INTERNATIONAL STANDARD

ISO 10521-1

First edition
2006-10-01

Road vehicles — Road load —

Part 1: Determination under reference atmospheric conditions

Véhicules routiers — Résistance sur route —

Partie 1: Détermination dans les conditions atmosphériques de référence

Reference number
ISO 10521-1:2006(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 10521-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 5, *Engine tests*.

This first edition, together with ISO 10521-2, cancels and replaces ISO 10521:1992, which has been technically revised.

ISO 10521 consists of the following parts, under the general title *Road vehicles — Road load*:

— *Part 1: Determination under reference atmospheric conditions*

— *Part 2: Reproduction on chassis dynamometer*

Introduction

It is known that wind gives much influence to vehicle road-load measurement on test roads. Therefore, no international standards or national standards/regulations allowed conducting on-road tests under windy (e.g. 3 m/s or more) conditions in terms of measurement accuracy. In this standard, wind effect correction methodology is newly introduced into the conventional coastdown method and torquemeter method, and it offers wider (up to wind speed of 10 m/s) opportunity of on-road tests. In addition, more realistic road load can be simulated even under lower wind conditions.

This part of ISO 10521 also adopts the off-road road-load measurement method as the comparable alternative. The method is based on the separation of the total road load into two components, aerodynamic drag and rolling resistance, where the former is measured in a wind tunnel and the latter with a chassis dynamometer. This alternative enables the standard users to carry out road-load measurement regardless of atmospheric conditions or other requirements necessary for the on-road test. It is not the scope of this standard to define all requirements of wind-tunnel design or test practice. Nevertheless, the standard users are encouraged to conduct the measurement with state-of-the-art wind-tunnel technologies and to respect the highest quality management standards such as ISO 17025, so as to secure the measurement reliability and repeatability.

In view of accessibility of the standard, International Standard ISO 10521 is divided into two parts in this second edition in order to provide two separate standards for the two different technical aspects, determination of road load and reproduction of road load on chassis dynamometer.

Road vehicles — Road load —

Part 1:
Determination under reference atmospheric conditions

1 Scope

This part of ISO 10521 specifies methods of determining the road load of road vehicles for subsequent test purposes, for example, fuel consumption tests or exhaust emission measurements. This determines the road load of a vehicle running on a level road under reference atmospheric conditions. It is achieved by either the coastdown method, the torquemeter method or the wind-tunnel/chassis-dynamometer method.

This part of ISO 10521 is applicable to motor vehicles, as defined in ISO 3833, up to a gross vehicle mass of 3 500 kg.

2 Normative references

The following referenced documents are indispensable for the application 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*

3 Terms and definitions

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

3.1
total resistance
total force-resisting movement of a vehicle, measured either by the coastdown method or by the wind-tunnel/chassis-dynamometer method, including the friction forces in the drive-train

3.2
running resistance
torque-resisting movement of a vehicle, measured by the torquemeter installed in the drive-train of a vehicle, including the friction torque in the drive-train downstream of the torquemeter

3.3
road load
general meaning of the force or torque which opposes the movement of a vehicle, including total resistance and/or running resistance

3.4
aerodynamic drag
resistance of the air to the motion of a vehicle

3.5
rolling resistance
opposing force in the drive-train, axles and tyres to the motion of a vehicle

3.6
reference speed
a vehicle speed at which a chassis-dynamometer load is verified

3.7
reference atmospheric conditions
atmospheric conditions of the following values, to which the road-load measurement results are corrected:

a) atmospheric pressure: p_0 = 100 kPa, unless otherwise specified by regulations;

b) atmospheric temperature: t_0 = 293 K, unless otherwise specified by regulations;

c) dry air density: ρ_0 = 1,189 kg/m^3, unless otherwise specified by regulations;

d) wind speed: 0 m/s.

3.8
stationary anemometry
measurement of wind speed and direction with an anemometer at a location and height above road level alongside the test road where the most representative wind conditions will be experienced

3.9
onboard anemometry
measurement of wind speed and direction with an anemometer appropriately installed to the test vehicle

3.10
wind correction
correction of the effect of wind on road load, which is achieved either by stationary or by onboard anemometry

3.11
aerodynamic stagnation point
point on the surface of a vehicle where the wind velocity is equal to zero

4 Required overall measurement accuracy

The required overall measurement accuracy shall be as follows:

a) vehicle speed: ± 0,5 km/h or ± 1 %, whichever is greater;

b) time: ± 50 ms or ± 0,1 %, whichever is greater;

c) wheel torque: ± 3 N·m or ± 0,5 %, whichever is greater;

d) wind speed: ± 0,3 m/s;

e) wind direction: ± 3°;

f) atmospheric temperature: ± 1 K;

g) atmospheric pressure: ± 0,3 kPa;

h) vehicle mass: ± 10 kg;

i) tyre pressure: ± 5 kPa;

j) product of aerodynamic coefficient and frontal projected area (SCd): ± 2 %;

k) chassis-dynamometer roller speed: ± 0,5 km/h or ± 1 %, whichever is greater;

l) chassis-dynamometer force:

Category 1 chassis dynamometer: ± 6 N, or

Category 2 chassis dynamometer: ± 10 N or ± 0,1 % of full scale, whichever is greater.

NOTE The Category 2 chassis dynamometer usually has a greater load capacity, e.g. 130 kW or more.

5 Road-load measurement on road

5.1 Requirements for road test

5.1.1 Atmospheric conditions for road test

5.1.1.1 Wind

The average wind speed over the test road shall not exceed 10 m/s, nor wind gusts exceed 14 m/s. Relevant wind correction shall be conducted according to the applicable type of anemometry specified in Table 1. In order to decide the applicability of each anemometry type, the average wind speed shall be determined by continuous wind speed measurement, using a recognized meteorological instrument, at a location and height above the road level alongside the test road where the most representative wind conditions will be experienced.

NOTE Wind correction may be waived when the average wind speed is 3 m/s or less.

Table 1 — Applicable anemometry depending on average wind speed and cross-wind component

Wind speed in metres per second (m/s)

Type of anemometry	Average wind speed		
	Absolute wind speed $v \le 5$		Absolute wind speed $5 < v \le 10$
	Cross-wind component (v_c) $v_c \le 3$	Cross-wind component (v_c) $3 < v_c \le 5$	
Stationary anemometry	Applicable	Not applicable	Not applicable
Onboard anemometry	Applicable	Applicable	Applicable
NOTE The stationary anemometry is recommended when the absolute wind speed is less than 1 m/s.			

5.1.1.2 Atmospheric temperature

The atmospheric temperature shall be within the range of 274 to 308 K, inclusive.

5.1.2 Test road

The road surface shall be flat, dry and hard, and its texture and composition shall be representative of current urban and highway road surfaces. The test-road longitudinal slope shall not exceed ± 1 %. The local

inclination between any points 3 m apart shall not deviate more than ± 0,5 % from this longitudinal slope. The maximum cross-sectional camber of the test road shall be 1,5 %.

5.2 Preparation for road test

5.2.1 Vehicle preparation

5.2.1.1 Vehicle condition

The test vehicle shall be suitably run-in for the purpose of the subsequent test. The tyres shall be suitably broken-in for the purpose of the subsequent test, while still having a tread depth of not less than 50 % of the initial tread depth.

Unless any particular purpose is intended, the vehicle shall be in normal vehicle conditions, as specified by the manufacturer. That is, tyre pressure (see 5.2.1.2), wheel alignment, vehicle height, lubricants in the drive-train and wheel-bearings, and brake adjustment to avoid unrepresentative parasitic drag.

During the road test, the engine bonnet/hood and all windows shall be closed so that they will not influence the road-load measurement. Any covers of the air ventilation system, headlamps, etc., shall be closed, and the air-conditioning switched off.

The vehicle mass shall be adjusted to meet the requirement of the intended subsequent test, including the mass of the driver and instruments.

5.2.1.2 Tyre-pressure adjustment

If the difference between the ambient and soak temperature is more than 5 K, the tyre pressure shall be adjusted as follows.

Soak the tyres for more than 4 h at 10 % above the target pressure. Just before testing, reduce the pressure down to the manufacturer's recommended inflation pressure, adjusted for difference between the soaking-environment temperature and the ambient test temperature at a rate of 0,8 kPa per 1 K using the following formula:

$$\Delta P_t = 0{,}8 \times \left(T_{\text{soak}} - T_{\text{amb}}\right)$$

where

- ΔP_t is the tyre pressure adjustment, in kilopascals (kPa);
- 0,8 is the pressure adjustment factor, in kilopascals per kelvin (kPa/K);
- T_{soak} is the tyre-soaking temperature, in kelvins (K);
- T_{amb} is the test ambient temperature, in kelvins (K).

5.2.2 Installation of instruments

Any instruments, especially for those installed outside the vehicle, shall be installed on the vehicle in such a manner as to minimize effects on the operating characteristics of the vehicle.

5.2.3 Vehicle preconditioning

Prior to the test, the vehicle shall be preconditioned appropriately, until stabilized and normal vehicle operating temperatures have been reached. It is recommended that the vehicle should be driven at the most appropriate reference speed for a period of 30 min. During this preconditioning period, the vehicle speed shall not exceed the highest reference speed.

5.3 Measurement of total resistance by coastdown method

The total resistance shall be determined by either the multi-segment method (5.3.1), the average deceleration method (5.3.2) or the direct regression method (5.3.3).

5.3.1 Multi-segment method

5.3.1.1 Selection of speed points for road-load curve determination

In order to obtain a road-load curve as a function of vehicle speed, a minimum of four speed points, V_j (j = 1, 2, etc.) shall be selected. The highest speed point shall not be lower than the highest reference speed, and the lowest speed point shall not be higher than the lowest reference speed. The interval between each speed point shall not be greater than 20 km/h.

5.3.1.2 Data collection

During the test, a) and b) shall be measured and recorded at a maximum of 0,2 s intervals, and c) and d) at a maximum of 1,0 s intervals.

a) elapsed time;

b) vehicle speed;

c) wind speed;

d) wind direction.

NOTE The wind speed and the wind direction are measured by the stationary anemometry.

5.3.1.3 Vehicle coastdown

5.3.1.3.1 Following preconditioning, and immediately prior to each test measurement, drive the vehicle at the highest reference speed for, at most, 1 min, if necessary. Then accelerate the vehicle to 5 km/h more than the speed at which the coastdown time measurement begins ($V_j + \Delta V$) and begin the coastdown immediately.

5.3.1.3.2 During coastdown, the transmission shall be in neutral, and the engine shall run at idle. In the case of vehicles with manual transmission, the clutch shall be engaged. Movement of steering-wheel shall be avoided as much as possible, and the vehicle brakes shall not be operated until the end of the coastdown.

5.3.1.3.3 Repeat the test, taking care to begin the coastdown at the same speed and preconditions.

5.3.1.3.4 Although it is recommended that each coastdown run be performed without interruption, split runs are permitted if data cannot be collected in a continuous fashion for the entire speed range. For split runs, care shall be taken so that the vehicle condition be constant as much as possible at each split point.

5.3.1.4 Determination of total resistance by coastdown time measurement

5.3.1.4.1 Measure the coastdown time corresponding to the speed V_j as the elapsed time from the vehicle speed ($V_j + \Delta V$) to ($V_j - \Delta V$). It is recommended that ΔV be 10 km/h when the vehicle speed is more than 60 km/h, and 5 km/h when the vehicle speed is 60 km/h or less.

5.3.1.4.2 Carry out these measurements in both directions until a minimum of three consecutive pairs of figures have been obtained which satisfy the statistical accuracy p, in percent, defined below.

$$p = \frac{ts}{\sqrt{n}} \times \frac{100}{\Delta T_j} \leq 3\ \%$$

where

n is the number of pairs of measurements;

ΔT_j is the mean coastdown time at speed V_j, in seconds (s), given by the formula:

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

in which

ΔT_{ji} is the harmonized average coastdown time of the ith pair of measurements at speed V_j, in seconds (s) given by the formula:

$$\Delta T_{ji} = \frac{2}{\left(1/\Delta T_{jai}\right) + \left(1/\Delta T_{jbi}\right)}$$

and in which

ΔT_{jai} and ΔT_{jbi} are the coastdown times of the i^{th} measurement at speed V_j in each direction, respectively, in seconds (s);

s is the standard deviation, in seconds (s), defined by the formula:

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} \left(\Delta T_{ji} - \Delta T_j\right)^2}$$

t is the coefficient given in Table 2.

Table 2

n	t	$\frac{t}{\sqrt{n}}$
3	4,3	2,48
4	3,2	1,60
5	2,8	1,25
6	2,6	1,06
7	2,5	0,94
8	2,4	0,85
9	2,3	0,77
10	2,3	0,73
11	2,2	0,66
12	2,2	0,64
13	2,2	0,61
14	2,2	0,59
15	2,2	0,57