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Road vehicles — Road load —

Part 2:
Reproduction on chassis dynamometer

Véhicules routiers — Résistance sur route —

Partie 2: Reproduction sur banc dynamométrique

Reference number
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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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Foreword

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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 10521-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 5, *Engine tests*.

This first edition, together with ISO 10521-1, 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*

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Introduction

This part of ISO 10521 has been prepared to reflect the state-of-the-art technique for the vehicle road-load setting on chassis dynamometers. ISO10521-1 should be referred to for the basic road-load measurement method. This part contains the following technical and editorial changes compared with ISO 10521:1992:

— to simulate the road load on the chassis dynamometer precisely, the hydraulic absorber type dynamometer is excluded;

— only the chassis dynamometer of coefficient control is described in this part of ISO10521.

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Road vehicles — Road load —

Part 2:
Reproduction on chassis dynamometer

1 Scope

This part of ISO 10521 specifies methods of setting the target road load on chassis dynamometers for the purpose of a subsequent test, for example the fuel consumption test or the exhaust-emission measurement test.

The road-load setting method on chassis dynamometers depends on the road-load measurement method, such as the coastdown method, the torquemeter method or the wind-tunnel and chassis-dynamometer method. This part of ISO 10521 gives detailed instructions on the methods of the chassis-dynamometer setting procedure for road-load value, obtained by the various measurement methods specified in ISO 10521-1.

This part of ISO 10521 is applicable to chassis dynamometers that can set road load at a minimum of three speed points, and 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*

ISO 10521-1:2006, *Road vehicles — Road load — Part 1: Determination under reference atmospheric conditions*

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 movement, measured either by the coastdown method or by the wind-tunnel and 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

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

3.4
reference speed
vehicle speed at which a chassis-dynamometer load is verified

NOTE Reference speeds may be continuous speed points covering the complete speed range.

3.5
target road load
road load to be reproduced on the chassis dynamometer

3.6
chassis-dynamometer setting load
load to be set on the power-absorption unit of the chassis dynamometer

3.7
simulated road load
road load to be calculated from measured coastdown data using the least-square regression

NOTE See Annex A for the calculation procedure.

3.8
speed range
range of speed of chassis-dynamometer roller between 15 km/h and maximum reference speed plus 10 km/h, over which the coastdown test is conducted

3.9
chassis dynamometer of coefficient control
chassis dynamometer of which absorption characteristics are determined by giving coefficients of a road-load approximation polynomial

3.10
chassis dynamometer of polygonal control
chassis dynamometer of which absorption characteristics are determined by giving load values at several speed points

4 Required overall measurement accuracy

The required overall measurement accuracy shall be as follows:

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

b) 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 Category 2 chassis dynamometer usually has greater load capacity, e.g. 130 kW or more.

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

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

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e) atmospheric temperature: ± 1 K;

f) tyre pressure: ± 5 kPa.

5 Preparation for chassis-dynamometer test

5.1 Setting parameter

The following parameters shall be determined prior to the test, in accordance with the purpose of the subsequent test:

a) target road load;

b) speed range;

c) reference speed.

5.2 Laboratory condition

5.2.1 Roller

The chassis-dynamometer roller shall be clean, dry and free from anything which might cause tyre slippage. In the case of chassis dynamometers with multiple rollers, the chassis dynamometers shall be run in the same coupled or uncoupled state as the subsequent emission test, fuel consumption test, etc., and the chassis-dynamometer speed shall be measured from the roller coupled to the power-absorption unit.

5.2.2 Room temperature

The laboratory atmospheric temperature shall be within 293 K to 303 K as the standard condition, unless otherwise required by the subsequent test.

5.3 Preparation of chassis dynamometer

5.3.1 Inertia-mass setting

Set the equivalent inertia mass of the chassis dynamometer in accordance with the vehicle mass or vehicle mass category.

5.3.2 Preconditioning of chassis dynamometer

Precondition the chassis dynamometer in accordance with the dynamometer manufacturer's recommendations, or as appropriate, so that the friction loss of the chassis dynamometer can be stabilized.

5.4 Vehicle preparation

5.4.1 Tyre-pressure adjustment

The tyre pressure shall be adjusted to the recommended values for the test. These values shall correspond to those recommended for the range of vehicle speeds encountered during the subsequent emission test, fuel consumption test, etc., in conjunction with roller geometry of the chassis dynamometer to be used. If small-diameter roller(s) are being used, the tyre pressure may be increased so as to ensure a safe test. This pressure increase should be typically 50 %.

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5.4.2 Vehicle setting

The tested vehicle shall be installed on the chassis-dynamometer roller in a straight position and restrained in a safe manner. In the case of a single roller, the tyre contact point shall be within ± 25 mm or ± 2 % of the roller diameter, whichever is smaller, from the top of the roller.

5.4.3 Vehicle preconditioning

The power-absorption unit of the chassis dynamometer shall be set in the way specified in 6.1.1.1 or 6.2.1.1, so that an adequate load will be applied to the test vehicle during preconditioning.

Prior to the test, the vehicle shall be preconditioned appropriately until 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.

6 Load setting on the chassis dynamometer

6.1 Chassis-dynamometer setting by coastdown method

This method is applicable when the road load is determined using the coastdown method, or the wind-tunnel and chassis-dynamometer method as specified in ISO 10521-1:2006, 5.3, 5.4 or Clause 6.

6.1.1 Load setting of chassis dynamometer

6.1.1.1 Initial load setting

For a chassis dynamometer of coefficient control, the chassis-dynamometer power-absorption unit shall be adjusted with the arbitrary initial coefficients, A_d, B_d and C_d, of the following equation:

$$F_d = A_d + B_d V + C_d V^2$$

where

F_d is the chassis-dynamometer setting load, in newtons (N);

V is the speed of the chassis-dynamometer roller, in kilometres per hour (Km/h).

The following are the recommended coefficient assumptions to be used for the initial load setting:

a) $A_d = 0,5 \times A_t$, $B_d = 0,2 \times B_t$, $C_d = C_t$, in the case of single-axis chassis dynamometers, or

$A_d = 0,1 \times A_t$, $B_d = 0,2 \times B_t$, $C_d = C_t$, in the case of dual-axis chassis dynamometers,

where A_t, B_t and C_t are the coefficients for the target road load;

b) empirical values, such as those used for the setting for a similar type of vehicle.

For a chassis dynamometer of polygonal control, adequate load values at each speed point shall be set to the chassis-dynamometer power-absorption unit.

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6.1.1.2 Coastdown

Perform the coastdown test on the chassis dynamometer once with the procedure given in ISO 10521-1:2006, 5.3.1.3.1 and 5.3.1.3.2. Then proceed to 6.1.1.3.

6.1.1.3 Verification

6.1.1.3.1 Calculate the target road-load value using the target road-load coefficient A_t, B_t *and* C_t for each reference speed V_j.

$$F_{tj} = A_t + B_t V_j + C_t V_j^2$$

where

F_{tj} is the target road load at reference speed V_j, in newtons (N);

V_j is the j^{th} reference speed, in kilometres per hour (km/h).

6.1.1.3.2 Calculate the error, ε_j, in percent of the simulated road load F_{sj}, which is calculated using the method specified in A.1, for target road load F_{tj} at each reference speed V_j, using the following equation.

$$\varepsilon_j = \frac{\left| F_{sj} - F_{tj} \right|}{F_{tj}} \times 100$$

NOTE F_{mj}, obtained in A.1.1, may be used in the above equation instead of F_{sj}.

Verify whether errors at all reference speeds satisfy the following error criteria in two consecutive coastdown runs, unless otherwise specified by regulations.

$\varepsilon_j \leq 3$ % for $V_j \geq$ 50 km/h

$\varepsilon_j \leq 5$ % for 20 km/h $< V_j <$ 50 km/h

$\varepsilon_j \leq 10$ % for $V_j \leq$ 20 km/h

If an error at any reference speed does not satisfy the criteria, then proceed to 6.1.1.4 for the adjustment of the chassis-dynamometer setting load.

6.1.1.4 Adjustment

Adjust the chassis setting load in order to minimise the error in accordance with the procedure specified in B.1. Then repeat 6.1.1.2 and 6.1.1.3.

6.2 Chassis-dynamometer setting using torquemeter method

This method is applied when the road load is determined using the torquemeter method, as specified in ISO 10521-1:2006, 5.5.

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6.2.1 Load setting of chassis dynamometer

6.2.1.1 Initial load setting

For a chassis dynamometer of coefficient control, the chassis-dynamometer power-absorption unit shall be adjusted with the arbitrary initial coefficients, A_d, B_d and C_d, of the following equation:

$$F_d = A_d + B_d V + C_d V^2$$

where

F_d s the chassis-dynamometer setting load, in newtons (N);

V is the speed of the chassis-dynamometer roller, in kilometres per hour (Km/h).

The following are the recommended coefficient assumptions to be used for the initial load setting:

a) A_d = 0,5 × a_t/r', B_d = 0,2 × b_t/r', C_d = c_t/r', in the case of single-axis chassis dynamometers, or

A_d = 0,1 × a_t/r', B_d = 0,2 × b_t/r', C_d = c_t/r', in the case of dual-axis chassis dynamometers,

where

a_t, b_t and c_t are the coefficients for the target torque;

r' is the dynamic radius of the tyre on the chassis dynamometer, in metres (m), that is obtained by averaging the r'_j values calculated in A.2.1;

b) empirical values, such as those used for the setting for a similar type of vehicle.

For a chassis dynamometer of polygonal control, adequate load values at each speed point shall be set to the chassis-dynamometer power-absorption unit.

6.2.1.2 Wheel torque measurement

Perform the torque measurement test on the chassis dynamometer with the procedure defined in ISO 10521-1:2006, 5.5.2. The torquemeter(s) shall be identical with the one(s) used in the preceding road test.

6.2.1.3 Verification

6.2.1.3.1 Calculate the target road-load value using the target torque coefficients a_t, b_t, *and* c_t for each reference speed V_j.

$$F_{tj} = \frac{a_t + b_t V_j + c_t V_j^2}{r'}$$

where

F_{tj} is the target road load at reference speed V_j, in newtons (N);

V_j is the j^{th} reference speed, in kilometres per hour (km/h);

r' is the dynamic radius of the tyre on the chassis dynamometer, in metres (m), that is obtained by averaging the r'_j values calculated in A.2.1.

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6.2.1.3.2 Calculate the error, ε_j, in percent of simulated road load F_{si} , which is calculated with the method specified in A.2, for target road load $F_{t\,j}$ at each reference speed V_j.

$$\varepsilon_j = \frac{\left|F_{sj} - F_{tj}\right|}{F_{tj}} \times 100$$

NOTE $C_{j\,m}/\,r'$ obtained in A.2.1 and 6.2.1.3.1, respectively, may be used in the above equation instead of F_{sj}.

Verify whether errors at all reference speeds satisfy the following error criteria in two consecutive coastdown runs, unless otherwise specified by regulations.

$\varepsilon_j \leq 3$ % for $V_j \geq$ 50 km/h

$\varepsilon_j \leq 5$ % for 20 km/h $< V_j <$ 50 km/h

$\varepsilon_j \leq 10$ % for $V_j \leq$ 20 km/h

If the error at any reference speed does not satisfy the criteria, then proceed to 6.2.1.4 for the adjustment of the chassis-dynamometer setting load.

6.2.1.4 Adjustment

Adjust the chassis-dynamometer setting load in order to minimise the error in accordance with the procedure specified in B.2. Then repeat 6.2.1.2 and 6.2.1.3.

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Annex A
(normative)

Calculation of road load for the dynamometer test

A.1 Calculation of simulated road load for the coastdown method

When the road load is measured by the coastdown method as specified in ISO 10521-1:2006, 5.3 or 5.4, calculation of the simulated road load F_{sj} for each reference speed V_j, in kilometres per hour, shall be conducted as described in A.1.1 to A.1.3.

A.1.1 Calculate the measured road load using the following formula:

$$F_{mj} = \frac{1}{3,6} \times \left(m_d + m_r' \right) \times \frac{2 \times \Delta V}{\Delta T_j}$$

where

F_{mj} is the measured road load for each reference speed V_j, in newtons (N);

m_d is the equivalent inertia-mass of the chassis dynamometer, in kilograms (kg);

m_r' is the equivalent effective mass of drive wheels and vehicle components rotating with the wheels during coastdown on the dynamometer, in kilograms (kg); m_r' may be measured or calculated by an appropriate technique. As an alternative, m_r' may be estimated as 3 % of the unladen vehicle mass for a permanent four-wheel-drive vehicle, and 1,5 % of the unladen vehicle mass for a two-wheel-drive vehicle;

ΔT_j is the coastdown time corresponding to speed V_j, in seconds (s).

A.1.2 Calculate the coefficients A_s, B_s and C_s of the following approximate equation by the least-square regression using the calculated $F_{m\,j}$:

$$F_s = A_s + B_s V + C_s V^2$$

A.1.3 Determine the simulated road load for each reference speed V_j using the following equation, using the calculated A_s, B_s and C_s:

$$F_{sj} = A_s + B_s V_j + C_s V_j{}^2$$

A.2 Calculation of simulated road load for the torquemeter method

When the road load is measured by the torquemeter method as specified in ISO 10521-1:2006, 5.5, calculation of the simulated road load F_{sj} for each reference speed V_j, in kilometres per hour, shall be conducted as described in A.2.1 to A.2.3.

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A.2.1 Calculate the mean speed $V_{j\,\mathrm{m}}$, in kilometres per hour, and the mean torque $C_{j\,\mathrm{m}}$, in newton metres, for each reference speed V_j using the following formulae:

$$V_{j\mathrm{m}} = \frac{1}{k}\sum_{i=1}^{k} V_{ji}$$

and

$$C_{j\mathrm{m}} = \frac{1}{k}\sum_{i=1}^{k} C_{ji} - C_{j\mathrm{c}}$$

where

V_{ji} is the vehicle speed of the i^{th} data set, in kilometres per hour (km/h);

k is the number of data sets;

and

C_{ji} is the torque of the i^{th} data set, in newton metres (N·m);

$C_{j\mathrm{c}}$ is the compensation term for the speed drift, in newton metres, which is given by the following formula.

$C_{j\mathrm{c}}$ shall be no greater than 5 % of the mean torque before compensation, and may be neglected if $|\alpha_{\mathrm{j}}|$ is no greater than 0,005 m/s^2.

$$C_{j\mathrm{c}} = \left(m_{\mathrm{d}} + m'_{\mathrm{r}}\right)\alpha_j r'_j$$

in which

m_{d} and m'_{r} are the equivalent inertia mass of the chassis dynamometer and the equivalent effective mass of drive wheels and vehicle components rotating with the wheel during coastdown on the chassis dynamometer, respectively, both in kilograms (kg), as defined in A.1;

α_j is the mean acceleration, in metres per second squared (m/s^2), which shall be calculated by the formula:

$$\alpha_j = \frac{1}{3{,}6} \times \frac{k\sum_{i=1}^{k} t_i V_{ij} - \sum_{i=1}^{k} t_i \sum_{i=1}^{k} V_{ji}}{k\sum_{i=1}^{k} t_i^2 - \left(k\sum_{i=1}^{k} t_i\right)^2}$$

and in which t_i is the time at which the i^{th} data set was sampled, in seconds (s).

r'_j is the dynamic radius of the tyre, in metres (m), given by the formula:

$$r'_j = \frac{1}{3{,}6} \times \frac{V_{j\mathrm{m}}}{2 \times \pi N}$$

and in which N is the rotational frequency of the driven tyre, in revolutions per second (s^{-1}).

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A.2.2 Calculate the coefficients a_s, b_s and c_s of the following approximate equation by the least-square regression using the calculated $V_{j\,m}$ and the $C_{j\,m}$.

$$F_s = \frac{f_s}{r'} = \frac{a_s + b_s V + c_s V^2}{r'}$$

A.2.3 Determine the simulated road load for each reference speed V_j using the following equation, using the calculated a_s, b_s and c_s:

$$F_{sj} = \frac{f_{sj}}{r'} = \frac{a_s + b_s V_j + c_s V_j^2}{r'}$$

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Annex B
(normative)

Adjustment of chassis-dynamometer setting load

B.1 Adjustment of chassis-dynamometer setting load by coastdown method

When the load setting on the chassis dynamometer is performed by the coastdown method, the chassis-dynamometer setting load shall be adjusted using the following equations:

$$F_{\mathrm{d}j}^* = F_{\mathrm{d}j} - F_j$$

$$= F_{\mathrm{d}j} - F_{\mathrm{s}j} + F_{\mathrm{t}j}$$

$$= \left(A_\mathrm{d} + B_\mathrm{d} V_j + C_\mathrm{d} V_j^2\right) - \left(A_\mathrm{s} + B_\mathrm{s} V_j + C_\mathrm{s} V_j^2\right) + \left(A_\mathrm{t} + B_\mathrm{t} V_j + C_\mathrm{t} V_j^2\right)$$

$$= \left(A_\mathrm{d} + A_\mathrm{t} - A_\mathrm{s}\right) + \left(B_\mathrm{d} + B_\mathrm{t} - B_\mathrm{s}\right) V_j + \left(C_\mathrm{d} + C_\mathrm{t} - C_\mathrm{s}\right) V_j^2$$

$$\therefore A_\mathrm{d}^* = A_\mathrm{d} + A_\mathrm{t} - A_\mathrm{s}$$

$$\therefore B_\mathrm{d}^* = B_\mathrm{d} + B_\mathrm{t} - B_\mathrm{s}$$

$$\therefore C_\mathrm{d}^* = C_\mathrm{d} + C_\mathrm{t} - C_\mathrm{s}$$

where

$F_{\mathrm{d}j}^*$	is the new chassis-dynamometer setting load, in newtons (N);
F_j	is the adjustment road load, which is equal to $F_{\mathrm{s}j} - F_{\mathrm{t}j}$, in newtons (N);
$F_{\mathrm{s}j}$	is the simulated road load at reference speed V_j, in newtons (N);
$F_{\mathrm{t}j}$	is the target road load at reference speed V_j, in newtons (N);
A_d^*, B_d^* and C_d^*	are the new chassis-dynamometer setting coefficients.

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B.2 Adjustment of chassis-dynamometer setting load by torquemeter method

When the load setting on the chassis dynamometer is performed by the torquemeter method, the chassis-dynamometer load setting shall be adjusted using the following equation:

$$F_{dj}^{*} = F_{dj} - f_{ej}/r'$$

$$= F_{dj} - f_{sj}/r' + f_{tj}/r'$$

$$= \left(A_d + B_d V_j + C_d V_j^2\right) - \left(a_s + b_s V_j + c_s V_j^2\right)/r' + \left(a_t + b_t V_j + c_t V_j^2\right)/r'$$

$$= \left\{A_d + \left(a_t - a_s\right)/r'\right\} + \left\{B_d + \left(b_t - b_s\right)/r'\right\}V_j + \left\{C_d + \left(c_t - c_s\right)/r'\right\}V_j^2$$

$$\therefore A_d^{*} = A_d + \left(a_t - a_s\right)/r'$$

$$\therefore B_d^{*} = B_d + \left(b_t - b_s\right)/r'$$

$$\therefore C_d^{*} = C_d + \left(c_t - c_s\right)/r'$$

where

$F_{dj}{}^{*}$ is the new chassis-dynamometer setting load, in newtons (N);

f_{ej} is the adjustment torque, which is equal to $f_{sj} - f_{tj}$, in newton metres (N·m);

f_{sj} is the simulated torque at reference speed V_j, in newton metres (N·m);

f_{tj} is the target torque at reference speed V_j, in newton metres (N·m);

$A_d{}^{*}$, $B_d{}^{*}$ and $C_d{}^{*}$ are the new chassis-dynamometer setting coefficients;

r' is the dynamic radius of the tyre on the chassis dynamometer, in metres (m), that is obtained by averaging the r'_j values calculated in A.2.1.

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