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Motorcycles — Methods of measuring fuel consumption

Motocycles — Méthodes de mesure de la consommation de carburant

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 7860 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

This second edition cancels and replaces the first edition (ISO 7860:1983), of which it constitutes a technical revision.

Annexes A and B form an integral part of this International Standard.

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Motorcycles — Methods of measuring fuel consumption

1 Scope

This International Standard specifies the methods of determining the fuel consumption of motorcycles.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4106:1993, *Motorcycles — Engine test code — Net power.*

ISO 6460:1981, *Road vehicles — Measurement method of gaseous pollutants emitted by motorcycles equipped with a controlled ignition engine.*

ISO 7117:1995, *Motorcycles — Measurement of maximum speed.*

ISO 11486:1993, *Two-wheeled motorcycles — Fuel consumption measurements — Chassis dynamometer setting by coastdown method.*

3 Definition

For the purposes of this International Standard, the following definition applies.

3.1 reference speed: Running speed of the motorcycle to be tested for the fuel consumption, specified in accordance with the classification of the motorcycle maximum speed.

4 Tests

The motorcycle shall be subjected to tests of two types.

a) Type 1 test: measurement of average fuel consumption during conventional driving cycle.

The motorcycle is placed on a chassis dynamometer equipped with a brake and an inertia simulation system. The test includes two cycles as described in 8.1, carried out without interruption, during which the fuel consumption is measured with equipment as specified in 8.3.2 and 8.3.3.

The test method is specified in clause 8.

b) Type 2 test: measurement of fuel consumption at constant speed.

The test is carried out either on the road or on a chassis dynamometer as specified in clause 9.

5 Atmospheric and test conditions

The atmospheric conditions shall be as follows:

- relative humidity: ≤ 95 %
- maximum wind speed: 3 m/s
- maximum wind gust speed: 8 m/s
- air temperature 278 K to 303 K

The reference test conditions shall be as follows:

- pressure, p_0: 100 kPa
- temperature, T_0: 293 K
- relative air density, d_0: 0,919 7

During the test, the relative air density, d, calculated from the following equation:

$$d = d_0 \times \frac{p}{p_0} \times \frac{T_0}{T}$$

where

p is the air pressure, in kilopascals;

T is the absolute temperature, in kelvins,

shall not vary by more than 7,5 % from the air density under reference conditions.

6 Description of test motorcycle

Full details of the motorcycle shall be provided, as specified in annex A.

7 Preparation of test motorcycle

7.1 The motorcycle shall conform in all its components with the production series or, if it is different from the production series, a full description shall be given in the test report.

7.2 The motorcycle shall be properly run in, according to the manufacturer's requirements.

7.3 The viscosity of the oils for the moving mechanical parts and the tyre pressures shall conform to the instructions given by the manufacturer of the motorcycle, or, if different, the specification shall be given in the test report.

7.4 Before the test, all parts of the motorcycle shall be stabilized at the normal temperature for the motorcycle in use.

7.5 The mass of the motorcycle shall be the kerb mass, as defined in ISO 11486:1993, definition 3.4.

7.6 The total test mass, including the masses of the rider and the instruments, shall be measured before beginning the test.

7.7 The distribution of the load between the wheels shall conform to the manufacturer's instructions.

7.8 When installing the speed sensor and/or fuel consumption measurement equipment outside the motorcycle, care shall be taken to minimize the additional aerodynamic loss.

7.9 For the test, the following reference fuels shall be used as appropriate:

reference fuel CEC[1] RF-01-A-80;

reference fuel CEC[1] RF-05-T-79;

reference fuel CEC[1] RF-08-A-85;

reference fuel CEC[1] RF-03-A-84.

The lubrication of the engine, including engines lubricated by mixture, shall comply, as to grade and quantity of oil, with the manufacturer's recommendation.

8 Measurement of average fuel consumption of motorcycle during conventional driving cycle (Type 1 test)

8.1 Operating cycle on roller bench

8.1.1 Description of cycle

The operating cycle on the roller bench shall be that indicated in table 1 and figure 1.

8.1.2 General cycle conditions

8.1.2.1 Preliminary testing cycles should be carried out, if necessary, to determine how best to actuate the throttle, gearbox, clutch and brake controls so as to achieve a cycle approximating to the theoretical cycle within the prescribed limits.

8.1.2.2 If the acceleration of the motorcycle is sufficient, the theoretical cycle described in 8.1.1 shall be carried out.

8.1.2.3 If the acceleration of the motorcycle is not sufficient to carry out the acceleration phases within the prescribed limits of tolerances, the motorcycle shall be driven with the throttle fully open until the speed prescribed for the cycle is reached; the cycle shall then be followed normally.

8.1.3 Use of gearbox

8.1.3.1 The use of the gearbox shall be determined as indicated in 8.1.3.1.1 to 8.1.3.1.3.

1) Coordinating European Council for the development of performance tests for lubricants and engine fuels.

8.1.3.1.1 At constant speed, the rotating speed of the engine shall be, if possible, within 50 % to 90 % of the speed corresponding to the maximum power of the engine. When this speed can be reached in two or more gears, the motorcycle shall be tested with the highest gear engaged.

8.1.3.1.2 During acceleration, the motorcycle shall be tested in whichever gear is appropriate to the acceleration imposed by the cycle. A higher gear shall be engaged at the latest when the rotating speed is equal to 110 % of the speed corresponding to the maximum power of the engine. If a motorcycle reaches the speed of 20 km/h in first gear, or 35 km/h in second gear, the next higher gear shall be engaged at these speeds. In these cases no further gear-shifts into higher gears shall be allowed. If, during the acceleration phase, the gear-shifts have taken place at these fixed vehicle speeds, the following constant speed phase shall be performed in the gear which is engaged when the motorcycle enters that constant speed phase, regardless of the engine speed.

8.1.3.1.3 During deceleration, a lower gear shall be engaged either before the engine starts to idle roughly or when the engine revolutions are equal to 30 % of the speed corresponding to the maximum power of the engine, whichever of these conditions is reached first. No change down to first gear shall be effected during deceleration.

8.1.3.2 Motorcycles equipped with automatic-shift gearboxes shall be tested with the highest gear engaged. The accelerator shall be used in such a way as to obtain the steadiest possible acceleration at which the various gears can be engaged in the normal order. The tolerances given in 8.1.4.1 shall apply.

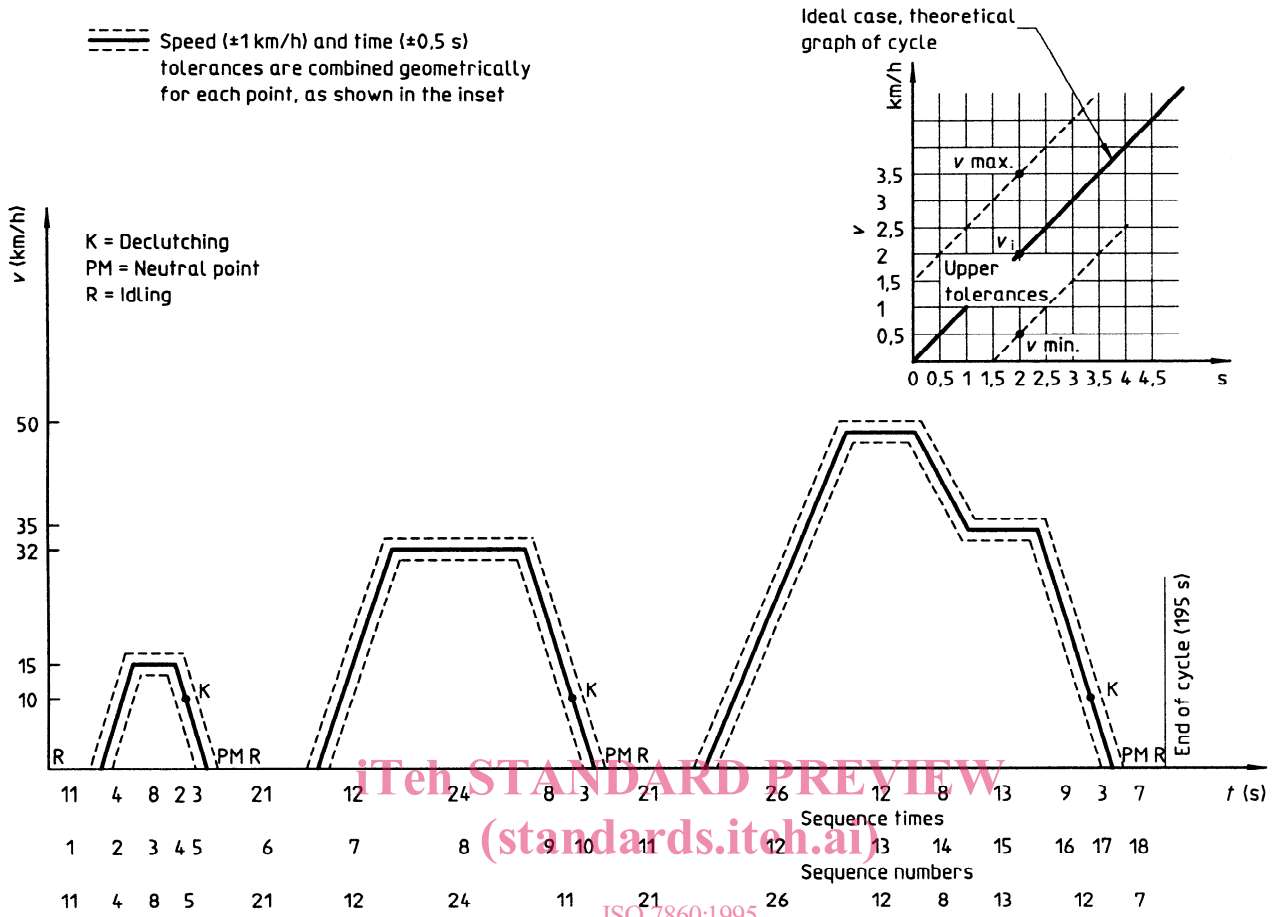

Figure 1 — Operating cycle on roller bench (Type 1 test)

Table 1 — Operating cycle on roller bench

Operation No.	Operation	Phase	Acceleration m/s²	Speed km/h	Duration of each operation s	Duration of each phase s	Cumulative time s	Distance covered m
1	Idling	1	0	0	11	11	11	0
2	Acceleration	2	1,04	0 to 15	4	4	15	8
3	Constant speed	3	0	15	8	8	23	34
4	Deceleration	4	−0,69	15 to 10	2	5	25	7
5	Deceleration, clutch disengaged		−0,92	10 to 0	3		28	4
6	Idling	5	0	0	21	21	49	0
7	Acceleration	6	0,74	0 to 32	12	12	61	54
8	Constant speed	7	0	32	24	24	85	214
9	Deceleration	8	−0,75	32 to 10	8	11	93	48
10	Deceleration, clutch disengaged		−0,92	10 to 0	3		96	4
11	Idling	9	0	0	21	21	117	0
12	Acceleration	10	0,53	0 to 50	26	26	143	183
13	Constant speed	11	0	50	12	12	155	167
14	Deceleration	12	−0,52	50 to 35	8	8	163	95
15	Constant speed	13	0	35	13	13	176	127
16	Deceleration	14	−0,68	35 to 10	9	12	185	64
17	Deceleration, clutch disengaged		−0,92	10 to 0	3		188	4
18	Idling	15	0	0	7	7	195	0
						Total		1 013

8.1.4 Tolerances

8.1.4.1 A tolerance of ±1 km/h on the theoretical speed shall be allowed during acceleration, during steady speed and during deceleration. If the motorcycle decelerates more rapidly without the use of the brakes, the requirements of 8.4.5.3 shall apply.

Speed tolerances greater than those prescribed shall be accepted during phase changes provided that the tolerances are never exceeded for more than 0,5 s on any one occasion.

8.1.4.2 The time tolerance shall be ±0,5 s.

8.1.4.3 The speed and time tolerances shall be combined as indicated in figure 1.

8.2 Test equipment

8.2.1 Roller bench

The main characteristics of the roller bench shall be as follows:

— number of points of contact between tyre(s) and roller(s): one to each driven wheel;

— roller diameter: ⩾ 400 mm;

— roller surface: metallic, polished or knurled.

The dynamometer shall meet the following conditions:

a) constant simulation of the road load power within ±3 % for speeds from 20 km/h to 50 km/h;

b) constant maintenance of the absorbed power as set throughout the test period within ±2 % at the set speed of 50 km/h;

c) when used to determine fuel consumption, the measurement systems for the fuel consumed, for the distance covered and for time shall be simultaneously engaged.

NOTE 1 It can be assumed that the power lost between the tyre(s) and the roller(s) equals the loss between the tyre(s) and the road.

8.2.2 Fuel consumption device

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

a) volumetric method;

b) gravimetric method;

c) flowmeter method;

d) carbon balance method (for four-stroke engines only).

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

8.2.2.2 Fuel shall be supplied to the engine by a device capable of measuring the quantity of fuel supplied with an accuracy of ±2 % in accordance with annex B, and which does not interfere with the supply of fuel to the engine. When the measuring system is volumetric, 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 effected by a valve system and shall take no more than 0,2 s.

8.2.2.3 For the carbon balance method, the test equipment shall be in compliance with ISO 6460.

8.2.2.4 Annex B gives the description and the methods of use of the appropriate devices.

8.3 Preparation for test

8.3.1 Dynamometer setting

The dynamometer should be set by one of the methods described in ISO 11486, according to the type of dynamometer. If it is not possible to carry out this power measurement, the brake shall be adjusted in accordance with table 2.

8.3.1.1 Dynamometer with fixed load curve

In the case of a dynamometer with hydraulic or aerodynamic absorption, the setting can be done only at one speed point. The absorber should be set to the value $F_{pau}(v_0)$ at the reference speed of 50 km/h. The accuracy shall be ±5 %.

The power absorbed, P_a, by the brake and the internal frictions of the bench shall be

$0 \leqslant P_a \leqslant kv_{12}^3 + 0{,}05\ kv_{12}^3 + 0{,}05\ P_{v50}$ for speeds less than or equal to 12 km/h;

$P_a = kv^3 \pm 0{,}05\ kv^3 \pm 0{,}05\ P_{v50}$ (without being negative) for speeds greater than 12 km/h.

8.3.1.2 Dynamometer with polygonal function

In the case of a dynamometer with polygonal function, in which the absorption characteristics are determined by load values at several speed points, the dynamometer should be set to the value $F_{pau}(v_j)$ obtained at 50 km/h, 40 km/h, 30 km/h and 20 km/h. The accuracy shall be ±5 % at 50 km/h, 40 km/h and 30 km/h, and 10 % at 20 km/h.

8.3.1.3 Dynamometer with coefficient control

In the case of a dynamometer with coefficient control, in which the absorption characteristics are determined by given coefficients of a polynomial function, the value of $F_{pau}(v_j)$ should be calculated at 50 km/h, 40 km/h, 30 km/h and 20 km/h with the same accuracy as 8.3.1.2.

Assuming the load characteristics as

$$F_{pau}(v) = av^2 + bv + c,$$

the coefficients a, b, and c should be determined by the polynomial regression method.

8.3.1.4 Dynamometer with F^* polygonal digital setter

In the case of a dynamometer with F^* polygonal digital setter, where a CPU is incorporated in the system, F^* is input directly, and Δt, F_f and F_{pau} are automatically measured and calculated to set, on the dynamometer, the target running resistance $F^* = f_0^* + f_2^* v^2$.

8.3.1.5 Dynamometer with f_0^*, f_2^* coefficient digital setter

In the case of a dynamometer with f_0^*, f_2^* coefficient digital setter, where a CPU is incorporated in the system, the target running resistance $F^* = f_0^* + f_2^* v^2$ is automatically set on the dynamometer.

8.3.2 Adjustment of equivalent inertias to motorcycle translatory inertias

The inertia simulation system shall be adjusted to obtain a total inertia of the rotating masses representing the motorcycle kerb mass, in accordance with table 2.

8.3.3 Conditioning of motorcycle

8.3.3.1 Adjustment of tyre pressures

The tyre pressures shall be those recommended by the manufacturer for normal road use conditions.

Table 2 — Dynamometer setting of brake: fixed load values

Motorcycle reference mass, m[1)] kg	Equivalent inertia mass kg	Power absorbed by chassis dynamometer, P_{v50} kW
$m \leq 105$	100	0,88
$105 < m \leq 115$	110	0,9
$115 < m \leq 125$	120	0,91
$125 < m \leq 135$	130	0,93
$135 < m \leq 145$	140	0,94
$145 < m \leq 165$	150	0,96
$165 < m \leq 185$	170	0,99
$185 < m \leq 205$	190	1,02
$205 < m \leq 225$	210	1,05
$225 < m \leq 245$	230	1,09
$245 < m \leq 270$	260	1,14
$270 < m \leq 300$	280	1,17
$300 < m \leq 330$	310	1,21
$330 < m \leq 360$	340	1,26
$360 < m \leq 395$	380	1,33
$395 < m \leq 435$	410	1,37
$435 < m \leq 475$	450	1,44
$475 < m \leq 515$	500	1,51

NOTE — Additional masses may be replaced by some other device, provided that it is demonstrated that the results obtained are equivalent.

1) As defined in ISO 6460:1981, definition 3.2.

8.3.3.2 Load on driving wheel

The load on the driving wheel shall be within ±3 % of that of a motorcycle in normal road use with a rider of 75 kg ± 5 kg in the upright position.

8.4 Procedure for tests on roller bench

8.4.1 Special conditions for carrying out cycle

8.4.1.1 The temperature in the room housing the roller bench shall be between 293 K and 303 K throughout the test, and approximate as closely as possible to that of the room in which the motorcycle was conditioned for the test.

8.4.1.2 The motorcycle shall be as nearly level as possible when tested, in order to prevent abnormal fuel distribution and, if appropriate, engine oil distribution.

8.4.1.3 Throughout the test, a variable speed cooling blower shall be positioned in front of the motorcycle, so as to direct cooling air to the engine 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 is within ±5 km/h of the corresponding roller speed. At roller speeds of less than 10 km/h, air velocity may be zero. With the manufacturer's agreement, engine cooling can be effected by a constant speed blower giving a current of air delivered at a speed between 20 km/h and 50 km/h. The blower outlet shall have a cross-sectional area of at least 0,4 m^2 and the bottom of the blower outlet shall be between 15 cm and 20 cm above floor level.

The blower outlet shall be perpendicular to the longitudinal axis of the 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 in the middle of the stream at 20 cm from the air outlet. This velocity shall be as nearly as possible across the whole of the blower outlet surface.

8.4.1.4 When the cycle is carried out, the speed considered shall be that of the rollers. During the test, the speed shall be plotted versus time so that the validity of the cycle performed can be assessed.

8.4.2 Engine starting

Start the engine by means of the devices provided for this purpose, such as choke, starter valve, etc., in accordance with the manufacturer's instructions.

8.4.3 Idling

8.4.3.1 Manual gearbox

8.4.3.1.1 During periods of idling, the clutch shall be engaged and the gears in neutral.

8.4.3.1.2 To enable acceleration to be performed according to the normal cycle, place the motorcycle in first gear, with the clutch disengaged, within 5 s before the acceleration following the idling period considered.

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

8.4.3.1.4 For the idling periods in the middle of each type, the corresponding times shall be 16 s in neutral and 5 s in first gear with the clutch disengaged. These times may be modified if necessary when the motorcycle tested does not have sufficient accelerative capacity to follow the theoretical driving cycle (see 8.1.2.2).

8.4.3.1.5 The idling period between two successive cycles shall comprise 13 s in neutral with the clutch engaged (except for the cases considered in 8.1.2.2).

8.4.3.2 Automatic gearbox and torque converter

Lock the gear selector at the start of the test and allow it to remain in the position defined in 8.1.3.2 throughout the whole of the test.

8.4.4 Acceleration

8.4.4.1 Perform acceleration so that the rate of acceleration is as constant as possible throughout the phase.

8.4.4.2 If acceleration cannot be carried out in the prescribed time, drive the motorcycle in accordance with the method prescribed in 8.1.2.3.

8.4.5 Deceleration

8.4.5.1 Carry out all deceleration by closing the throttle completely, the clutch remaining engaged. Disengage the clutch independently of gear selection, at a speed of 10 km/h or before the engine starts to idle roughly.

8.4.5.2 If the rate of deceleration is slower than that prescribed for the corresponding phase, use the motorcycle brake to enable the cycle to be followed.

8.4.5.3 If the rate of deceleration is faster than that prescribed for the corresponding phase, restore the timing of the theoretical cycle by a period of constant speed or idling speed merging into the following operation.

8.4.5.4 At the end of the deceleration periods (the motorcycle being stationary on the roller), the gears shall be in neutral and the clutch engaged.

8.4.6 Constant speed

8.4.6.1 Avoid "pumping" or complete closing of the throttle when passing from acceleration to the following constant speed.

8.4.6.2 Achieve periods of stabilized speed by keeping the throttle in a constant position.

8.5 Measurement of fuel consumption

Fuel consumption shall be determined by measuring the quantity of fuel consumed during two consecutive operating cycles.

8.6 Calculation of results

8.6.1 If the fuel consumption is measured gravimetrically, the consumption, C, shall be expressed, in litres per 100 km, by means of the formula

$$C = \frac{m}{l \times \rho} \times 100$$

where

m is the fuel consumed, in kilograms;

ρ is the density (mass/volume) of the fuel in the reference conditions (293 K), in kilograms per cubic decimetre;

l is the distance covered during the test, in kilometres.

8.6.2 If the fuel consumption is measured volumetrically, the consumption, C, shall be expressed in litres per 100 km by the formula

$$C = \frac{V\left[1+\alpha\left(T_0 - T_F\right)\right]}{l} \times 100$$

where

V is the measured volume of fuel consumed in litres;

α is the coefficient of volumetric expansion for the fuel: for both diesel and petrol fuel this is 0,001 K^{-1};

T_0 is the reference temperature, expressed in kelvins;

T_F is the fuel temperature measured at the burette, expressed in kelvins;

l is the distance covered during the test, in kilometres.

8.6.3 If the fuel consumption is measured by the carbon balance method, the consumption, C_1, in kilometres per litre shall be measured by the following formula, where the masses of CO, HC and CO_2 are measured as specified in 8.2.2.3.

$$C_1 = \frac{1\,000 \times \rho \times 0{,}866}{(0{,}429 \times CO) + (0{,}866 \times HC) + (0{,}273 \times CO_2)}$$

where

ρ is the density (mass/volume) of the fuel in the reference conditions (293 K), in kilograms per cubic decimetre;

CO is the mass of carbon monoxide, expressed in grams per kilometre;

HC is the mass of hydrocarbons, expressed in grams per kilometre;

CO_2 is the mass in carbon dioxide, expressed in grams per kilometre.

8.6.4 In the case of a fuel/oil mixture, the volume of oil used during the test shall be deducted.

8.6.5 Whatever the measuring method used, the results shall be expressed in litres per 100 km.

8.7 Presentation of results

8.7.1 The fuel consumption on a conventional driving cycle shall be determined by establishing the arithmetic mean of the amount of fuel consumed, measured in accordance with 8.5 and 8.6, during three consecutive measurements. Between consecutive pairs of cycles, there may be an idling period of not more than 60 s during which no fuel consumption is measured.

8.7.2 If the difference between the extreme measurements is more than 5 % of the mean value of the three measurements, further measurements shall immediately be made to obtain a degree of accuracy of measurement at least equal to 5 %.

8.7.3 The accuracy of measurement, A, shall be calculated by the formula:

$$A = K \times \frac{s}{\sqrt{n}} \times \frac{100}{\overline{C}}$$

where

K is found from table 3;

n is the number of measurements;

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(\overline{C} - C_i\right)^2}{n-1}}$$

in which

C_i is the amount of fuel consumed during ith measurement;

$\overline{C}$ is the arithmetic means of n values of C.

Table 3 — Values of K

n	K	$\frac{K}{\sqrt{n}}$
4	3,2	1,6
5	2,8	1,25
6	2,6	1,06
7	2,5	0,94
8	2,4	0,85
9	2,3	0,77
10	2,3	0,73
11	2,2	0,66
12	2,2	0,64
13	2,2	0,61
14	2,2	0,59
15	2,2	0,57

8.7.4 If an accuracy of measurement at least equal to 5 % is not obtained after ten measurements, the test shall be carried out with another motorcycle of the same type.

9 Constant speed test

9.1 General requirements

9.1.1 Measurement of fuel consumption of a motorcycle based on the constant speed method shall be performed on a road or on a dynamometer.

9.1.2 Fuel shall be supplied to the engine by a device capable of measuring the quantity of fuel supplied with an accuracy of ±2 %, and which does not interfere with the supply of fuel to the engine. Where the measuring system is volumetric, the temperature of fuel in the device or in the outlet of the device shall be measured.

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

9.1.4 Annex B gives the description and the methods of use of the appropriate devices.

9.2 Road measurement method

9.2.1 Rider and riding position

9.2.1.1 The rider shall wear a well-fitting suit (one-piece) or similar clothing, and a protective helmet.

9.2.1.2 The rider in the conditions given in 8.2.1.1 shall have a mass of 75 kg ± 5 kg and be 1,75 m ± 0,05 m tall.

9.2.1.3 He shall be seated on the seat provided for the rider, with his feet on the footrests and his arms normally extended. This position shall allow the rider at all times to have proper control of the motorcycle during the test.

The position of the rider should remain unchanged during the whole measurement: the description of the position shall be indicated in the test report or shall be replaced by photographs.

9.2.2 Test track

The test track shall be a closed circuit allowing a steady speed to be maintained. It shall form a circuit of at least 2 000 m, have a minimum radius of 200 m and the surface shall be in good condition. A straight road may be used however, provided that a minimum run of 500 m is made in both directions.

The test track or road shall be clean and smooth, and covered with asphalt, concrete or a similar material. The gradient shall not exceed 2 %.

The test track shall be free of any significant film of water.

The measurement of consumption shall be performed driving a number of complete laps.

9.3 Chassis dynamometer measurement method

The chassis dynamometer shall be set by one of the coastdown methods described in ISO 11486 for each reference speed.

9.4 Test method

9.4.1 The test shall be performed at a constant speed in the highest gear. The maximum speed of the motorcycle shall be measured as specified in ISO 7117.

The test shall be carried out at the speeds defined in table 4.

9.4.2 The reference fuel shall be used for the test. The lubrication of the engine, including lubrication by