$ | nitrogen oxides concentration in the dilution air | ppm |
| $c_{\mathrm{NOx,e}}$ | nitrogen oxides concentration in the diluted exhaust mixture | ppm |

[a] ppm = parts per million.

**Table 1** *(continued)*

| Symbols | Definition | Unit [a] |
|---|---|---|
| $c_{\mathrm{NOx,ec}}$ | volumetric concentration of nitrogen oxides in the diluted exhaust mixture, corrected to take account of nitrogen oxides in the dilution air | ppm |
| $c_{\mathrm{O2,d}}$ | oxygen concentration in the dilution air | % |
| $c_{\mathrm{P}i\mathrm{,ec}}$ | concentration of the pollutant *i* in the diluted exhaust mixture, corrected to take account of the amount of the pollutant *i* contained in the dilution air | ppm |
| $c_{\mathrm{THC,d}}$ | total hydrocarbon concentration in the dilution air, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{THC,e}}$ | total hydrocarbon concentration in the diluted exhaust mixture, expressed in ppm carbon equivalent | ppmC |
| $c_{\mathrm{THC,ec}}$ | volumetric concentration of total hydrocarbon in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of total hydrocarbon in the dilution air | ppmC |
| $C_{\mathrm{d}}$ | discharge coefficient of the SSV | — |
| $d_{\mathrm{in}}$ | diameter of the SSV inlet pipe inner | m |
| $d_{\mathrm{v}}$ | diameter of the SSV throat | m |
| $D_{\mathrm{f}}$ | dilution factor | — |
| $E_{\mathrm{E}}$ | ethane conversion efficiency | — |
| $E_{\mathrm{M}}$ | methane conversion efficiency | — |
| $F_{\mathrm{c}}$ | specific fuel consumption | km/l |
| $F_{\mathrm{c100}}$ | fuel consumption per 100 km | l/100 km |
| $H_{\mathrm{a}}$ | absolute humidity in grams of water per kilogram of dry air | — |
| $H_{\mathrm{d}}$ | relative humidity of dilution air | % |
| $H_{\mathrm{r}}$ | relative humidity in the test room | % |
| $H_0$ | standard relative humidity | % |
| $K_{\mathrm{H}}$ | humidity correction factor used for the calculation of the mass emissions of nitrogen oxides | — |
| $k_1$ | critical flow venturi correction factor | — |
| $k_2$ | ratio of pressure to temperature at the standard reference conditions | — |
| $k_3$ | collection of constants and unit conversions | — |
| $m_{\mathrm{CO}}$ | mass of carbon monoxide in the gaseous exhaust emissions | g/km |
| $m_{\mathrm{CO2}}$ | mass of carbon dioxide in the gaseous exhaust emissions | g/km |
| $m_{\mathrm{F}}$ | mass of fuel consumed | g |
| $m_{\mathrm{NMHC}}$ | mass of non-methane hydrocarbon in the gaseous exhaust emissions | g/km |
| $m_{\mathrm{NOx}}$ | mass of nitrogen oxides in the gaseous exhaust emissions | g/km |
| $m_{\mathrm{P}i}$ | mass emission of the pollutant *i* | g |
| $m_{\mathrm{THC}}$ | mass of total hydrocarbon in the gaseous exhaust emissions | g/km |
| $N$ | number of revolutions of positive displacement pump during the test while samples are being collected | — |
| $p_{\mathrm{a}}$ | mean barometric pressure during the test in the test room | kPa |
| $p_{\mathrm{d}}$ | saturated water vapour pressure during the test in the test room | kPa |
| $p_{\mathrm{p}}$ | absolute pressure of the diluted exhaust mixture at the inlet of positive displacement pump | kPa |
| $p_{\mathrm{v}}$ | absolute pressure at the venturi inlet | kPa |
| $p_{\mathrm{v}\,(t)}$ | absolute pressure of the diluted exhaust mixture at the venturi inlet | kPa |
| $p_0$ | total barometric pressure at the standard reference conditions | kPa |

[a] ppm = parts per million.

**Table 1** *(continued)*

| Symbols | Definition | Unit [a] |
|---|---|---|
| $Q_a$ | measured flow rate of venturi using the other gas flowmeter | $m^3/s$ |
| $Q_{cal}$ | measured flow rate of venturi at standard reference conditions | $m^3/s$ |
| $r_x$ | ratio of the SSV throat pressure to inlet absolute static pressure, $1-(\Delta p / p_v)$ | — |
| $r_y$ | ratio of the SSV throat diameter $d_v$ to the inlet pipe inner diameter $d_{in}$, $d_v / d_{in}$ | — |
| $R_{HC,ex}$ | atom number ratio of hydrogen and carbon in the gaseous exhaust emissions | — |
| $R_{HC,F}$ | atom number ratio of hydrogen and carbon in the fuel | — |
| $R_{OC,ex}$ | atom number ratio of oxygen and carbon in the gaseous exhaust emissions | — |
| $R_{OC,F}$ | atom number ratio of oxygen and carbon in the fuel | — |
| $R_{f,CH4}$ | response factor of $CH_4$ for an FID | — |
| $R_{f,C3H6}$ | response factor of $C_3H_6$ for an FID | — |
| $R_{f,C3H8}$ | response factor of $C_3H_8$ for an FID | |
| $R_{f,C7H8}$ | response factor of $C_7H_8$ for an FID | — |
| $S$ | running distance actually travelled | km |
| $t$ | time | s |
| $t_{test}$ | total test time | s |
| $T_a$ | measured ambient temperature during the test in the test room | K |
| $T_F$ | fuel temperature measured at the burette | K |
| $T_p$ | temperature of diluted exhaust mixture at the positive displacement pump inlet during the test while samples are being collected | K |
| $T_v$ | temperature at the venturi inlet | K |
| $T_{v\ (t)}$ | temperature of diluted exhaust mixture at the venturi inlet | K |
| $T_0$ | air temperature at the standard reference conditions | K |
| $V$ | measured volume of fuel consumed | l |
| $V_d$ | dilution air volume | $m^3$ |
| $V_e$ | volume of the diluted exhaust mixture expressed corrected to the standard reference conditions | $m^3/km$ |
| $V_{ex}$ | gaseous exhaust emissions volume | $m^3$ |
| $V_{i,e}$ | volume of the diluted exhaust mixture in one test under the standard reference conditions | l |
| $V_p$ | diluted exhaust mixture volume pumped by the positive displacement pump per one revolution | l |
| $V_s$ | total diluted exhaust mixture volume during one test | $m^3$ |
| $\alpha$ | coefficient of volumetric expansion for the fuel | $K^{-1}$ |
| $\rho_{CO}$ | carbon monoxide density at the standard reference conditions | $g/m^3$ |
| $\rho_{CO2}$ | carbon dioxide density at the standard reference conditions | $g/m^3$ |
| $\rho_F$ | fuel density at 288,15 K | kg/l |
| $\rho_{NMHC}$ | non-methane hydrocarbon density at the standard reference conditions | $g/m^3$ |
| $\rho_{NOx}$ | nitrogen oxides density at the standard reference conditions, expressed in equivalent $NO_2$ | $g/m^3$ |
| $\rho_{Pi}$ | density of the pollutant $i$ at the standard reference conditions | g/l |
| $\rho_{THC}$ | total hydrocarbon density at the standard reference conditions | $g/m^3$ |
| $\rho_0$ | air volumetric mass at the standard reference conditions | $kg/m^3$ |

[a] ppm = parts per million.

# 5 Standard reference conditions

The standard reference conditions shall be as follows:

| | |
|---|---|
| Total barometric pressure, $p_0$: | 101,325 kPa; |
| Air temperature, $T_0$: | 273,15 K; |
| Relative humidity, $H_0$: | 65 %; |
| Air volumetric mass, $\rho_0$: | 1,293 kg/m$^3$. |

# 6 Tests

## 6.1 Measurement of gaseous exhaust emissions

### 6.1.1 Average gaseous exhaust emissions during conventional test cycles

The test shall be carried out in accordance with the procedure described in ISO 6460-2. The appropriate test cycle shall be selected.

### 6.1.2 Measurement of gaseous exhaust emissions at an idling speed

The test shall be carried out in accordance with the procedure described in ISO 6460-2.

## 6.2 Measurement of fuel consumption

### 6.2.1 Average fuel consumption during conventional test cycles

The test shall be carried out in accordance with the procedure described in ISO 6460-2. The appropriate test cycle shall be selected.

### 6.2.2 Fuel consumption at a constant speed

The test shall be carried out in accordance with the procedure described in ISO 6460-3.

# 7 Measurement equipment

## 7.1 General

Irrespective of the provisions in this clause, any measurement system(s) may be used when the performance of the equipment is proven by the equipment manufacturer to be equivalent to the constant volume sampler (CVS) system.

## 7.2 Chassis dynamometer

The chassis dynamometer shall be set in accordance with ISO 11486. The equivalent inertia mass for the table method shall be in accordance with ISO 11486:2006, Table 4.

## 7.3 Gas-collection equipment

**7.3.1** The gas-collection equipment shall be a closed type system that can collect all exhaust emissions at the motorcycle exhaust outlet(s) providing that it satisfies the backpressure condition of ±1,25 kPa. An open type system may be used as well if it is confirmed that all the exhaust emissions are collected.

The exhaust emissions collection shall be such that there is no condensation, which may appreciably modify the nature of exhaust emissions at the test temperature.

**7.3.2** The gas-collection equipment and connecting tube between the gas-collection equipment and the exhaust emissions sampling system shall be made of stainless steel or of some other material which does not affect the composition of the exhaust emissions collected and which withstands the temperature of the exhaust emissions.

**7.3.3** The CVS system with a critical flow venturi (CFV) or the CVS system with a positive displacement pump (PDP) shall be used for the exhaust emissions sampling system.

**7.3.3.1** The CVS system with CFV shall be applicable to the requirements in this subclause.

a) The capacity of CFV shall be large enough to ensure the inlet of all the diluted exhaust mixture.

b) An instrument capable of calculating the venturi flow rate based on the measuring results of temperature and absolute pressure of the diluted exhaust mixture sucked into CFV shall be equipped.

c) A dilution air sampling probe of the closed type exhaust emissions sampling system shall be set at the lower reaches of the dilution air filter. This sampling probe shall be capable of collecting the dilution air at a constant flow rate through the sampling pump, the filter and the flow meter during the test. The dilution air sampling probe of the open type exhaust emissions sampling system shall be set in the vicinity of and outside of the exhaust emissions sampling system of the open type CVS system. This sampling probe shall be capable of collecting the dilution air at a constant flow rate through the sampling pump, the filter and the flow meter during the test.

d) A diluted exhaust mixture sampling probe pointing to the upper reaches of the diluted exhaust mixture shall be set at the upper part in the vicinity of CFV inlet. The diluted exhaust mixture shall be collected at the flow rate in proportion to the diluted exhaust mixture flow rate through the sampling pump, the filter and the flow meter during the test.

e) A flow rate integrator for integrating the diluted exhaust mixture flow rate during the test shall be equipped.

**7.3.3.2** The CVS system with PDP shall be applicable to the requirements in this subclause.

a) A heat exchanger shall be capable of limiting the temperature variation of the diluted exhaust mixture at PDP inlet to ±5 K throughout the test. This exchanger shall be equipped with a preheating system capable of bringing the exchanger to its operating temperature (with the tolerance of ±5 K) before the test begins.

b) PDP for drawing in the diluted exhaust mixture shall be equipped with a motor capable of controlling the diluted exhaust mixture flow speed to several constant speeds strictly. The capacity of PDP shall be large enough to ensure the intake of all the exhaust emissions.

c) A device capable of continuous recording of the temperature of the diluted exhaust mixture entering PDP shall be equipped. A device to allow continuous recording of the temperature of the diluted exhaust mixture entering PDP shall be equipped.

d) An instrument capable of measuring the pressure depression of the diluted exhaust mixture entering PDP relative to the atmospheric pressure and an instrument capable of measuring the pressure difference between the inlet and the outlet of PDP shall be equipped.

e) A dilution air sampling probe of the closed type exhaust emissions sampling system shall be set at the lower reaches of the dilution air filter. This sampling probe shall be capable of collecting the dilution air through the sampling pump, the filter and the flow meter at a constant flow rate during the test. A dilution air sampling probe of the open type exhaust emissions sampling system shall be set in the vicinity of and outside of the exhaust emissions sampling system of the open type CVS system. This sampling probe shall be capable of collecting the dilution air at a constant flow rate through the sampling pump, the filter and the flow meter during the test.

f) A diluted exhaust mixture sampling probe pointing to the upper reaches of the diluted exhaust mixture shall be set at the upper reaches of PDP. This sampling probe shall be capable of collecting the diluted exhaust mixture at a constant flow rate through the sampling pump, the filter and the flow meter during the test.

g) A revolution counter for counting the revolution of PDP during the test shall be equipped.

**7.3.4** A device using a subsonic venturi (SSV) may also be used. The use of SSV for the CVS system is based on the principles of flow mechanics. The flow rate of the diluted exhaust mixture is maintained at a subsonic velocity which is calculated from the physical dimensions of the subsonic venturi and measurement of the absolute temperature and pressure at the venturi inlet and the pressure in the throat of the venturi. The flow rate is continually computed and integrated throughout the test.

**7.3.5** In the case of the CVS system with CFV, the sampling venturi shall be set at the place where the temperature and the absolute pressure are same as those of the main critical flow venturi inlet. The sampling flow rates in proportion to the diluted exhaust mixture flow rate shall be obtained.

In the case of the CVS system with PDP, the diluted exhaust mixture flow rate and the sampling flow rates shall be steady within ±5 %.

If the device cannot compensate for variations in the temperature of the mixture of exhaust emissions and dilution air at the measuring point, a heat exchanger shall be used to maintain the temperature to within ±6 K of the specified operating temperature for the CVS with PDP, and ±11 K for the CVS with CFV and SSV.

**7.3.6** A sampling system shall be equipped with the valves directing the samples either to the sampling bags or to the atmosphere. The minimum sampling flow rate shall be 150 l/h.

**7.3.7** The sampling bags shall be airtight for collecting the dilution air and the diluted exhaust mixture, and shall have sufficient capacity so as not to impede the normal sample flow and not to change the nature of the exhaust emissions to be measured. The sampling bags shall be equipped with the automatic self-locking devices, and shall be easily and tightly connected either to the sampling system during the sampling period and to the analysing system at the end of the test.

NOTE 1 Pay attention to the connecting method and the material or configuration of the connecting parts because there is a possibility that each section (e.g. adapters, couplers) of the sampling system becomes very hot. If the measurement cannot be performed normally due to the heat-damages of the sampling system, an auxiliary cooling device is used as long as the exhaust emissions are not affected.

NOTE 2 In the case of the open type exhaust emissions sampling system, there is a risk of the incomplete exhaust emissions collection and the exhaust emissions leakage into the test room. So it is important to make sure that there is no leakage during the sampling period.

NOTE 3 If a constant CVS flow rate is used during the test using the test cycles including low speeds and high speeds, it is important to pay attention to the water condensation in the high-speed range.

## 7.4 Analytical equipment

**7.4.1** The sample probe shall consist of a sampling tube leading into the collecting bags, or of a drainage tube. This sample probe shall be made of stainless steel or of some other material that will not adversely affect the composition of the exhaust emissions to be analysed. The temperature of the tubes connecting to the analyser, including the sampling probe, shall be same as the ambient temperature or above.

**7.4.2** Analysers shall be of the following types:

a) non-dispersive infrared absorption (NDIR) type for CO and $CO_2$;

b) flame ionization (FID) type for THC;

c) either a gas chromatograph combined with an FID (GC-FID), or an FID combined with a non-methane cutter (NMC-FID) for methane ($CH_4$);

d) chemiluminescence (CLD) type for NOx.

## 7.5 Cooling equipment

Throughout the test, a variable speed cooling blower shall be positioned in front of the test motorcycle, so as to direct the cooling air to the test motorcycle in a manner which simulates actual operating conditions. The blower speed shall be such that, within the operating range of 10 km/h to 50 km/h, the linear velocity of the air at the blower outlet should be 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 % of roller speed. At the roller speeds of less than 10 km/h, air velocity may be zero.

The 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 % of the average value of the 9 points.

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 cm and 20 cm above floor level. The blower outlet shall be perpendicular to the longitudinal axis of the test motorcycle between 30 cm 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 cm and 20 cm from the air outlet.

## 7.6 Fuel consumption measurement

**7.6.1** One of the following methods shall be used to measure the fuel consumption, depending on the characteristics of each method and on the type of test to be performed (conventional test cycle or constant speed):

a) carbon balance method;

b) volumetric method;

c) gravimetric method;

d) flowmeter method.

The carbon balance method shall be applied in accordance with 12.1.

Other methods may be used if it can be proved that the results given are equivalent.

**7.6.2** Fuel shall be supplied to the engine by a device capable of measuring the quantity of fuel supplied with an accuracy of ±1 % in accordance with Annex A, and which does not interfere with the supply of fuel to the engine. When the measuring system is the volumetric method or the flowmeter method, the temperature of the fuel in the device or in the device outlet shall be measured.

Switching from the normal supply system to the measuring supply system shall be done by means of a valve system and shall take no more than 0,2 s.

Annex A gives the description and the methods of use of the appropriate devices for fuel flow measurement.

## 7.7 Accuracy of instruments and measurements

**7.7.1** The distance travelled by the test motorcycle shall be measured with an accuracy of ±1 %.

**7.7.2** The speed of the test motorcycle shall be measured with an accuracy of ±1 % to the resolution of 0,1 km/h. For speeds less than 10 km/h, the speed shall be measured to the resolution of 0,1 km/h.

**7.7.3** The ambient temperatures shall be measured with an accuracy of ±1 K.

**7.7.4** The atmospheric pressure shall be measured with an accuracy of ±0,2 kPa.

**7.7.5** The relative humidity of the ambient air shall be measured with an accuracy of ±5 %.

**7.7.6** The pressures considered in 7.3.3.1 b) and 7.3.3.2 d) shall be measured with an accuracy of ±0,4 kPa.

**7.7.7** The analysers shall have a measuring range compatible with the accuracy required to measure the content of the various pollutants and carbon dioxide with an accuracy of ±1 %, regardless of the accuracy of the calibration gases. The overall response time of the analysing circuit shall be less than 1 min.

**7.7.8** The cooling air speed shall be measured with an accuracy of ±5 km/h.

**7.7.9** The duration of test cycles and the exhaust emissions collection shall be controlled with an accuracy of ±1 s. These times shall be measured with an accuracy of 0,1 s.

**7.7.10** The total volume of the diluted exhaust mixture shall be measured with an accuracy of ±2 %.

**7.7.11** For the fuel consumption measurement at a constant speed specified in ISO 6460-3, the wind speed on the test road shall be measured with an accuracy of ±5 % to the resolution of 0,1 m/s.

# 8 Preparing the test

## 8.1 Engine fuel and lubricants

The specification of test fuel shall be reported. An example of the record form is given in Annex B.

With regard to grade and quantity of oil, the lubrication of the engine shall comply with the manufacturer's recommendation.

## 8.2 Description of the test motorcycle

The main specifications of the test motorcycle shall be provided in accordance with ISO 6460-2:2014, Annexes A and B, and in ISO 6460-3:2007, Annex B.

## 8.3 Conditioning/preparation of the test motorcycle

**8.3.1** The test motorcycle shall be run in properly in accordance with the manufacturer's requirements.

**8.3.2** The test motorcycle shall be adjusted in accordance with the manufacturer's requirements (e.g. tyre pressures, chain tension). If there is any alteration, the full description shall be given in the test report.

**8.3.3** The distribution of the load between the wheels shall be in conformity with the manufacturer's instructions.

## 8.4 Calibration and adjustment of analysers

### 8.4.1 Calibration of the analysers

### 8.4.1.1 Analyser calibration intervals

Each analyser may be calibrated as specified by the instrument manufacturer or at least as often as described in Table 2.

**Table 2 — Analyser calibration intervals**

| Checks | Interval | Criterion |
|---|---|---|
| Gas analyser linearization (calibration) | Every 6 months | ±2 % of reading |
| Mid-span for calibration | Every 6 months | ±2 % |
| $CO_2/H_2O$ interference for CO analyser | Monthly | -1 to 3 ppm |
| NOx converter check | Monthly | > 95 % |
| $CH_4$ cutter check | Yearly | 98 % of ethane |
| FID $CH_4$ response | Yearly | See 8.4.2.1 |
| FID air/fuel flow | At major maintenance | According to the instrument manufacture |

### 8.4.1.2 Analyser calibration procedures

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

**8.4.1.2.2** The calibration gas concentration required may be obtained by means of a gas divider, diluting with purified $N_2$ or with purified synthetic air.

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

**8.4.1.2.4** The linearization curve shall not differ by more than ±2 % from the nominal value of each calibration gas.

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

a) analyser and gas component;

b) range;

c) data of the linearization.

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

### 8.4.2 Adjustment of the analysers

#### 8.4.2.1 FID hydrocarbon response check procedure

##### 8.4.2.1.1 Detector response optimisation

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

##### 8.4.2.1.2 Calibration of the THC analyser

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

##### 8.4.2.1.3 Response factors of different hydrocarbons and recommended limits

The response factor, $R_f$, for a particular hydrocarbon compound is the ratio of the FID reading to the gas cylinder concentration, expressed in ppm carbon equivalent. The concentration of the test gas shall be at a level to give a response of approximately 80 % of full-scale deflection, for the operating range. The concentration shall be known to an accuracy of ±2 % in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder shall be pre-conditioned for 24 h at a temperature between 293,15 K and 303,15 K (20 °C and 30 °C).

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

- $CH_4$ and purified air: $1{,}00 < R_{f,CH4} < 1{,}15$
- propylene ($C_3H_6$) and purified air: $0{,}90 < R_{f,C3H6} < 1{,}10$
- toluene ($C_7H_8$) and purified air: $0{,}90 < R_{f,C7H8} < 1{,}10$

These are relative to a response factor ($R_{f,C3H8}$) of 1,00 for propane and purified air.

#### 8.4.2.2 NOx converter efficiency test procedure

**8.4.2.2.1** Using the test set up as shown in Figure 1 and the procedure described in 8.4.2.2, the efficiency of converters for the conversion of $NO_2$ into NO shall be tested by means of an ozonator as follows.

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

**8.4.2.2.1.2** Via a T-fitting, oxygen or synthetic air shall be added continuously to the calibration gas flow until the concentration indicated is approximately 10 % less than the indicated calibration concentration given in 8.4.2.2.1.1. The indicated concentration (value *c*) shall be recorded. The ozonator shall be kept deactivated throughout this process.

**8.4.2.2.1.3** The ozonator shall now be activated to generate enough ozone to bring the NO concentration down to 20 % (minimum 10 %) of the calibration concentration. The indicated concentration (value *d*) shall be recorded.

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

**8.4.2.2.1.5** The ozonator shall now be deactivated. The mixture of gases described in 8.4.2.2.1.2 shall pass through the converter into the detector. The indicated concentration (value *b*) shall be recorded.

**8.4.2.2.1.6** With the ozonator deactivated, the flow of oxygen or synthetic air shall be shut off. The $NO_2$ reading of the analyser shall then be no more than 5 % above the value given in 8.4.2.2.1.1.

**8.4.2.2.1.7** The efficiency of the NOx converter shall be calculated by Formula (1) using the concentrations *a*, *b*, *c* and d determined in 8.4.2.2.1.2 through 8.4.2.2.1.5 as follows:

$$E = \left(1 + \frac{a-b}{c-d}\right) \times 100 \tag{1}$$

where

$E$ is NOx converter efficiency, in percentage;

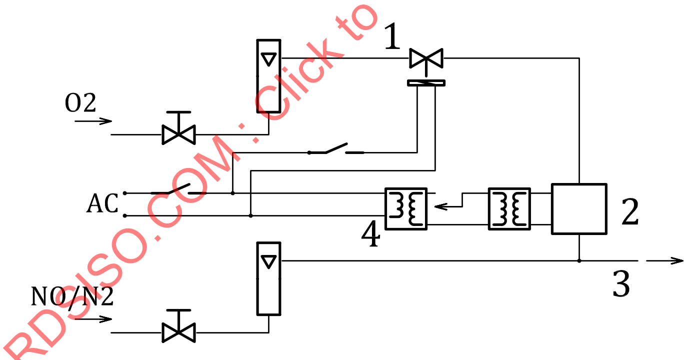
$a$ is the concentration obtained in 8.4.2.2.1.4;

$b$ is the concentration obtained in 8.4.2.2.1.5;

$c$ is the concentration obtained in 8.4.2.2.1.2;

$d$ is the concentration obtained in 8.4.2.2.1.3.

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



**Key**

| | |
|---|---|
| 1 | solenoid valve |
| 2 | ozonator |
| 3 | to analyser |
| 4 | variac |

**Figure 1 — NOx converter efficiency test configuration**

### 8.4.3 Reference gases and accuracy of the mixing device

#### 8.4.3.1 Reference gases

##### 8.4.3.1.1 Pure gases

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

- purified nitrogen: (purity: ≤ 1 ppm C1, ≤ 1 ppm CO, ≤ 400 ppm $CO_2$, ≤ 0,1 ppm NO);
- purified synthetic air: (purity: ≤ 1 ppm C1, ≤ 1 ppm CO, ≤ 400 ppm $CO_2$, ≤ 0,1 ppm NO); oxygen content between 18 % and 21 % by volume;
- purified oxygen: (purity > 99,5 % by volume $O_2$);
- purified hydrogen [and mixture containing helium (He) or nitrogen ($N_2$)]: (purity ≤ 1 ppm C1, ≤ 400 ppm $CO_2$); hydrogen content between 39 % and 41 % by volume;
- carbon monoxide: (minimum purity 99,5 %);
- propane: (minimum purity 99,5 %).

##### 8.4.3.1.2 Calibration gases

The true concentration of a calibration gas shall be within ±1 % of the stated value or as given in this subclause. Mixtures of gases having the following compositions shall be available with a bulk gas specification according to 8.4.3.1.1:

- $C_3H_8$ in synthetic air (see 8.4.3.1.1);
- CO in nitrogen;
- $CO_2$ in nitrogen;
- $CH_4$ in synthetic air;
- NO in nitrogen (the amount of $NO_2$ contained in this calibration gas shall not exceed 5 % of the NO content).

#### 8.4.3.2 Accuracy of the mixing device

In the case that a gas divider is used to perform the calibrations, the accuracy of the mixing device shall be such that the concentrations of the diluted calibration gases may be determined to within ±2 %. A calibration curve shall be verified by a mid-span check. A calibration gas with a concentration below 50 % of the analyser range shall be within 2 % of its certified concentration.

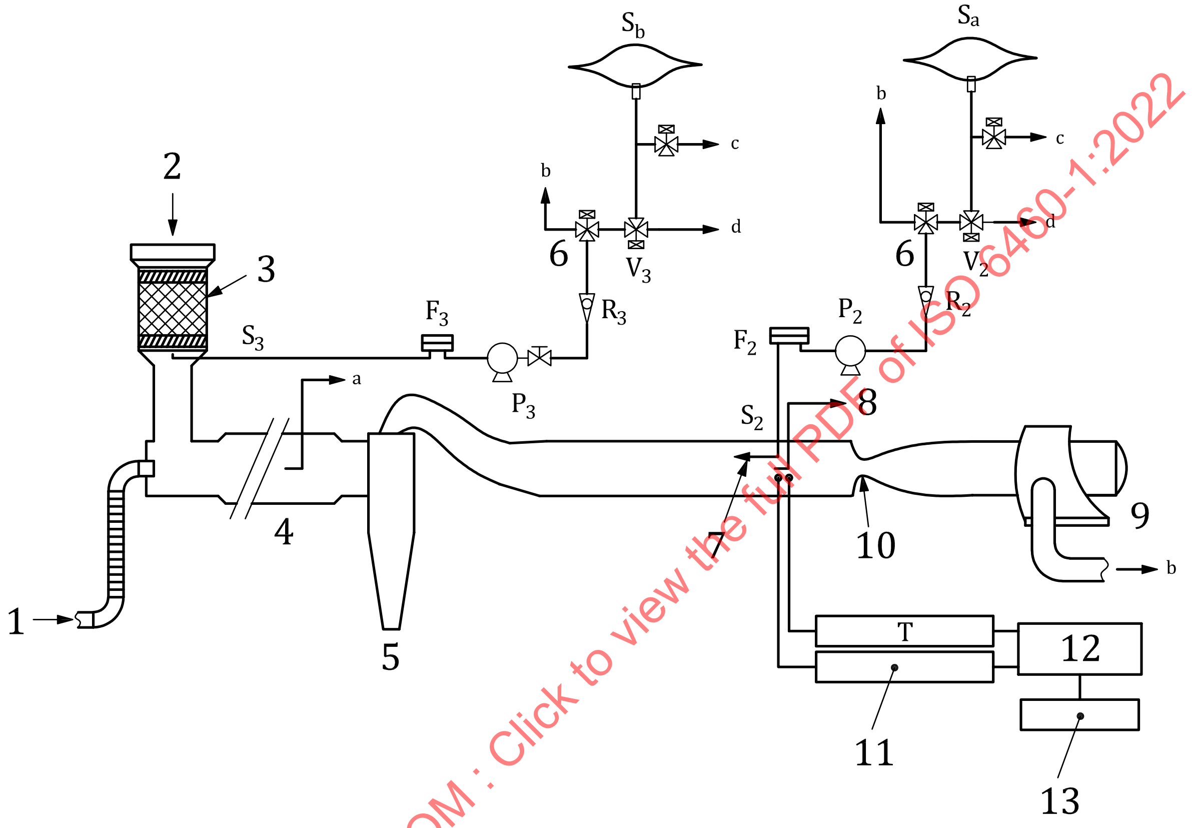
## 9 CVS system check procedure

The CVS system shall be calibrated and checked in accordance with the manufacturer's instruction. The CVS system check procedure is described in Annex G for reference.

# 10 Procedure for sampling, analysing and measuring the volume of gaseous exhaust emissions

## 10.1 Operations to be carried out before the test motorcycle start up

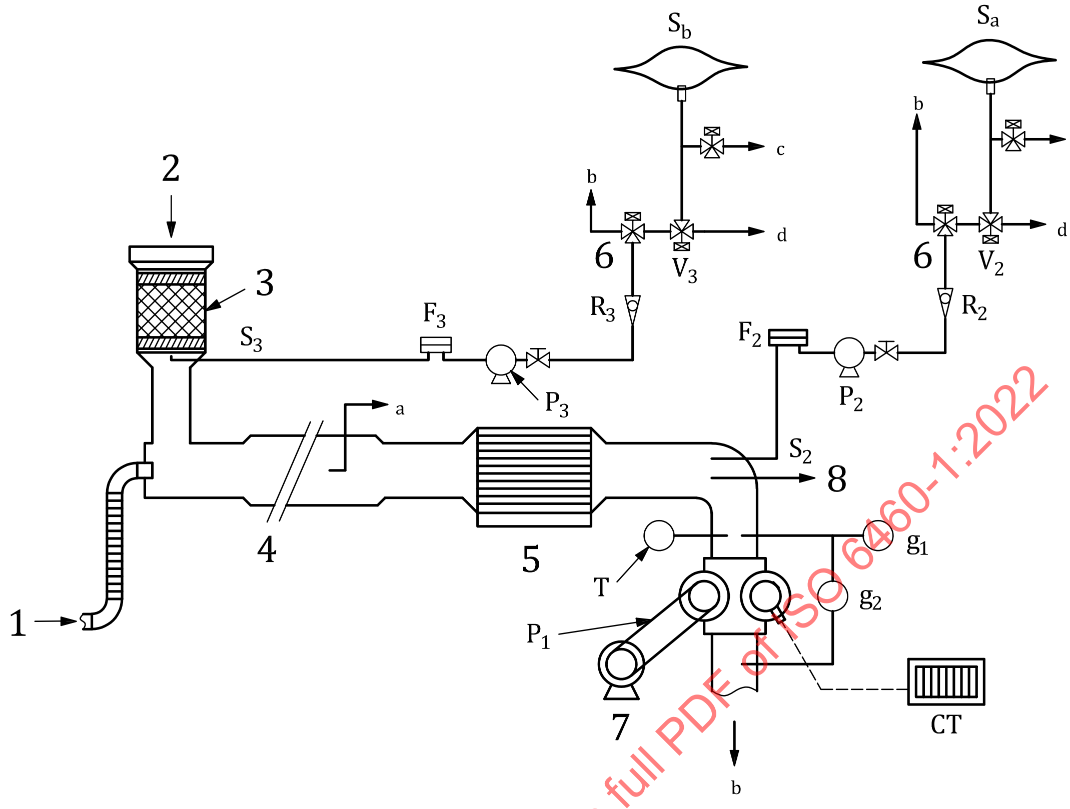
A schematic diagram is shown in Figure 2 for the representative closed type CVS system with CFV, and in Figure 3 for the representative closed type CVS system with PDP and in Figure 4 for the representative closed type CVS system with SSV.



**Key**

| | |
|---|---|
| 1 | exhaust emissions |
| 2 | dilution air |
| 3 | dilution air filter |
| 4 | mixing chamber |
| 5 | cyclone |
| 6 | diversion valve |
| 7 | sampling venturi |
| 8 | continuous sampling probe |
| 9 | blower |
| 10 | main critical flow venturi |
| 11 | pressure gauge |
| 12 | calculator |
| 13 | integrator |
| $F_2$, $F_3$ | filters |
| $P_2$, $P_3$ | sampling pumps |
| $R_2$, $R_3$ | flowmeters |
| $S_a$, $S_b$ | sampling bags |
| $S_2$, $S_3$ | sampling probes |
| T | temperature gauge |
| $V_2$, $V_3$ | valves |
| [a] | To HFID; special sampling line when HFID is used. |
| [b] | To atmosphere. |
| [c] | To exhaust pump. |
| [d] | To analysing system. |

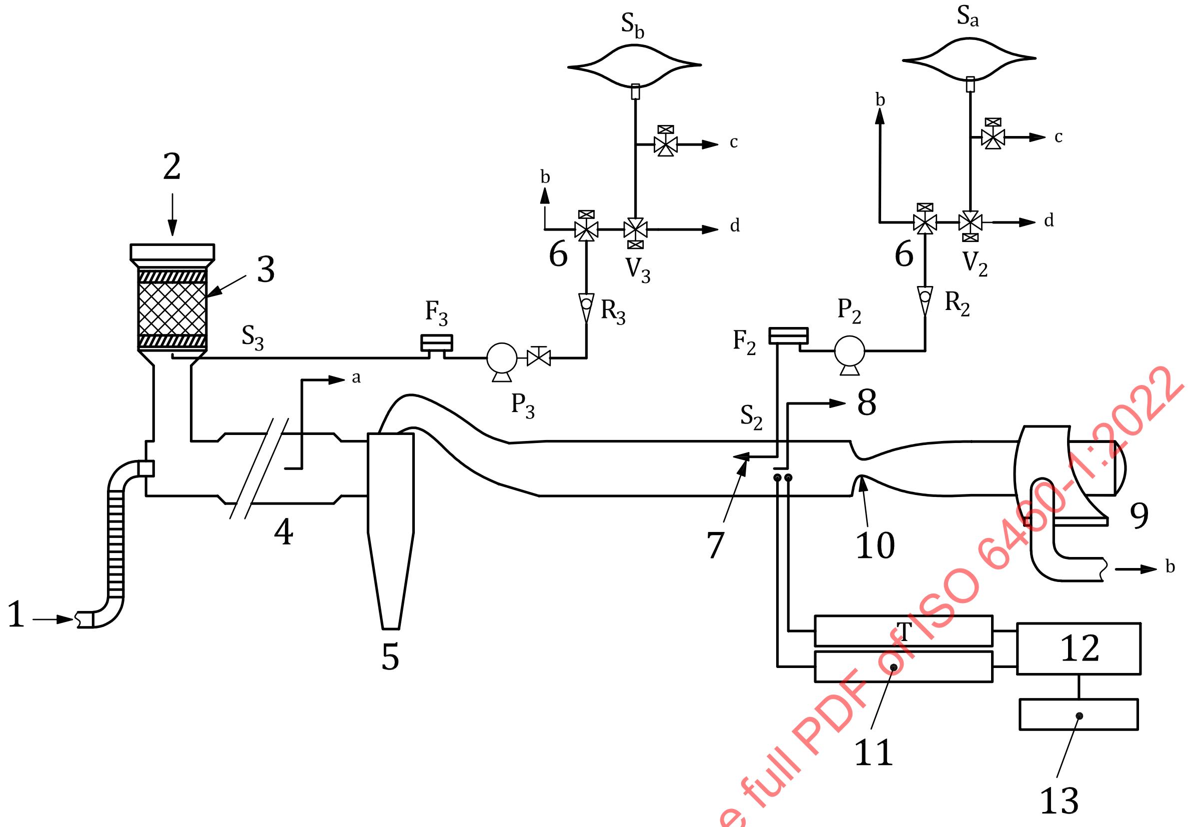
Figure 2 — Schematic diagram for the representative closed type CVS system with CFV



**Key**

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

**Figure 3 — Schematic diagram for the representative closed type CVS system with PDP**



**Key**

| | |
|---|---|
| 1 | exhaust emissions |
| 2 | dilution air |
| 3 | dilution air filter |
| 4 | mixing chamber |
| 5 | cyclone |
| 6 | diversion valve |
| 7 | sampling venturi |
| 8 | continuous sampling probe |
| 9 | blower |
| 10 | subsonic venturi |
| 11 | pressure gauge |
| 12 | calculator |
| 13 | integrator |
| $F_2$, $F_3$ | filters |
| $P_2$, $P_3$ | sampling pumps |
| $R_2$, $R_3$ | flowmeters |
| $S_a$, $S_b$ | sampling bags |
| $S_2$, $S_3$ | sampling probes |
| T | temperature gauge |
| $V_2$, $V_3$ | valves |
| [a] | To HFID; special sampling line when HFID is used. |
| [b] | To atmosphere. |
| [c] | To exhaust pump. |
| [d] | To analysing system. |

Figure 4 — Schematic diagram for the representative closed type CVS system with SSV

**10.1.1** The bags for collecting the samples shall be emptied and sealed.

**10.1.2** Preparation of CVS system includes the following:

NOTE The information in parenthesis refers to the keys of Figures 2 and 3.

a) CVS system with CFV:

1) the blower (Figure 2, key 9) shall be activated without starting up the integrator (Figure 2, key 13);

2) the sampling pumps (Figure 2, key $P_2$ and $P_3$) for collecting the samples shall be activated with the diversion valves (Figure 2, key 6) set to divert the samples into the atmosphere;

3) the temperature gauge (Figure 2, key T) and the pressure gauge (Figure 2, key 11) shall be activated;

4) the integrator (Figure 2, key 13) and the revolution counter for the chassis dynamometer roller shall be set to zero.

b) CVS system with PDP:

1) the positive displacement pump (Figure 3, key $P_1$) shall be activated without starting up the revolution counter (Figure 3, key CT);

2) the sampling pumps (Figure 3, key $P_2$ and $P_3$) for collecting the samples shall be activated with the diversion valves (Figure 3, key 6) set to divert the samples into the atmosphere;

3) the temperature gauge (Figure 3, key T) and the pressure gauges (Figure 3, key $g_1$ and $g_2$) shall be activated;

4) the revolution counter (Figure 3, key CT) and the revolution counter for the chassis dynamometer roller shall be set to zero.

## 10.2 Beginning of sampling and volume measurement

**10.2.1** The operations specified in 10.2.2 to 10.2.4 shall be performed simultaneously.

**10.2.2** The diversion valves (6), which have previously been directed towards the atmosphere, shall be set to collect the samples continuously through the sampling probes ($S_2$ and $S_3$) in the sampling bags ($S_a$ and $S_b$).

**10.2.3** In the case of the CVS system with CFV, the integrator (Figure 2, key 13) shall be activated. In the case of the CVS system with PDP, the revolution counter (Figure 3, key CT) shall be activated.

**10.2.4** The cooling equipment indicated in 7.5 shall be activated.

## 10.3 End of sampling and volume measurement

**10.3.1** At the end of the test cycle, the operations described in 10.3.2 to 10.3.4 shall be performed simultaneously.

**10.3.2** The diversion valves shall be set to close the sampling bags and to discharge into the atmosphere the samples sucked in by the sampling pumps through the sampling probes.

**10.3.3** In the case of the CVS system with CFV, the integrator (Figure 2, key 13) shall be stopped. In the case of the CVS system with PDP, the revolution counter (Figure 3, key CT) shall be stopped.

**10.3.4** The cooling equipped indicated in 7.5 shall be stopped.

## 10.4 Analysis

**10.4.1** The gaseous exhaust emissions contained in the bags shall be analysed as soon as possible, unless otherwise specified in ISO 6460-2.

**10.4.2** Prior to each sample analysis, the analyser range to be used for each pollutant shall be set to zero with the appropriate zero gas.

**10.4.3** The analysers shall then be set to the calibration curves by using span gases of nominal concentrations of 70 % to 100 % of the range.

**10.4.4** The analysers' zeros shall be then rechecked. If the reading values differ by more than 2 % of the range from those set in 10.4.2, the procedure shall be repeated.

**10.4.5** The samples shall then be analysed.

**10.4.6** After the analysis, zero and span points shall be rechecked by using the same gases. If the result of these rechecks are within 2 % of those in 10.4.3 and zero points are within 2 % of the range, the analysis is considered acceptable.

**10.4.7** In all processes of 10.4 the flow rates and pressures of the various gases shall be the same as those used during calibration of the analysers.

**10.4.8** The figure adopted for the concentration of each gaseous exhaust emissions shall be that read-off after stabilization of the measured values.

### 10.5 Measuring the driving distance

The distance actually travelled, expressed in kilometres, shall be obtained by multiplying the total number of revolutions shown on the revolution counter by the circumference of the roller.

### 10.6 Open type CVS system

When the open type CVS system is used, the exhaust emissions shall not leak from the connecting part of the sampling pipe(s) of the CVS system and the tailpipe(s) of the test motorcycle. The gaseous exhaust emissions leakage shall be checked.

NOTE The exhaust emissions leakage check procedure for the open type CVS system is described in Annex C.

## 11 Determination of the quantity of gaseous exhaust emissions

### 11.1 Total diluted exhaust mixture volume corrected to the standard reference conditions

The total diluted exhaust mixture volume flowed into the CVS system during the test shall be calculated and corrected to the standard reference conditions of temperature and pressure. In the case of the CVS system with CFV the procedure in 11.1.1 shall be used for the CVS system with PDP the procedure in 11.1.2 shall be used, and for the CVS system with SSV the procedure in 11.1.3 shall be used.

#### 11.1.1 Total diluted exhaust mixture volume for the CVS system with CFV

The diluted exhaust mixture volume, $V_e$, for the CVS system equipped with the CFV shall be obtained from Formulae (2) and (3):

$$V_e = V_S \times \frac{1}{S} \qquad (2)$$

$$V_S = k_1 \int_0^{t_{\text{test}}} \frac{p_v(t)}{\sqrt{T_v(t)}} \mathrm{d}t \tag{3}$$

The critical flow venturi correction factor, $k_1$, shall be determined from the measured flow rate of main critical flow venturi, $Q_{\text{cal}}$, using the other gas flowmeter (e.g. the laminar flowmeter) and the venturi correction factor shall be calculated from Formulae (4) and (5):

$$k_1 = Q_{\text{cal}} \times \frac{\sqrt{T_V}}{p_V} \tag{4}$$

$$Q_{\text{cal}} = k_2 \times Q_a \frac{p_a}{T_a} \tag{5}$$

The ratio of pressure to temperature at the standard reference conditions, $k_2$, shall be $k_2 = 273{,}15/101{,}325 = 2{,}696$.

### 11.1.2 Total diluted exhaust mixture volume for the CVS system with PDP

The volume of diluted exhaust mixture pumped during the test, $V_e$, shall be calculated by Formula (6):

$$V_e = k_2 \times \frac{V_p}{1\,000} \times N \times \frac{p_p}{T_p} \times \frac{1}{S} \tag{6}$$

The diluted exhaust mixture volume pumped by the PDP per one revolution, $V_p$, is dependent upon the pressure difference between the inlet and the outlet of the PDP.

The diluted exhaust mixture absolute pressure at the inlet of PDP, $p_p$, is the difference between atmospheric pressure and the depression at the inlet to the PDP while samples are being collected.

### 11.1.3 Total diluted exhaust mixture volume for the CVS system with SSV

The diluted exhaust mixture volume, $V_e$, for the CVS system equipped with the SSV shall be obtained from Formulae (7) and (8):

$$V_e = V_S \times \frac{1}{S} \tag{7}$$

$$V_S = k_3 d_V{}^2 C_d \int_0^{t_{\text{test}}} p_V(t) \sqrt{\left[ \frac{1}{T_V(t)} \left( r_x{}^{1{,}4286} - r_x{}^{1{,}7143} \right) \left( \frac{1}{1 - r_y{}^4 r_x{}^{1{,}4286}} \right) \right]} \mathrm{d}t \tag{8}$$

The discharge coefficient of the SSV, $C_d$, shall be determined from the measured flow rate of subsonic venturi, $Q_{\text{cal}}$, using the other gas flowmeter (e.g. the laminar flowmeter) and the discharge correction factor shall be calculated from Formulae (9) and (10):

$$C_d = \frac{Q_{\text{cal}}}{k_3 d_V{}^2 p_V \sqrt{\left[ \frac{1}{T_V} \left( r_x{}^{1{,}4286} - r_x{}^{1{,}7143} \right) \left( \frac{1}{1 - r_y{}^4 r_x{}^{1{,}4286}} \right) \right]}} \tag{9}$$

$$Q_{\text{cal}} = k_2 \times Q_a \frac{p_a}{T_a} \tag{10}$$

To determine the range of subsonic flow, $C_d$ shall be plotted as a function of Reynolds number *Re* at the SSV throat. The Reynolds number at the SSV throat shall be calculated from Formula (11):

$$Re = A_1 \times \frac{Q_{cal}}{d_V \times \mu} \tag{11}$$

where

$A_1$ is 25,551 52 in SI, $(\frac{kg}{m^3})(\frac{min}{s})(\frac{mm}{m})$;

$d_V$ is diameter of the SSV throat, in m;

$\mu$ is the absolute or dynamic viscosity of the gas, in kg/ms, calculated from Formula (12).

$$\mu = \frac{b \times {T_v}^{1,5}}{S_e + T_v} \tag{12}$$

$b$ is $1,458 \times 10^6$ (empirical constant), in kg/msK$^{0,5}$;

$S_e$ is 110,4 (empirical constant), in Kelvin (K).

## 11.2 Exhaust emissions sampling and the dilution factor

### 11.2.1 Exhaust emissions sampling

The whole exhaust emissions emitted from the tailpipe(s) of the test motorcycle shall be flowed into the CVS system and the adequate volume to analyse the diluted exhaust mixture (e.g. 50 l to 100 l) shall be collected in the bag.

### 11.2.2 Dilution factor

The dilution factor, $D_f$, shall be calculated by Formula (13). (Detailed information is given in Annex D.)

It is recommended that the amount of the dilution air should be determined so that the dilution factor becomes eight or more to prevent water condensation in the CVS system.

The dilution factor is defined as the volume ratio of the diluted exhaust mixture to the exhaust emissions.

$$D_f = \frac{100 / \{1 + (R_{HC,F} / 2) + [(4 + R_{HC,F}) / 4 - (R_{OC,F} / 2)] \times [(100 - c_{O2,d}) / c_{O2,d}]\}}{c_{CO2,e} + (c_{THC,e} + c_{CO,e}) \times 10^{-4}} \tag{13}$$

The oxygen concentration in the ambient air, $c_{O2,d}$, in percentage, is assumed to be 20,9 %.

$R_{HC,F}$ and $R_{OC,F}$ values shall be determined by the content analysis of the fuel in accordance with Annex F. If it is not possible to measure $R_{HC,F}$ and $R_{OC,F}$, the $R_{HC,F}$ value of 1,85 for gasoline (E0), 1,89 for gasoline (E5), 1,93 for gasoline (E10) and 2,64 for LPG, and the $R_{OC,F}$ value of zero for gasoline (E0), 0,016 for gasoline (E5), 0,033 for gasoline (E10) and zero for LPG, which is common for these fuels, may be used.

In this case, the dilution factor shall be calculated by Formulae (14), (15), (16) or (17), which are the transformations of Formula (13).

For gasoline (E0),

$$D_f = \frac{13{,}4}{c_{CO2,e} + (c_{THC,e} + c_{CO,e}) \times 10^{-4}} \tag{14}$$

For gasoline (E5),

$$D_f = \frac{13{,}4}{c_{CO2,e} + (c_{THC,e} + c_{CO,e}) \times 10^{-4}} \tag{15}$$

For gasoline (E10),

$$D_f = \frac{13{,}3}{c_{CO2,e} + (c_{THC,e} + c_{CO,e}) \times 10^{-4}} \tag{16}$$

For LPG,

$$D_f = \frac{11{,}6}{c_{CO2,e} + (c_{THC,e} + c_{CO,e}) \times 10^{-4}} \tag{17}$$

## 11.3 Mass of the gaseous exhaust emissions

### 11.3.1 Mass of carbon monoxide

The quantity of carbon monoxide in the exhaust emissions, $m_{CO}$, in grams per kilometre shall be calculated by Formula (18):

$$m_{CO} = V_e \times \rho_{CO} \times c_{CO,ec} \times 10^{-6} \tag{18}$$

The carbon monoxide density, $\rho_{CO}$, in grams per cubic metre, at standard reference conditions shall be 1,25 × $10^3$ g/m$^3$.

The volumetric concentration of carbon monoxide in the diluted exhaust mixture, corrected to take account of carbon monoxide in the dilution air, $c_{CO,ec}$, shall be determined by Formula (19):

$$c_{CO,ec} = c_{CO,e} - c_{CO,d}\left(1 - \frac{1}{D_f}\right) \tag{19}$$

If the absorbent is intended to remove water vapour and carbon dioxide from the diluted exhaust mixture is used, $c_{CO,e}$ and $c_{CO,d}$ shall be corrected by Formulae (20) and (21):

$$c_{CO,e} = \left[1 - (0{,}01 + 0{,}005 \times R_{HC,F}) c_{CO2,e} - 0{,}000\ 323 H_d\right] c_{CO,em} \tag{20}$$

$$c_{CO,d} = (1 - 0{,}000\ 323 H_d) c_{CO,dm} \tag{21}$$

### 11.3.2 Mass of total hydrocarbons

The quantity of total hydrocarbon in the exhaust emissions, $m_{\mathrm{THC}}$, in grams per kilometre, shall be calculated by Formula (22):

$$m_{\mathrm{THC}} = V_{\mathrm{e}} \times \rho_{\mathrm{THC}} \times c_{\mathrm{THC,ec}} \times 10^{-6} \tag{22}$$

The total hydrocarbon density, $\rho_{\mathrm{THC}}$, in grams per cubic metre, at standard reference conditions shall be determined by Formula (23):

$$\rho_{\mathrm{THC}} = \frac{12{,}01 + 1{,}008 R_{\mathrm{HC,F}} + 16{,}00 R_{\mathrm{OC,F}}}{22{,}4} \times 1\ 000 \tag{23}$$

$R_{\mathrm{HC,F}}$ and $R_{\mathrm{OC,F}}$ shall be determined by the content analysis of the fuel in accordance with Annex F. If it is not possible to measure $R_{\mathrm{HC,F}}$ and $R_{\mathrm{OC,F}}$, the $R_{\mathrm{HC,F}}$ value of 1,85 for gasoline (E0), 1,89 for gasoline (E5), 1,93 for gasoline (E10) and 2,64 for LPG, and the $R_{\mathrm{OC,F}}$ value of zero for gasoline (E0), 0,016 for gasoline (E5), 0,033 for gasoline (E10) and zero for LPG, which is common for these fuels, may be used.

The volumetric concentration of total hydrocarbon in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of total hydrocarbon in the dilution air, $c_{\mathrm{THC,ec}}$, shall be determined by Formula (24):

$$c_{\mathrm{THC,ec}} = c_{\mathrm{THC,e}} - c_{\mathrm{THC,d}} \left(1 - \frac{1}{D_{\mathrm{f}}}\right) \tag{24}$$

### 11.3.3 Mass of non-methane hydrocarbons

The quantity of non-methane hydrocarbon in the exhaust emissions, $m_{\mathrm{NMHC}}$, in grams per kilometre, shall be calculated by Formula (25):

$$m_{\mathrm{NMHC}} = V_{\mathrm{e}} \times \rho_{\mathrm{NMHC}} \times c_{\mathrm{NMHC,ec}} \times 10^{-6} \tag{25}$$

The non-methane hydrocarbon density, $\rho_{\mathrm{NMHC}}$, in grams per cubic metre, at standard reference conditions shall be equal to that of total hydrocarbons at standard reference conditions and is fuel-dependent.

#### 11.3.3.1 Calculation for the methane and non-methane hydrocarbon concentrations using the GC-FID

For methane measurement using a GC-FID, the volumetric concentration of non-methane hydrocarbon (NMHC) in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of non-methane hydrocarbon in the dilution air, $c_{\mathrm{NMHC,ec}}$, shall be calculated by Formula (26):

$$c_{\mathrm{NMHC,ec}} = c_{\mathrm{THC,ec}} - \left(R_{\mathrm{f,CH4}} \times c_{\mathrm{CH4,ec}}\right) \tag{26}$$

The volumetric concentration of methane ($CH_4$) in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of methane in the dilution air, $c_{\mathrm{CH4,ec}}$, shall be determined by Formula (27):

$$c_{\mathrm{CH4,ec}} = c_{\mathrm{CH4,e}} - c_{\mathrm{CH4,d}} \left(1 - \frac{1}{D_{\mathrm{f}}}\right) \tag{27}$$

#### 11.3.3.2 Calculation for the methane and non-methane hydrocarbon concentrations using the NMC-FID

For methane measurement using an NMC-FID, the calculation of NMHC depends on the calibration gas/method used for the calibration adjustment. The FID used for the HC measurement (without NMC) shall be calibrated with propane/air in the normal manner. For the calibration of the FID in series with an NMC, the following methods are permitted:

a) the calibration gas consisting of propane/air bypasses the NMC;

b) the calibration gas consisting of methane/air passes through the NMC.

It is highly recommended to calibrate the methane FID with methane/air through the NMC.

In case a), the volumetric concentration of $CH_4$ and NMHC in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of methane in the dilution air, $c_{\mathrm{CH4,ec}}$ and $c_{\mathrm{NMHC,ec}}$ shall be calculated by Formulae (28) and (29):

$$c_{\mathrm{CH4,ec}} = \frac{c_{\mathrm{HC(w/\,NMC),ec}} - c_{\mathrm{HC(w/o\,NMC),ec}} \times (1 - E_{\mathrm{E}})}{R_{\mathrm{f,CH4}} \times (E_{\mathrm{E}} - E_{\mathrm{M}})} \tag{28}$$

$$c_{\mathrm{NMHC,ec}} = \frac{c_{\mathrm{HC(w/o\,NMC),ec}} \times (1 - E_{\mathrm{M}}) - c_{\mathrm{HC(w/\,NMC),ec}}}{E_{\mathrm{E}} - E_{\mathrm{M}}} \tag{29}$$

If $R_{\mathrm{f}} < 1{,}05$, it may be omitted from the formula for case a) in this subclause for $c_{\mathrm{CH4,ec}}$.

In case b), the volumetric concentration of $CH_4$ and NMHC in the diluted exhaust mixture, expressed in ppm carbon equivalent, corrected to take account of methane in the dilution air, $c_{\mathrm{CH4,ec}}$ and $c_{\mathrm{NMHC,ec}}$ shall be calculated by Formulae (30) and (31):

$$c_{\mathrm{CH4,ec}} = \frac{c_{\mathrm{HC(w/\,NMC),ec}} \times R_{\mathrm{f,CH4}} \times (1 - E_{\mathrm{M}}) - c_{\mathrm{HC(w/o\,NMC),ec}} \times (1 - E_{\mathrm{E}})}{R_{\mathrm{f,CH4}} \times (E_{\mathrm{E}} - E_{\mathrm{M}})} \tag{30}$$

$$c_{\mathrm{NMHC,ec}} = \frac{c_{\mathrm{HC(w/o\,NMC),ec}} \times (1 - E_{\mathrm{M}}) - c_{\mathrm{HC(w/\,NMC),ec}} \times R_{\mathrm{f,CH4}} \times (1 - E_{\mathrm{M}})}{E_{\mathrm{E}} - E_{\mathrm{M}}} \tag{31}$$

If $R_{\mathrm{f}} < 1{,}05$, it may be omitted in the formulae for case (b) in this subclause for $c_{\mathrm{CH4,ec}}$. and $c_{\mathrm{NMHC,ec}}$.

Here, the volumetric concentration of hydrocarbon in the diluted exhaust mixture with sample gas flowing through the NMC, expressed in ppm carbon equivalent, corrected to take account of hydrocarbon in the dilution air, $c_{\mathrm{HC(w/\,NMC),ec}}$ shall be determined by Formula (32):

$$c_{\mathrm{HC(w/\,NMC),ec}} = c_{\mathrm{HC(w\,/NMC),e}} - c_{\mathrm{HC(w/\,NMC),d}} \left(1 - \frac{1}{D_{\mathrm{f}}}\right) \tag{32}$$

Here, the volumetric concentration of hydrocarbon in the diluted exhaust mixture with sample gas bypassing the NMC, expressed in ppm carbon equivalent, corrected to take account of hydrocarbon in the dilution air, $c_{\mathrm{HC(w/o\,NMC),ec}}$ shall be determined by Formula (33):

$$c_{\mathrm{HC(w/o\,NMC),ec}} = c_{\mathrm{HC(w/o\,NMC),e}} - c_{\mathrm{HC(w/o\,NMC),d}} \left(1 - \frac{1}{D_{\mathrm{f}}}\right) \tag{33}$$

##### 11.3.3.2.1 Conversion efficiencies of the non-methane cutter (NMC)

The NMC is used for the removal of the non-methane hydrocarbons from the sample gas by oxidizing all hydrocarbons except methane. Ideally, the conversion for methane is 0 %, and for the other hydrocarbons represented by ethane is 100 %. For the accurate measurement of NMHC, the two efficiencies shall be determined and used for the calculation of the NMHC emission.

#### 11.3.3.2.2 Methane conversion efficiency

The methane/air calibration gas shall flow to the FID through the NMC and bypassing the NMC and the two concentrations recorded. The efficiency shall be determined by Formula (34):

$$E_{\mathrm{M}} = 1 - \frac{c_{\mathrm{HC(w/\,NMC)}}}{c_{\mathrm{HC(w/o\,NMC)}}} \tag{34}$$

#### 11.3.3.2.3 Ethane conversion efficiency

The ethane/air calibration gas shall flow to the FID through the NMC and bypassing the NMC and the two concentrations recorded. The efficiency shall be determined by Formula (35):

$$E_{\mathrm{E}} = 1 - \frac{c_{\mathrm{HC(w/\,NMC)}}}{c_{\mathrm{HC(w/o\,NMC)}}} \tag{35}$$

If the ethane conversion efficiency of the NMC is 0,98 or higher, $E_{\mathrm{E}}$ shall be set to 1 for any subsequent calculation.

#### 11.3.3.2.4 Methane FID is calibrated through the cutter

If the methane FID is calibrated through the cutter, then $E_{\mathrm{M}}$ shall be 0.

### 11.3.4 Mass of nitrogen oxides

The quantity of nitrogen oxides in the exhaust emissions, $m_{\mathrm{NOx}}$, in grams per kilometre, shall be calculated by Formula (36):

$$m_{\mathrm{NOx}} = V_{\mathrm{e}} \times \rho_{\mathrm{NOx}} \times c_{\mathrm{NOx,ec}} \times K_{\mathrm{H}} \times 10^{-6} \tag{36}$$

The nitrogen dioxides density, $\rho_{\mathrm{NOx}}$, in grams per cubic metre, under the standard reference conditions, expressed in equivalent $NO_2$, shall be 2,05 × $10^3$ g/m$^3$.

The volumetric concentration of nitrogen oxides in the diluted exhaust mixture, corrected to take account of nitrogen oxides in the dilution air, $c_{\mathrm{NOx,ec}}$, shall be determined by Formula (37):

$$c_{\mathrm{NOx,ec}} = c_{\mathrm{NOx,e}} - c_{\mathrm{NOx,d}} \left(1 - \frac{1}{D_{\mathrm{f}}}\right) \tag{37}$$

The humidity correction factor, $K_{\mathrm{H}}$, using for calculation of mass of nitrogen oxides, shall be defined by Formula (38).

$$K_{\mathrm{H}} = \frac{1}{1 - 0{,}032\,9 \times (H_{\mathrm{a}} - 10{,}71)} \tag{38}$$

where

$$H_{\mathrm{a}} = \frac{6{,}211 H_{\mathrm{r}} \times p_{\mathrm{d}}}{p_{\mathrm{a}} - [(p_{\mathrm{d}} \times H_{\mathrm{r}})/100]} \tag{39}$$

### 11.3.5 Mass of carbon dioxide

The quantity of carbon dioxide in the exhaust emissions, $m_{\mathrm{CO2}}$, in grams per kilometre shall be calculated by Formula (40):

$$m_{\mathrm{CO2}} = V_{\mathrm{e}} \times \rho_{\mathrm{CO2}} \times c_{\mathrm{CO2,ec}} \times 10^{-2} \tag{40}$$

The carbon dioxide density, $\rho_{\mathrm{CO2}}$, in grams per cubic metre, at the standard reference conditions shall be $1{,}96 \times 10^3$ g/m$^3$.

The volumetric concentration of carbon dioxide in the diluted exhaust mixture, corrected to take account of carbon dioxide in the dilution air, $c_{\mathrm{CO2,ec}}$, shall be determined by Formula (41):

$$c_{\mathrm{CO2,ec}} = c_{\mathrm{CO2,e}} - c_{\mathrm{CO2,d}}\left(1 - \frac{1}{D_{\mathrm{f}}}\right) \tag{41}$$

## 12 Determination of the fuel consumption

### 12.1 Carbon balance method

#### 12.1.1 Fuel consumption for four-stroke engines

Formula (42) shall be used for the calculation of fuel consumption. (Detailed information is given in Annex E.)

$$F_c = \frac{12{,}01}{12{,}01 + 1{,}008R_{\mathrm{HC,F}} + 16{,}00R_{\mathrm{OC,F}}} \times \frac{\rho_{\mathrm{F}}}{(12{,}01/44{,}01)m_{\mathrm{CO2}} + (12{,}01/28{,}01)m_{\mathrm{CO}} + \left[12{,}01/\left(12{,}01 + 1{,}008R_{\mathrm{HC,F}} + 16{,}00R_{\mathrm{OC,F}}\right)\right]m_{\mathrm{THC}}} \tag{42}$$

$R_{\mathrm{HC,F}}$ and $R_{\mathrm{OC,F}}$ values shall be determined by the content analysis of the fuel in accordance with Annex F. If it is not possible to measure $R_{\mathrm{HC,F}}$ and $R_{\mathrm{OC,F}}$, the $R_{\mathrm{HC,F}}$ value of 1,85 for gasoline (E0), 1,89 for gasoline (E5), 1,93 for gasoline (E10) and 2,64 for LPG, and the $R_{\mathrm{OC,F}}$ value of zero for gasoline (E0), 0,016 for gasoline (E5), 0,033 for gasoline (E10) and zero for LPG, which is common for these fuels, may be used.

In this case, the fuel consumption can be calculated by Formulae (43), (44), (45) or (46), which are the transformation of Formula (42).

For gasoline (E0) four-stroke spark ignition engine,

$$F_c = \frac{866 \times \rho_F}{(0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}866 \times m_{THC})} \tag{43}$$

For gasoline (E5) four-stroke spark ignition engine,

$$F_c = \frac{848 \times \rho_F}{(0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}848 \times m_{THC})} \tag{44}$$

For gasoline (E10) four-stroke spark ignition engine,

$$F_c = \frac{829 \times \rho_F}{(0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}829 \times m_{THC})} \tag{45}$$

For LPG four-stroke spark ignition engines,

$$F_c = \frac{819 \times \rho_F}{(0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}819 \times m_{THC})} \tag{46}$$

### 12.1.2 Calculation of results in litres per 100 km

When the fuel consumption is expressed in litres per 100 km, the fuel consumption can be calculated by Formulae (47), (48), (49) or (50):

For gasoline (E0) four-stroke spark ignition engine,

$$F_{c100} = \frac{0{,}116}{\rho_F} \times (0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}866 \times m_{THC}) \tag{47}$$

For gasoline (E5) four-stroke spark ignition engine,

$$F_{c100} = \frac{0{,}118}{\rho_F} \times (0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}848 \times m_{THC}) \tag{48}$$

For gasoline (E10) four-stroke spark ignition engine,

$$F_{c100} = \frac{0{,}121}{\rho_F} \times (0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}829 \times m_{THC}) \tag{49}$$

For LPG four-stroke spark ignition engines,

$$F_{c100} = \frac{0{,}122}{\rho_F} \times (0{,}273 \times m_{CO2}) + (0{,}429 \times m_{CO}) + (0{,}819 \times m_{THC}) \tag{50}$$

## 12.2 Fuel flow measurement method

Methods for fuel consumption are shown in Annex A.

### 12.2.1 Fuel consumption for four-stroke engines

#### 12.2.1.1 Fuel consumption measured by the volumetric method

In cases where fuel consumption is measured volumetrically, the fuel consumption, $F_c$, shall be calculated by Formula (51):

$$F_c = \frac{S}{V[1+\alpha(T_0 - T_F)]} \tag{51}$$

The coefficient of volumetric expansion for the fuel, $\alpha$, shall be 0,001 $K^{-1}$.

#### 12.2.1.2 Fuel consumption measured by the gravimetric method

In cases where fuel consumption is measured gravimetrically, the fuel consumption, $F_c$, shall be calculated by Formula (52):

$$F_c = \frac{S \times \rho_F}{m_F} \tag{52}$$

#### 12.2.1.3 Fuel consumption measured by the flowmeter method

In cases where the fuel consumption is measured by the flowmeter, the fuel consumption, $F_c$, shall be calculated by Formula (53):

$$F_c = \frac{S}{V} \tag{53}$$

### 12.2.2 Calculation of results in litres per 100 km

When the fuel consumption is expressed in litres per 100 km, Formula (54) shall be used:

$$F_{c100} = \frac{100}{F_c} \tag{54}$$

# Annex A
(normative)

# Method and equipment for measuring fuel consumption by the fuel flow measurement method

## A.1 Methods

### A.1.1 Volumetric method

The volumetric method uses a container with a known volume, allowing the volume of the fuel consumed to be calculated.

This container may be a constant or variable volume type.

The constant volume container only allows the reading of a fixed quantity of fuel that has been determined beforehand. This prefixed quantity depends on container volume or markings on the container.

The variable volume container is one with division markings which allows the reading of a volume that has not been determined beforehand.

### A.1.2 Gravimetric method

The gravimetric method uses a weighing device to determine the mass of fuel consumed. This device can be of the constant or variable mass type.

The constant mass device only allows the reading of a fixed quantity of fuel that has been determined beforehand. This fixed quantity depends on the device itself and on its characteristics.

The variable mass device allows the reading of a quantity of fuel that has not been determined beforehand.

### A.1.3 Flowmeter method

The flowmeter method uses devices allowing measurement, in a continuous or discontinuous way, of the quantified mass or volume of fuel passing through during a certain interval.

The continuous device gives an indication with respect to the flow, while the discontinuous type gives an indication based on counting small elementary volumes.

## A.2 Installation of measuring equipment

### A.2.1 General

**A.2.1.1** Whatever the measuring method used, the installation of the equipment shall in no case disturb or modify significantly the fuel feed system of the motorcycle, referring mainly to pressure drops, diameters and lengths of fuel feed pipes.

**A.2.1.2** The conditions given in A.2.1.1 are considered to be met:

a) if the mounting of the installation for the volumetric or gravimetric methods is in accordance with Figures A.1, A.2, A.4 and A.5;

b) if the mounting of the installation for the flowmeter method is in accordance with Figures A.3, A.6, A.7, A.8 and A.9, and the pressure drop across the system is less than 1 hPa.

When the flowmeter is installed in high pressure pipe lines of fuel injection system, care shall be taken when setting the position of the flowmeter and following points:

- the resisting pressure of parts of flowmeter, e.g. sensors, filters, pipes, shall be sufficiently higher than the fuel pressure;
- the pressure drops caused by parts of the flowmeter, e.g. sensors, filters, pipes, shall not have an influence on the fuel injection pressure and the fuel flow rate;
- in cases where intermittent flow or reflux occurs in the vicinity of the flowmeter, the pipe arrangement shall be improved or the flowmeter shall have the compensator for the intermittent flow and reflux;
- no vapour shall be generated in the pipes and the flowmeter.

**A.2.1.3** Other installation locations may be used if it has been proved that these conditions do not influence the fuel feed of the motorcycle.

**A.2.1.4** To reduce the possibility of pressure loss in the fuel pipes, it is recommended that Formulae (A.1) to (A.4) are followed:

$$d_1 \leqq d_2 \tag{A.1}$$

$$d_2 = d_3 \tag{A.2}$$

where

$d_1$ is the original fuel pipe diameter (see Figure A.1 to Figure A.9);

$d_2$ is the fuel pipe diameter of the measuring device (see Figure A.1 to Figure A.9);

$d_3$ is the fuel pipe diameter of the measuring device (see Figure A.1 to Figure A.9).

$$d_4 \leqq d_5 \tag{A.3}$$

$$d_5 = d_5 \tag{A.4}$$

where

$d_4$ is the original fuel pipe diameter (see Figure A.7 and Figure A.8);

$d_5$ is the fuel pipe diameter of the measuring device (see Figure A.7 and Figure A.8);

$d_5$ is the fuel pipe diameter of the measuring device (see Figure A.7 and Figure A.8).

### A.2.2 Volumetric method

**A.2.2.1** A schematic diagram is shown in Figure A.1 for carburettor systems and in Figure A.4 for injection systems.

**A.2.2.2** Test conditions for the volumetric method for chassis dynamometer and road use shall be as follows:

a) the burette shall be placed at the side of the fuel tank in such a way that Formula (A.5) is followed.

$$h_a \leqq h_u - h_l + 300 \quad (A.5)$$

where

$h_a$ is the height measured by burette, in millimetres;

$h_u$ is the upper head of fuel, in millimetres;

$h_l$ is the lower head of fuel, in millimetres.

b) care shall be taken that the pressure in the burette is not influenced by wind pressure acting on the air vent of the burette.

### A.2.3 Gravimetric method

**A.2.3.1** A schematic diagram is shown in Figure A.2 for carburettor systems and in Figure A.5 for injection systems.

**A.2.3.2** The mass of consumed fuel shall be measured with an accuracy of ±1 % to the resolution of 0,1 g.

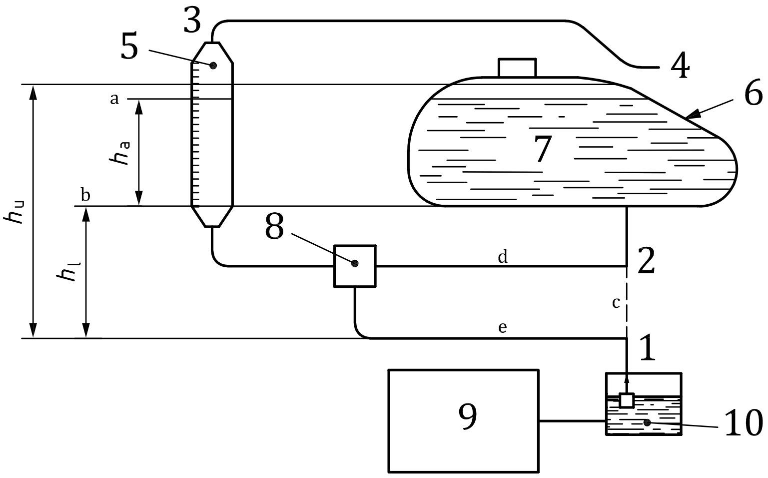
**A.2.3.3** The density (mass/volume) shall be measured with an accuracy of 1 kg/m$^3$ and then converted to the reference conditions.

### A.2.4 Flowmeter method

**A.2.4.1** The flowmeter shall be designed in such a way that the overall pressure loss through the device is not greater than 1 hPa.

**A.2.4.2** A schematic diagram of the flowmeter is shown in Figure A.3 for carburettor systems and in Figures A.6, A.7, A.8 and A.9 for injection systems.

**A.2.4.3** Accuracy shall be within ±1 % for the range of all the flows registered during that test.

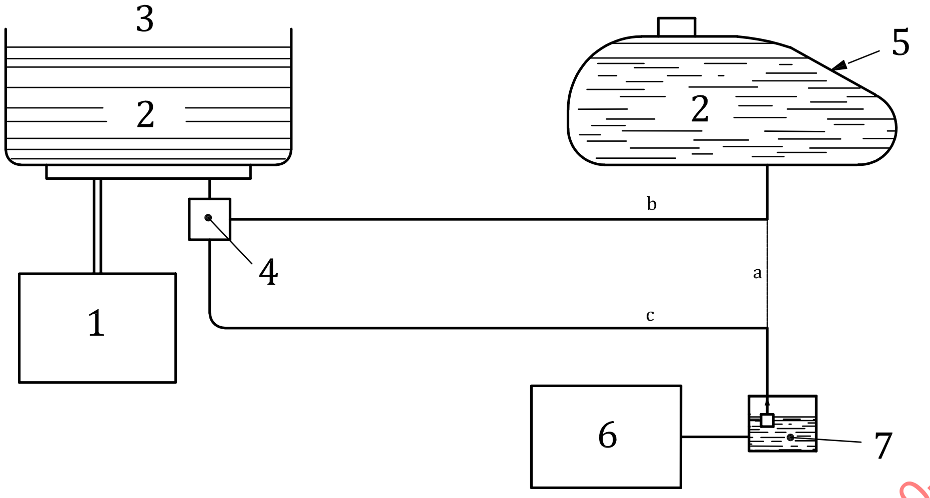


**Key**

| | |
|---|---|
| 1 | carburettor fuel inlet |
| 2 | fuel tank outlet |
| 3 | burette air vent |
| 4 | burette air vent pipe |
| 5 | burette |
| 6 | fuel tank |
| 7 | fuel |
| 8 | 3-way valve |
| 9 | engine |
| 10 | carburettor float chamber |

| | |
|---|---|
| $h_u$ | upper head of fuel, in millimetres |
| $h_l$ | lower head of fuel, in millimetres |
| $h_a$ | height measured by burette, in millimetres |
| a | On circuit. |
| b | Off circuit. |
| c | Original fuel pipe diameter, $d_1$. |
| d | Fuel pipe diameter of the measuring device, $d_2$. |
| e | Fuel pipe diameter of the measuring device, $d_3$. |

**Figure A.1 — Volumetric method — Carburettor system**

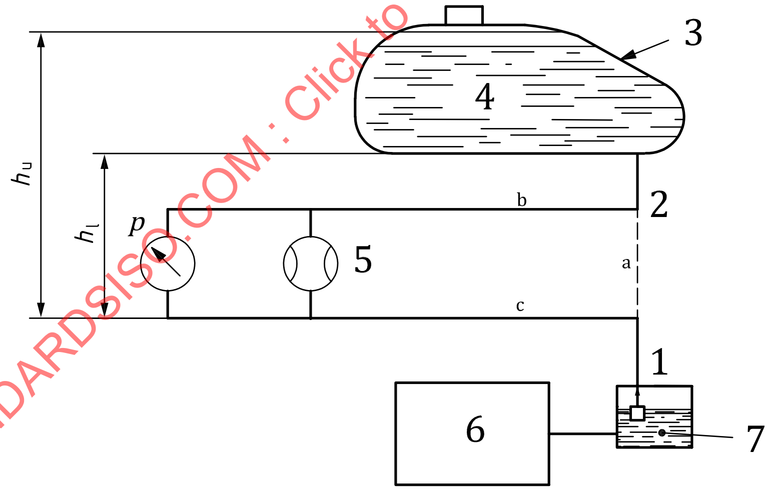


**Key**

| | |
|---|---|
| 1 | scales |
| 2 | fuel |
| 3 | auxiliary tank |
| 4 | 3-way valve |
| 5 | fuel tank |
| 6 | engine |
| 7 | carburettor float chamber |

| | |
|---|---|
| a | Original fuel pipe diameter, $d_1$. |
| b | Fuel pipe diameter of the measuring device, $d_2$. |
| c | Fuel pipe diameter of the measuring device, $d_3$. |

**Figure A.2 — Gravimetric method — Carburettor system**

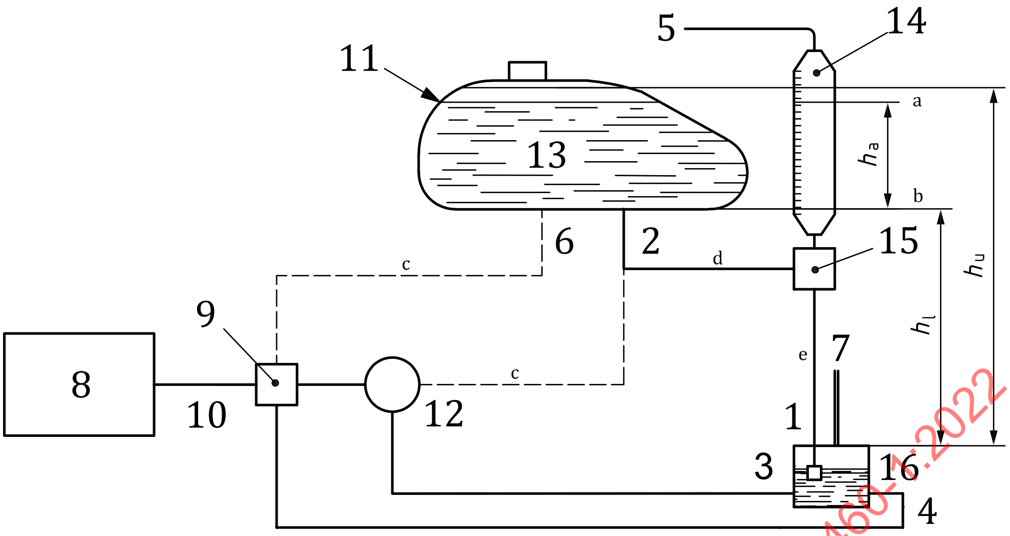


**Key**

| | |
|---|---|
| 1 | carburettor fuel inlet |
| 2 | fuel tank outlet |
| 3 | fuel tank |
| 4 | fuel |
| 5 | flowmeter |
| 6 | engine |
| 7 | carburettor float chamber |

| | |
|---|---|
| $h_u$ | upper head of fuel, in millimetres |
| $h_l$ | lower head of fuel, in millimetres |
| $p$ | pressure drop across flowmeter, in hectopascals |
| a | Original fuel pipe diameter, $d_1$. |
| b | Fuel pipe diameter of the measuring device, $d_2$. |
| c | Fuel pipe diameter of the measuring device, $d_3$. |

**Figure A.3 — Flowmeter method — Carburettor system**

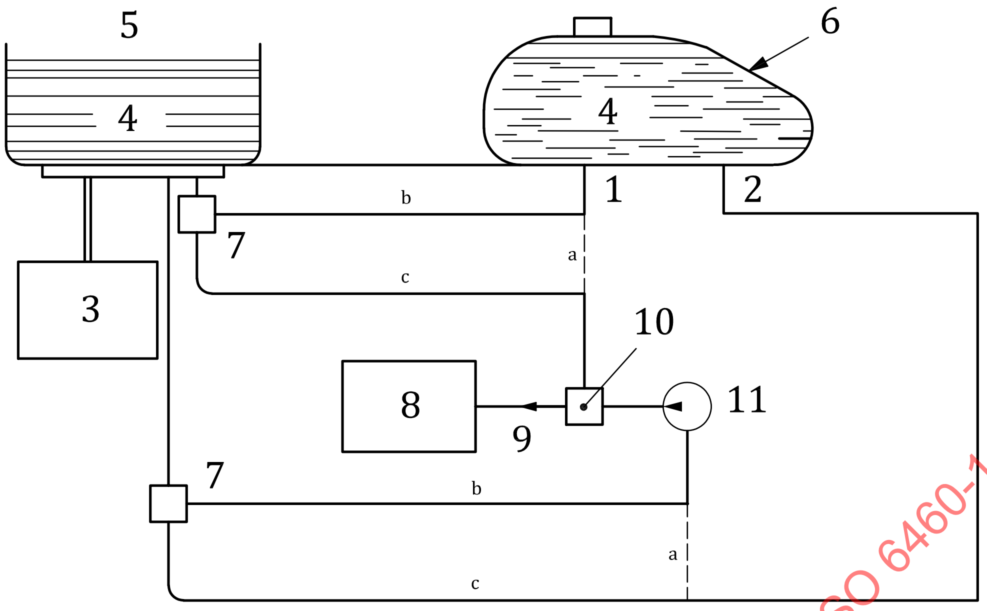


**Key**

| | |
|---|---|
| 1 | leveller fuel inlet |
| 2 | fuel tank outlet |
| 3 | leveller fuel outlet |
| 4 | leveller fuel inlet |
| 5 | burette air vent pipe |
| 6 | fuel tank inlet |
| 7 | leveller air vent pipe |
| 8 | engine |
| 9 | fuel pressure regulator |
| 10 | fuel injection |
| 11 | leveller fuel inlet |
| 12 | fuel tank outlet |
| 13 | leveller fuel outlet |
| 14 | leveller fuel inlet |
| 15 | burette air vent pipe |
| 16 | fuel tank inlet |

| | |
|---|---|
| $h_u$ | upper head of fuel, in millimetres |
| $h_l$ | lower head of fuel, in millimetres |
| $h_a$ | height measured by burette, in millimetres |
| a | On circuit. |
| b | Off circuit. |
| c | Original fuel pipe diameter, $d_1$. |
| d | Fuel pipe diameter of the measuring device, $d_2$. |
| e | Fuel pipe diameter of the measuring device, $d_3$. |

Figure A.4 — Volumetric method — Fuel injection system



**Key**

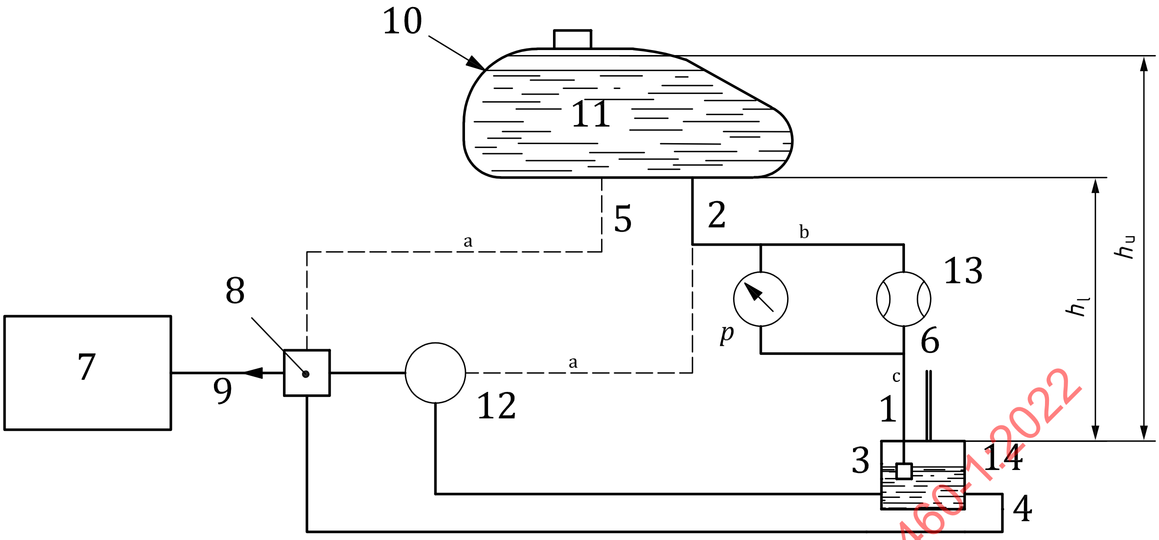
| | |
|---|---|
| 1 | fuel tank inlet |
| 2 | fuel tank outlet |
| 3 | scales |
| 4 | fuel |
| 5 | auxiliary tank |
| 6 | fuel tank |
| 7 | 3-way valve |
| 8 | engine |
| 9 | fuel injection |
| 10 | fuel pressure regulator |
| 11 | fuel pressure pump |

[a] Original fuel pipe diameter, $d_1$.

[b] Fuel pipe diameter of the measuring device, $d_2$.

[c] h Fuel pipe diameter of the measuring device, $d_3$.

Figure A.5 — Gravimetric method — Fuel injection system

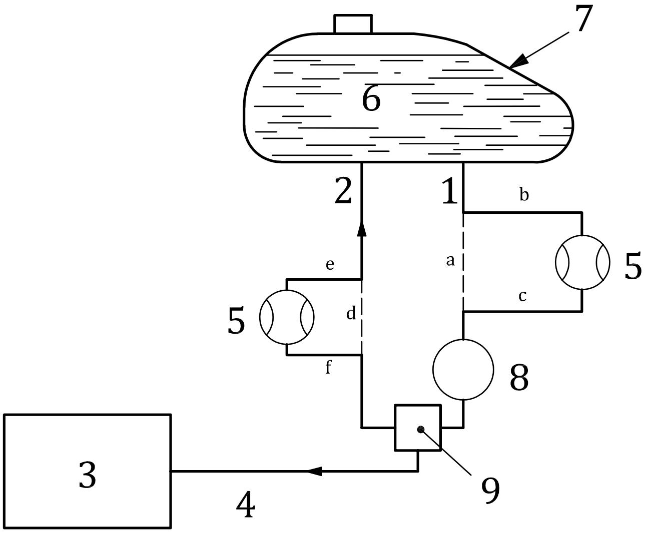


**Key**

| | |
|---|---|
| 1 | leveller fuel inlet |
| 2 | fuel tank outlet |
| 3 | leveller fuel outlet |
| 4 | leveller fuel inlet |
| 5 | fuel tank inlet |
| 6 | leveller air vent pipe |
| 7 | engine |
| 8 | fuel pressure regulator |
| 9 | fuel injection |
| 10 | fuel tank |
| 11 | fuel |
| 12 | fuel pressure pump |
| 13 | flowmeter |
| 14 | leveller |

| | |
|---|---|
| $h_u$ | upper head of fuel, in millimetres |
| $h_l$ | lower head of fuel, in millimetres |
| $p$ | pressure drop across flowmeter, in hectopascals |
| a | Original fuel pipe diameter, $d_1$. |
| b | Fuel pipe diameter of the measuring device, $d_2$. |
| c | Fuel pipe diameter of the measuring device, $d_3$. |

**Figure A.6 — Flowmeter method — Fuel injection system**

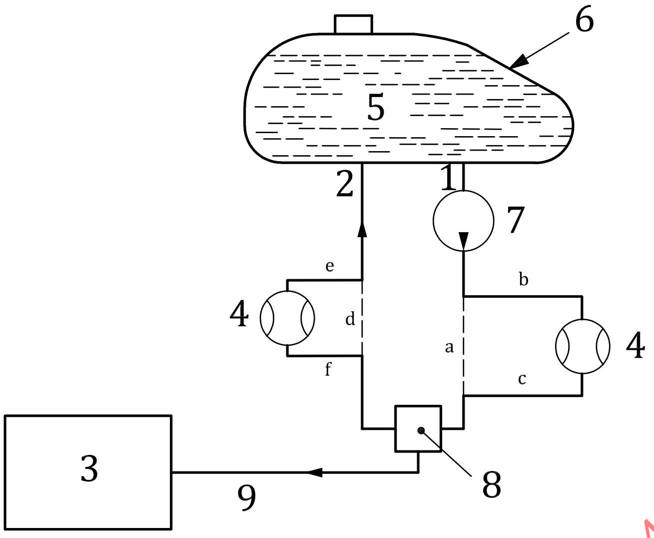


**Key**

| | |
|---|---|
| 1 | fuel tank outlet |
| 2 | fuel return |
| 3 | engine |
| 4 | fuel injection |
| 5 | flowmeter |
| 6 | fuel |
| 7 | fuel tank |
| 8 | fuel pressure pump |
| 9 | fuel pressure regulator |

| | |
|---|---|
| a | Original fuel pipe diameter, $d_1$. |
| b | Fuel pipe diameter of the measuring device, $d_2$. |
| c | Fuel pipe diameter of the measuring device, $d_3$. |
| d | Original fuel pipe diameter, $d_4$. |
| e | Fuel pipe diameter of the measuring device, $d_5$. |
| f | Fuel pipe diameter of the measuring device, $d_6$. |

Figure A.7 — Flowmeter method — Fuel injection system with fuel return — Type 1 method

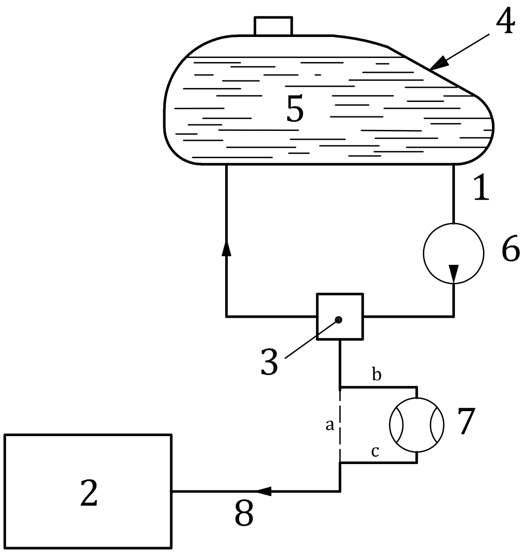


**Key**

| | |
|---|---|
| 1 | fuel tank outlet |
| 2 | fuel return |
| 3 | engine |
| 4 | flowmeter |
| 5 | fuel |
| 6 | fuel tank |
| 7 | fuel pressure pump |
| 8 | fuel pressure regulator |
| 9 | fuel injection |

| | |
|---|---|
| a | Original fuel pipe diameter, $d_1$. |
| b | Fuel pipe diameter of the measuring device, $d_2$. |
| c | Fuel pipe diameter of the measuring device, $d_3$. |
| d | Original fuel pipe diameter, $d_4$. |
| e | Fuel pipe diameter of the measuring device, $d_5$. |
| f | Fuel pipe diameter of the measuring device, $d_6$. |

**Figure A.8 — Flowmeter method — Fuel injection system with fuel return — Type 2 method**



**Key**

1 fuel tank outlet
2 engine
3 fuel pressure regulator
4 fuel tank
5 fuel
6 fuel pressure pump
7 flowmeter
8 fuel injection

[a] Original fuel pipe diameter, $d_1$.
[b] Fuel pipe diameter of the measuring device, $d_2$.
[c] Fuel pipe diameter of the measuring device, $d_3$.

**Figure A.9 — Flowmeter method — Fuel injection system without fuel return**

# Annex B
(informative)

# Example for record form of test fuel specifications

| Characteristic | Unit | Test method |
|---|---|---|
| Research octane number (RON) | — | ISO 5164 |
| Motor octane number (MON) | — | ISO 5163 |
| Density at 15 °C | kg/m$^3$ | ISO 3675 |
| Reid vapour pressure | kPa | ISO 3007 |
| Distillation | | ISO 3405 |
| initial boiling point | °C | |
| 10 % (volume) | °C | |
| 50 % (volume) | °C | |
| 90 % (volume) | °C | |
| evaporated at 70 °C | volume % | |
| evaporated at 100 °C | volume % | |
| evaporated at 150 °C | volume % | |
| final boiling point | °C | |
| residue | volume % | |
| Hydrocarbon analysis | | ISO 3837 |
| olefins | volume % | |
| aromatics | volume % | |
| saturates | volume % | |
| Oxidation stability | min | ISO 7536 |
| Existent gum | mg/100 ml | ISO 6246 |
| Sulphur content | mg/kg | ISO 20846,<br>ISO 20884 |
| Lead content | mg/l | ISO 3830 |
| Carbon/hydrogen ratio | — | |
| Carbon/oxygen ratio | — | |
| Oxygen content | weight % | ISO 22854 |
| Copper corrosion | — | ISO 2160 |
| Phosphorus content | mg/l | |
| Benzene | volume % | ISO 22854 |
| Ethanol | volume % | |
| Methanol | volume % | |
| Water content | volume % | |

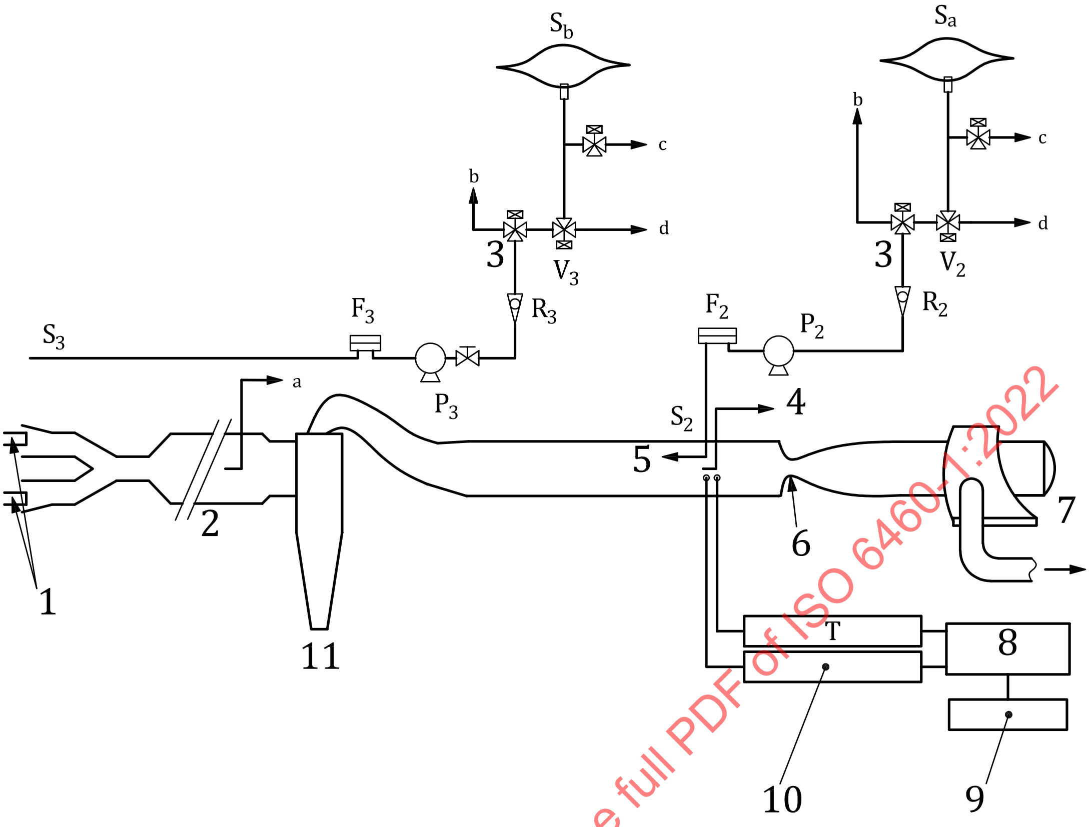
# Annex C
(informative)

# Exhaust emissions leakage check procedure for the open type CVS system

## C.1 Exhaust emissions leakage check procedure for the open type CVS system

The exhaust emissions leakage check method specified in C.2 and C.3 may be used to verify the open-type CVS system. If any exhaust gas leakage is identified during any of the tests, the test shall be stopped and the CVS system shall be repaired for the leakage.

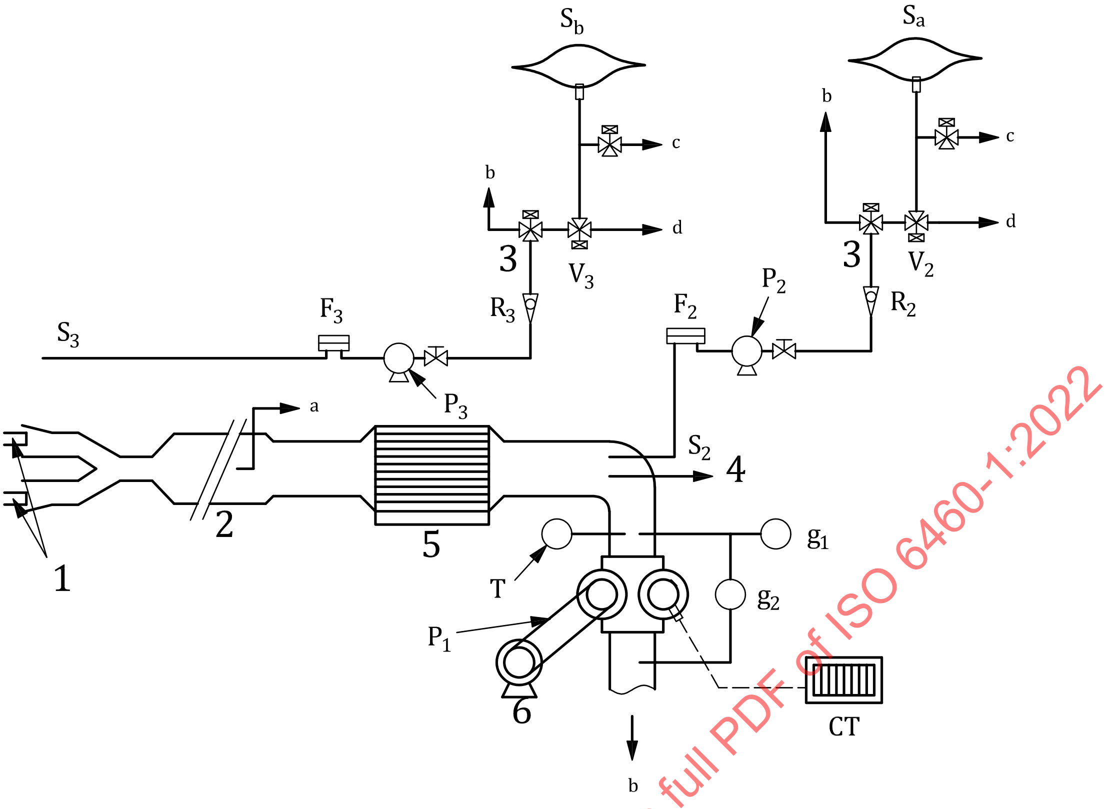
A schematic diagram is shown in Figure C.1 for the representative open type CVS system with CFV, in Figure C.2 for the representative open type CVS system with PDP and in Figure C.3 for the representative open type CVS system with SSV.



**Key**

| | |
|---|---|
| 1 | motorcycle exhaust pipes |
| 2 | mixing chamber |
| 3 | diversion valve |
| 4 | continuous sampling probe |
| 5 | sampling venturi |
| 6 | main critical flow venturi |
| 7 | blower |
| 8 | calculator |
| 9 | integrator |
| 10 | pressure gauge |
| 11 | cyclone |
| $F_2$, $F_3$ | filters |
| $P_2$, $P_3$ | sampling pumps |
| $R_2$, $R_3$ | flowmeters |
| $S_a$, $S_b$ | sampling bags |
| $S_2$, $S_3$ | sampling probes |
| T | temperature gauge |
| $V_2$, $V_3$ | valves |
| a | To HFID; special sampling line when HFID is used. |
| b | To atmosphere. |
| c | To exhaust pump. |
| d | To analysing system. |

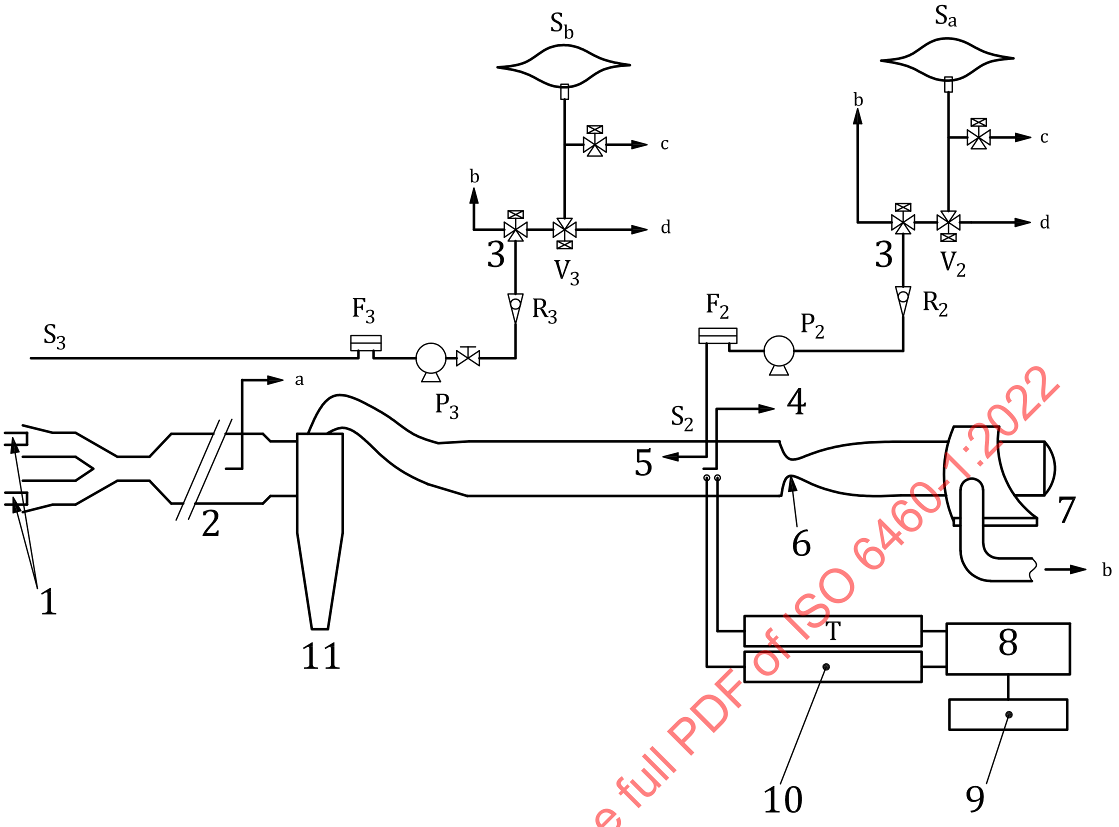
**Figure C.1 — Schematic diagram for the representative open type CVS system with CFV**



**Key**

| | | | |
|---|---|---|---|
| 1 | motorcycle exhaust pipes | $P_2$, $P_3$ | sampling pumps |
| 2 | mixing chamber | $R_2$, $R_3$ | flowmeters |
| 3 | diversion valve | $S_a$, $S_b$ | sampling bags |
| 4 | continuous sampling probe | $S_2$, $S_3$ | sampling probes |
| 5 | heat exchanger | T | temperature gauge |
| 6 | motor | $V_2$, $V_3$ | valves |
| CT | revolution counter | [a] | To HFID; special sampling line when HFID is used. |
| $F_2$, $F_3$ | filters | [b] | To atmosphere. |
| $g_1$, $g_2$ | pressure gauges | [c] | To exhaust pump. |
| $P_1$ | positive displacement pump | [d] | To analysing system. |

Figure C.2 — Schematic diagram for the representative open type CVS system with PDP



**Key**

| | | | |
|---|---|---|---|
| 1 | motorcycle exhaust pipes | $F_2$, $F_3$ | filters |
| 2 | mixing chamber | $P_2$, $P_3$ | sampling pumps |
| 3 | diversion valve | $R_2$, $R_3$ | flowmeters |
| 4 | continuous sampling probe | $S_a$, $S_b$ | sampling bags |
| 5 | sampling venturi | $S_2$, $S_3$ | sampling probes |
| 6 | subsonic venturi | T | temperature gauge |
| 7 | blower | $V_2$, $V_3$ | valves |
| 8 | calculator | [a] | To HFID; special sampling line when HFID is used. |
| 9 | integrator | [b] | To atmosphere. |
| 10 | pressure gauge | [c] | To exhaust pump. |
| 11 | cyclone | [d] | To analysing system. |

**Figure C.3 — Schematic diagram for the representative open type CVS system with SSV**

## C.2 Principle of leakage check procedure by the fuel consumption measurement

### C.2.1 General

The leakage check is based on the procedure described in this subclause.

a) The fuel consumption shall be determined using the following two methods:

   1) the carbon balance method with the gaseous exhaust emissions;

   2) the fuel flowmeter, the burette, the mass flowmeter and other fuel flow measuring methods.

b) The fuel consumption shall be measured simultaneously by both methods. The exhaust emissions leakage can be confirmed by comparison of the fuel consumption data results obtained by both the carbon balance and the fuel flow measuring method.

### C.2.2 Leakage check procedure

The exhaust emissions leakage check procedure shall consist of the low-speed range test (less than 50 km/h) and the high-speed range test (higher than 100 km/h). The same four-stroke engine motorcycle shall be used for both tests.

#### C.2.2.1 Low-speed range test procedure

The fuel consumption shall be simultaneously determined by both the carbon balance method and the fuel flow measuring method, in accordance with the test cycle specified in ISO 6460-2:2014, Clauses 3 and 4.

The fuel flow measuring method (e.g. the volumetric method, gravimetric method and flowmeter method specified in Annex A) shall be used. The measurement accuracy of the fuel measuring system shall be in accordance with 7.6.2 and Annex A.

The motorcycle preparation, the chassis dynamometer preparation, the rider mass and other specifications shall be in accordance with this document.

The gaseous exhaust emissions measurement and the fuel consumption calculation by the carbon balance method shall be determined in accordance with Clauses 11 and 12.

#### C.2.2.2 High-speed range test procedure

The fuel consumption shall be simultaneously measured by both the carbon balance method and the fuel flow measuring method at a constant motorcycle speed of 125 km/h. If that is not possible, it shall be measured at a constant speed of 100 km/h.

To warm up the test motorcycle, it shall be set on the chassis dynamometer and kept idling for 40 s. The motorcycle shall then be run at a constant speed of 100 km/h or 125 km/h for 390 s, which corresponds to the duration of two test cycles of ISO 6460-2:2014, Clauses 3 and 4.

Immediately after the warm up, the fuel consumption shall be simultaneously measured by both the carbon balance method and the fuel flow measuring method at a constant speed for 780 s, which corresponds to the duration of four test cycles of ISO 6460-2.

The fuel flow measuring method (e.g. the volumetric method, gravimetric method and flowmeter method specified in Annex A) shall be used. The measurement accuracy of the fuel measuring system shall be in accordance with 7.6.2 and Annex A.

The motorcycle preparation, the chassis dynamometer preparation, the rider mass and other specifications shall be in accordance with this document.

The measurement of the gaseous exhaust emissions and the calculation of the fuel consumption using the carbon balance method shall be determined in accordance with Clauses 11 and 12.

### C.2.3 Criterion of exhaust emissions leakage from the open type CVS system

The criterion of the fuel consumption error caused by the exhaust emissions leakage of the open type CVS system shall be within 5 % when the fuel consumption error in percentage, $E$, shall be calculated by Formula (C.1):

$$E = \frac{F_{\text{cCVS}} - F_{\text{cFlow}}}{F_{\text{cFlow}}} \times 100 \tag{C.1}$$

where

| | |
|---|---|
| $F_{\text{cFlow}}$ | is the fuel consumption measured by the fuel flow measuring method, in km/l; |
| $F_{\text{cCVS}}$ | is the fuel consumption measured by the carbon balance method with the open type CVS system, in km/l. |

## C.3 Principle of leakage check procedure by the gaseous exhaust emissions measurement in the background air

### C.3.1 General

The concentration of gaseous exhaust emissions in the air of test room (background air) should be increased by the leakage of the exhaust emissions from open type CVS system. The exhaust emissions leakage shall be verified from the background air measurements.

### C.3.2 Leakage check procedure

**C.3.2.1** The inlet of measurements system for the background air shall be located inside the test room. In cases where the dilution air for the CVS system is taken from the test room, a sample of dilution air can be used instead of the background air. Any doors and windows in the test room shall be closed.

**C.3.2.2** The gaseous exhaust emissions concentrations in the background air shall be measured before the test commencement.

**C.3.2.3** The gaseous exhaust emissions concentrations in the background air shall be measured during the test.

**C.3.2.4** The gaseous exhaust emissions concentrations in the background air before and during the test shall be compared.

### C.3.3 Verification of exhaust emissions leakage

Exhaust emissions leakage has not occurred when the measurement results of gaseous exhaust emissions concentrations in the background air before and during the test are the same level. When the increase of all gaseous exhaust emissions concentrations is confirmed, the exhaust emissions has leaked from the open type CVS system, and the sampling system should be improved and checked again by using the prescribed procedure.

# Annex D
(informative)

# Determination of the dilution factor

## D.1 Definition of the dilution factor

The dilution factor is defined as the volume ratio of diluted exhaust mixture to exhaust emissions [Formula (D.1)]:

$$D_f = \frac{V_{ex} + V_d}{V_{ex}} \tag{D.1}$$

where

$V_{ex}$ is exhaust emissions volume;

$V_d$ is dilution air volume.

## D.2 Combustion reaction formulae

The exhaust emissions, in moles, produced from combustion of 1 mole of fuel $C_xH_yO_z$ (for the numbers of carbon atom, $x$, of hydrogen atom, $y$, and of oxygen atom, $z$) is expressed by Formula (D.2):

$$\begin{aligned} & C_xH_yO_z + \lambda\left(x + \frac{y}{4} - \frac{z}{2}\right)\left(1 \times O_2 + \frac{100 - c_{O2,d}}{c_{O2,d}} I\right) \\ & = n_a\,(CO_2) + n_b\,(CO) + n_c\,(O_2) + n_d\,(C_xH_yO_z) + n_e\,(H_2) + n_f\,(H_2O) + \lambda\left(x + \frac{y}{4} - \frac{z}{2}\right)\left(\frac{100 - c_{O2,d}}{c_{O2,d}}\right) I \end{aligned} \tag{D.2}$$

where

$n_a$ is the number of carbon dioxide molecules in the exhaust emissions, in moles;

$n_b$ is the number of carbon monoxide molecules in the exhaust emissions, in moles;

$n_c$ is the number of oxygen molecules in the exhaust emissions, in moles;

$n_d$ is the number of unburned fuel $C_xH_yO_z$ molecules in the exhaust emissions, in moles;

$n_e$ is the number of hydrogen molecules in the exhaust emissions, in moles;

$n_f$ is the number of water molecules in the exhaust emissions, in moles;

$\lambda$ is the excess air factor;

$I$ is the inert gases in the air;

$c_{O2,d}$ is the oxygen concentration in the intake air, in percentage.