INTERNATIONAL STANDARD

ISO 11486

First edition
1993-06-01

Two-wheeled motorcycles — Fuel consumption measurements — Chassis dynamometer setting by coastdown method

Motocycles à deux roues — Mesurages de la consommation de carburant — Réglage du banc dynamométrique par la méthode de la décélération

Reference number
ISO 11486:1993(E)

Contents

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Annexes

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 11486 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Sub-Committee SC 22, *Motorcycles*.

Annexes A and B form an integral part of this International Standard. Annex C is for information only.

Two-wheeled motorcycles — Fuel consumption measurements — Chassis dynamometer setting by coastdown method

1 Scope

This International Standard specifies a method of setting the chassis dynamometer with the vehicle running resistance, for a bench test to measure the fuel consumption of two-wheeled motorcycles as defined in ISO 3833. The measurement method for the motorcycle running speed on the road, and the method of setting and transforming the measured results on the dynamometer are also specified.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was 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 edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3833:1977, *Road vehicles — Types — Terms and definitions*.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 running resistance: Total force resistant to a running motorcycle which, when measured by the coastdown method, includes the friction forces in the drivetrain.

3.2 reference speed, v_0**:** Running speed of the motorcycle to be tested for the fuel consumption, specified in accordance with the classification of the motorcycle maximum speed.

3.3 specified speed: Motorcycle speed at which the running resistance on the road is measured to determine the running resistance curve.

3.4 motorcycle kerb mass: Motorcycle dry mass to which is added the mass of the following:

- fuel: tank filled at least to 90 % of the capacity specified by the manufacturer;
- auxiliary equipment usually supplied by the manufacturer in addition to that necessary for normal operation [tool-kit, carrier(s), windscreen(s), protective equipment, etc.].

NOTE 1 This definition is adapted from ISO 6726:1988, definition 4.1.2.

3.5 motorcycle reference mass: Kerb mass of the motorcycle increased by a uniform figure of 75 kg.

4 Test motorcycle, dynamometer and instruments

A full description of the motorcycle shall be provided in accordance with annex A.

A full description of the dynamometer and instruments shall be provided in accordance with annex B.

5 Required accuracy of measurements

Measurements shall be made to the following accuracies:

	At measured value	Resolution
a) Running resistance force, F	+ 2 %	—
b) Motorcycle speed (v_1, v_2)	+ 1 %	0,45 km/h
c) Coastdown speed interval [$2\Delta v = v_1 - v_2$]	+ 1 %	0,10 km/h
d) Coastdown time (Δt)	+ 0,5 %	0,01 s
e) Coastdown deceleration	+ 1 %	0,002 6 m/s^2 [0,000 3g]
f) Total motorcycle mass [$m + m_{rid} + m_x$]	+ 1,0 %	1,4 kg
g) Wind speed	+ 10 %	0,1 m/s
h) Wind direction	—	5°
i) Ambient temperature	—	2 K
j) Barometric pressure	—	0,2 kPa

6 Road test

6.1 Requirement for road

The test road shall be flat, level, straight and smoothly paved. The road surface shall be dry and free of obstacles or wind barriers that might impede the measurement of the running resistance. The slope shall not exceed 0,5 % between any two points at least 2 m apart.

6.2 Ambient conditions for road test

During data collecting periods, the wind shall be steady. The wind speed and the direction of the wind shall be measured continuously or with adequate frequency at a location where the wind force during coastdown is representative.

The ambient conditions shall be within the following limits:

— maximum wind speed: 3 m/s

— maximum wind speed for gusts: 5 m/s

— average wind speed, parallel: 3 m/s

— average wind speed, perpendicular: 2 m/s

— relative humidity: 95 %

— air temperature: 278 K to 308 K

Standard ambient conditions shall be as follows:

— pressure, p_0: 100 kPa

— temperature, T_0: 293 K

— relative air density, d_0: 0,919 7

— wind speed: no wind

— air volumetric mass, ρ_0: 1,189 kg/m^3

The relative air density when the motorcycle is tested, calculated in accordance with the formula below, shall not differ by more than 7,5 % from the air density under the standard conditions.

The relative air density, d_0, shall be calculated by the formula:

$$d_T = d_0 \times \frac{p_T}{p_0} \times \frac{T_0}{T_T}$$

where

d_T is the relative air density under test conditions;

p_T is the ambient pressure under test conditions, in kilopascals;

T_T is the absolute temperature during the test, in kelvins.

6.3 Reference speed

Table 1 shows the reference speed, v_0, classified in accordance with the maximum speed category of the motorcycle.

Table 1

Maximum speed category of motorcycle, v_{max} km/h	Reference speeds, v_0 km/h
$130 < v_{max}$	120 and 90
$100 < v_{max} \leqslant 130$	90 and 60
$70 < v_{max} \leqslant 100$	60 and 45
$v_{max} \leqslant 70$	45
Urban cycle	50

6.4 Specified speed

The specified speed, v, is required to obtain the running resistance at the reference speed from the running resistance curve. To determine the running resistance as a function of motorcycle speed in the vicinity of the reference speed v_0, running resistances shall be measured at the specified speed v. At least four to five points indicating the specified speeds, in addition to the reference speeds, should be measured.

Table 2 shows the specified speeds in accordance with the maximum speed category of the motorcycle.

Table 2

Category, v_{max} km/h	Reference speeds, v_0 km/h	Specified speeds[1] km/h				
		I	II	III	IV	V
$130 < v_{max}$	90 and 120	120[2]	110	100	90[3]	80
$100 < v_{max} \leqslant 130$	60 and 90	90[2]	80	70	60[3]	50
$70 < v_{max} \leqslant 100$	45 and 60	60[2]	50	45[3]	40	30
$v_{max} \leqslant 70$	45	50	45[3]	40	35	—
Urban cycle	50	50[3]	40	30	20	—

1) Specified speeds include reference speed.
2) If within the motorcycle's capability.
3) Reference speed.

6.5 Coastdown starting speed

The coastdown starting speed $v_1 + \alpha$ shall be maintained at the value given in table 3 since sufficient time is required, for example, to hold the positions of both the motorcycle and rider and to cut the transmitted engine power off before the speed is reduced to the coastdown time beginning speed, v_1, which is where the measurement of the coastdown time is started.

Table 3

Reference speed, v_0 km/h	Coastdown starting speed[1) 2)], $v_1 + \alpha$ km/h
45	60 ± 2
50	65 ± 2
60	75 ± 2
90	110 ± 2
120	145 ± 2

1) Coastdown starting speed is for one speed point. In the case of multiple point measurements, the coastdown starting speed is always the highest value.
2) If attainable: if not, maximum speed is used.

6.6 Coastdown time beginning speed and ending speed

To ensure accuracy in measuring the coastdown time Δt, and coastdown speed interval $2\Delta v$, the beginning speed v_1, and ending speed v_2, in kilometres per hour, the following requirements shall be met:

$$\Delta v = 0{,}1v$$

$$\begin{cases} v_1 = v + 0{,}1v \\ v_2 = v - 0{,}1v \end{cases}$$

and/or

$$\begin{cases} v_1 = v_0 + 0{,}1v \\ v_2 = v_0 - 0{,}1v \end{cases}$$

Table 4 shows v_1 and v_2 in accordance with each of the reference speeds and specified speeds.

Table 4

Speeds in kilometres per hour

	Beginning coastdown speed, v_1	Ending coastdown speed, v_2
Reference and specified speed		
120[1]	132	108
110	121	99
100	110	90
90[1]	99	81
80	88	72
70	77	63
60[1]	66	54
50	55	45
45[1]	49,5	40,5
40	44	36
35	38,5	31,5
30	33	27
20	22	18

1) Reference speed.

Where the coastdown speed cannot be maintained at the speed v_1 due to the limitations of the motorcycle performance, testing course length, etc., the running resistance force can be obtained by extrapolating the running resistance curve plotted through measurements under a coastdown speed that has been started from the specified speed closest to the indicated reference speed.

6.7 Preparation of test motorcycle

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

6.7.2 The engine, transmission and motorcycle shall be properly run in, in accordance with the manufacturer's requirements.

6.7.3 The viscosity of the oils for the moving mechanical parts and the tyre pressures shall conform to the instructions given by the motorcycle manufacturer, or, if the motorcycle is different from the production series, a full description shall be given in the test report.

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

6.7.5 The kerb mass of motorcycle shall be as defined in 3.4.

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

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

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

6.8 Rider and riding position

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

6.8.2 The rider in the conditions given in 6.8.1 shall have a mass of 75 kg ± 5 kg and be 1,75 m ± 0,05 m tall.

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

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

6.9 Measurement of coastdown time and deceleration

6.9.1 Measurement of coastdown time

6.9.1.1 After warm-up, the vehicle shall be accelerated as quickly as possible. When the vehicle speed exceeds the coastdown starting speed $(v_1 + \alpha)$, the coastdown shall be started.

6.9.1.2 Since it can be dangerous and difficult from the viewpoint of its construction to have the transmission shifted to neutral, the coasting may be performed solely with the clutch disengaged. Further, the tractive method of using another motorcycle for traction may be applied to those motorcycles that have no way of cutting the transmitted engine power off during coasting.

6.9.1.3 The motorcycle steering shall be altered as little as possible and the brakes shall not be operated until the end of the coastdown measurement.

6.9.1.4 The coastdown time Δt_{ai} corresponding to the specified speed v_j shall be measured as the elapsed time from the vehicle speed $v_j + \Delta v$ to $v_j - \Delta v$.

6.9.1.5 The procedure from 6.9.1.1 to 6.9.1.4 shall be repeated in the opposite direction to measure the coastdown time Δt_{bi}.

6.9.1.6 Take the average ΔT_i of the two times Δt_{ai} and Δt_{bi}:

$$\Delta T_i = \frac{\Delta t_{ai} + \Delta t_{bi}}{2}$$

6.9.1.7 Perform at least four tests such that the statistical accuracy, P, of the average coastdown time ΔT_j

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

is equal to or less than 2 % (P ⩽ 2 %).

The statistical accuracy, P, as a percentage, is defined by

$$P = \frac{ts}{\sqrt{n}} \times \frac{100}{\Delta T_j}$$

where

t is the coefficient given in table 5;

s is the standard deviation given by the formula

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

n is the number of the test.

Table 5

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

6.9.1.8 In repeating the test, care shall be taken to start the coastdown under the same warm-up conditions.

6.9.1.9 The measurement of coastdown time for multiple specified speeds may be made by a continuous coastdown. In this case, the coastdown shall be repeated always from the same coastdown starting speed ($v_1 + \alpha$).

6.9.2 Measurement of average deceleration

6.9.2.1 When the average deceleration Γ is to be measured, the procedure in 6.9.1.1 to 6.9.1.3, 6.9.1.8 and 6.9.1.9 shall be carried out in the same way as that for the measurement of the coastdown time.

6.9.2.2 Record the successive values of deceleration between v_1 and v_2 and, with the procedure in 6.9.2.3 and 6.9.2.4, determine the value γ_{jai} of deceleration at speed v_j. The data sampling interval shall be no greater than 0,1 s.

6.9.2.3 The following function shall be fitted to the group of data by polynomial regression to determine the coefficients A_0, A_1, A_2 and A_3.

$$v(t) = A_0 + A_1 t + A_2 t^2 + A_3 t^3$$

where

$v(t)$ is the motorcycle speed;

t is the time;

A_0, A_1, A_2 and A_3 are the coefficients.

6.9.2.4 The deceleration, γ_j, at speed v_j, in metres per second squared shall be determined as follows:

$$\gamma_j = A_1 + 2A_2 t_j + 3A_3 t_j^2$$

where t_j is the time at which the motorcycle speed given by the function in 6.9.2.3 is equal to v_j.

6.9.2.5 Make the same test in the opposite direction and determine γ_{jbi}.

6.9.2.6 Take the average, Γ_{ji}, of the two deceleration values γ_{jai} and γ_{jbi}:

$$\Gamma_{ji} = \frac{\gamma_{jai} + \gamma_{jbi}}{2}$$

6.9.2.7 Perform at least four tests such that the statistical accuracy, P, of the average deceleration Γ_j

$$\Gamma_j = \frac{1}{n} \sum_{i=1}^{n} \Gamma_{ji}$$

is equal to or less than 2 %, calculating P using the same formula and coefficients as in 6.9.1.7.

7 Data processing

7.1 Calculation of running resistance force

7.1.1 The running resistance F_j, in newtons, at the specified speed v_j is calculated as follows:

$$F_j = \frac{1}{3{,}6}(m + m_r)\frac{2\Delta v}{\Delta T_j}$$

where

m is the test motorcycle mass, in kilograms, as tested including rider and instruments;

m_r is the equivalent inertia mass of all the wheels and vehicle portion rotating with the wheels during coastdown on the road. m_r should be measured or calculated as appropriate. As an alternative, m_r may be estimated as 7 % of the unladen motorcycle mass.

7.1.2 In the case of the average deceleration method, the running resistance F_j at specified speed v_j is calculated as follows:

$$F_j = (m + m_r)\Gamma_j$$

7.1.3 The running resistance F_j shall be corrected in accordance with 7.2 or 7.3 as appropriate.

7.2 Running resistance curve fitting

The wind shall be limited during tests.

The running resistance, F, in flat calm conditions is

$$F = f_0 + f_2 v^2$$

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

where

- F is the running resistance, including wind velocity resistance, if appropriate, in newtons;
- f_0 is the rolling resistance, in newtons;
- f_2 is the coefficient of aerodynamic drag in newton hours squared per square kilometre [N/(km/h)^2].

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

$$f_0^* = f_0 \, [1 + K_0(T_T - T_0)]$$

$$f_2^* = f_2 \times \frac{T_T}{T_0} \times \frac{p_0}{p_T}$$

where

- f_0^* is the corrected rolling resistance at standard ambient conditions in newtons;
- T_T is the mean ambient temperature, in kelvins;
- f_2^* is the corrected coefficient of aerodynamic drag in newton hours squared per square kilometre [N/(km/h)^2];
- p_T is the mean atmospheric pressure, in kilopascals;
- K_0 is the temperature correction factor of rolling resistance, that may be determined based on the empirical data for the particular vehicle and tyre tests, or may be assumed as follows if the information is not available: $K_0 = 6 \times 10^{-3}$ K^{-1}.

7.3 Single point running resistance fitting

The running resistance determined in 7.1 shall be corrected to the standard ambient conditions as follows:

$$F^* = KF$$

$$K = \frac{R_R}{R_T} [1 + K_R(T_T - T_0)] + \frac{R_{aero}}{R_T} \times \frac{\rho_0}{\rho_T}$$

where

$$\frac{\rho_0}{\rho_T} = \frac{T_T}{T_0} \times \frac{p_0}{p_T}$$

and

- F^* is the corrected running resistance at standard ambient conditions, in newtons;
- K is the correction factor for ambient conditions;
- R_R is the rolling resistance at speed v, in newtons;
- R_{aero} is the aerodynamic drag resistance at speed v, in newtons;
- R_T is the total running resistance $R_T = R_R + R_{aero}$, in newtons;
- K_R is the temperature correction factor of the rolling resistance;
- ρ_T is the air volumetric mass at test conditions;
- ρ_0 is the air volumetric mass at standard conditions.

The values R_R, R_{aero} and R_T shall be given by the manufacturer. K_R value shall be taken equal to 3,6 × 10^{-3} K^{-1} but different values of K_R may be used provided that manufacturer demonstrates better representativity of the rolling resistance.

7.4 Target running resistance for dynamometer setting

The target running resistance $F^*(v_0)$ on the chassis dynamometer at the reference vehicle speed (v_0), in newtons, is determined as follows:

$$F^*(v_0) = f_0^* + f_2^* \times v_0^2$$

or

$$F^*(v_0) = K \times F(v_0)$$

8 Dynamometer setting

8.1 Requirements for equipment

8.1.1 The instrumentation for the speed and time measurement shall have the accuracies specified in clause 5 a) to g).

8.1.2 The chassis dynamometer rolls shall be clean, dry and free from anything which might cause the tyre to slip.

8.1.3 Equivalent inertia masses for the urban cycle test shall be as specified in table 6.

Table 6

Reference mass, m_{ref} kg	Equivalent inertia kg
$m_{ref} \leqslant 105$	100
$105 < m_{ref} \leqslant 115$	110
$115 < m_{ref} \leqslant 125$	120
$125 < m_{ref} \leqslant 135$	130
$135 < m_{ref} \leqslant 150$	140
$150 < m_{ref} \leqslant 165$	150
$165 < m_{ref} \leqslant 185$	170
$185 < m_{ref} \leqslant 205$	190
$205 < m_{ref} \leqslant 225$	210
$225 < m_{ref} \leqslant 245$	230
$245 < m_{ref} \leqslant 270$	260
$270 < m_{ref} \leqslant 300$	280
$300 < m_{ref} \leqslant 330$	310
$330 < m_{ref} \leqslant 360$	340
$360 < m_{ref} \leqslant 395$	380
$395 < m_{ref} \leqslant 435$	410
$435 < m_{ref} \leqslant 475$	450
$475 < m_{ref} < 515$	490

8.2 Inertia mass setting

8.2.1 When the test bench is to be set with the running resistance by the coastdown method, the flywheel equivalent inertia mass, m_i, closest to the actual mass m_a obtained by adding the rotating mass of the front wheel m_{rf} to the total mass of the motorcycle, rider and instruments measured during the actual running test, or the equivalent inertia mass in accordance with table 6 when the dynamometer is set for the urban cycle test, shall be set as the equivalent inertia mass for the chassis dynamometer.

$$m_i \approx m_a$$

where $m_a = m + m_{rf}$

m_{rf} may be measured or calculated, in kilograms, as appropriate. As an alternative, m_{rf} may be estimated as 3 % of m.

8.2.2 If the actual mass m_a cannot be equalized to the flywheel equivalent inertia mass m_i, to make the target running resistance F^* equal to the running resistance F_E which is to be set to the dynamometer, corrected coastdown time ΔT_E may be corrected in accordance with the total mass ratio of the target coastdown time ΔT_{road} as follows:

$$\Delta T_{road} = \frac{1}{3,6}(m_a + m_{r1})\frac{2\Delta v}{F^*}$$

$$\Delta T_E = \frac{1}{3,6}(m_i + m_{r1})\frac{2\Delta v}{F_E}$$

$$F_E = F^*$$

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

with $0,95 < \dfrac{m_i + m_{r1}}{m_a + m_{r1}} < 1,05$

and where

ΔT_{road} is the target coastdown time;

ΔT_E is the corrected coastdown time at the inertia mass $(m_i + m_{r1})$;

F_E is the equivalent running resistance of the chassis dynamometer;

m_{r1} is the equivalent inertia mass of the rear wheel and vehicle portions rotating with the wheel during coastdown. m_{r1} may be measured or calculated, in kilograms, as appropriate. As an alternative, m_{r1} may be estimated as 4 % of m.

8.3 Warming up of chassis dynamometer

Before the test, the chassis dynamometer shall be appropriately warmed up to stabilized frictional force F_f.

8.4 Adjustment of tyre pressures

The tyre pressures shall be adjusted to the specifications of the manufacturer or to that where the speed of the motorcycle under the actual running test and the motorcycle speed obtained on the chassis dynamometer are equalized.

8.5 Motorcycle warming up

The test motorcycle shall be warmed up on the chassis dynamometer in the same way as in 8.3.

8.6 Procedures for setting dynamometer

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

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