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Motor vehicle road load — Determination under reference atmospheric conditions and reproduction on chassis dynamometer

Résistance sur route des véhicules à moteur — Détermination dans les conditions atmosphériques de référence et reproduction sur banc dynamométrique

Reference number
ISO 10521:1992(E)

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

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

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Motor vehicle road load — Determination under reference atmospheric conditions and reproduction on chassis dynamometer

1 Scope

This International Standard specifies methods of setting a chassis dynamometer for test purposes, for example for fuel consumption tests or exhaust emission measurements. This setting reproduces the road load of a vehicle running on a level road under reference atmospheric conditions. It is achieved by either the coastdown or the torquemeter method.

This International Standard gives detailed instructions on the measurement of relevant parameters during data collection, on the analysis techniques for the reduction and correction of these data to the reference conditions and on the methods used for transfer of the corrected data to a chassis dynamometer.

It does not deal either with the procedures concerning the various tests that may be performed on the chassis dynamometer or with any necessary corrections to the measurement results obtained during such tests.

This International Standard applies to motor vehicles as defined in ISO 3833 up to a gross vehicle mass of 3 500 kg.

NOTE 1 This International Standard has been prepared taking into account existing regulations. Its objective is not to summarize all existing methods but rather to define a reference method.

For information, annex E gives a comparative table with the following existing regulations:

- ECE 15/04 TRANS/SC1/WP29/R374 (22 November 1985)
- USA EPA A/C 55C (12 December 1986)
- Japan TRIAS 24-3-1985 (22 October 1985)

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 total resistance: Total force resisting movement of a vehicle, measured by the coastdown method which includes 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. It includes the friction torque in the drive-train downstream of the torquemeter.

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

3.4 reference speed: Vehicle speed at which the dynamometer load setting is required. Where a steady state test is to be performed subsequently, the reference speed should be identical to the steady state test speed.

4 Requirements for road test

4.1 Accuracy for test parameter measurements

4.1.1 Required overall accuracy

The required overall accuracy of each method is as follows:

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

b) coastdown time, ΔT: ± 100 ms or ± 1 %, whichever is greater;

c) deceleration, Γ: ± 2 %;

d) torque: ± 3 N·m or ± 2 %, whichever is greater.

4.1.2 Required test condition accuracy

The required accuracy of the parameters which are used in conjunction with the test measurement is as follows:

a) wind speed: ± 0,3 m/s;

b) air temperature: ± 1 K;

c) atmospheric pressure: ± 0,3 kPa.

4.1.3 Suitable auxiliary parameter accuracy

Accuracy of the measurements below, if necessary, is as follows:

a) mass: ± 1 %;

b) length or distance: ± 0,5 %;

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

d) force: ± 2,5 N or ± 1,5 %, whichever is greater.

4.2 Requirements for test road

4.2.1 Layout

The test road layout shall be level, straight and free of obstacles or wind barriers which adversely affect the variability of road load measurement.

4.2.2 Slope

The test road longitudinal slope shall not exceed ± 2 %. This slope is defined as the ratio of the difference in elevation between both ends of the test road and its overall length. In addition, the local inclination between any two points 3 m apart shall not deviate by more than ± 0,5 % from this longitudinal slope.

The maximum cross-sectional camber of the test road shall be 1,5 % or less.

4.2.3 Even coating tolerance

The even coating tolerance shall be less than 3 mm deflection within a three-metre rolling rule or its equivalent. (Refer to A.1.)

4.2.4 Surface

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 road surface measured by the sand patch method shall exhibit an H_s value within the recommended range of 0,4 mm to 0,8 mm or its equivalent. (Refer to A.2.)

4.3 Atmospheric conditions for road test

4.3.1 Wind

During data collecting periods, the averaged wind velocity over the test road shall be less than 3 m/s.

The wind velocity shall be continuously measured, using a recognized meteorological instrument, at a location and height above road level alongside the test road where the most representative wind conditions will be experienced.

4.3.2 Atmospheric temperature

The atmospheric temperature shall be within 274 K to 308 K inclusive.

4.3.3 Air density

The air density shall not deviate more than ± 7,5 % from the reference air density set in 4.3.4. The air density under test conditions, ϱ, in kilograms per cubic metre, is calculated by the formula:

$$\varrho = \varrho_0 \frac{p}{p_0} \times \frac{T_0}{T}$$

where

ϱ_0 is the dry air density under reference conditions, in kilograms per cubic metre;

p is the atmospheric pressure under test conditions, in kilopascals;

p_0 is the atmospheric pressure under reference conditions, in kilopascals;

T is the atmospheric temperature under test conditions, in kelvins;

T_0 is the atmospheric temperature under reference conditions, in kelvins.

4.3.4 Reference conditions

The reference conditions are as follows:

— atmospheric pressure: $p_0 = 100$ kPa

— atmospheric temperature: $T_0 = 293$ K

— dry air density: $\varrho_0 = 1{,}189$ kg/m^3

— wind speed: nil

5 Selection of speed points for road load curve determination

5.1 In order to obtain a road load curve as a function of vehicle speed, road load values shall be measured at a minimum of four speed points, v_j ($j = 1$, 2, etc.) which shall be selected in accordance with the criteria in 5.2 to 5.4.

5.2 The range of speed points (the interval between maximum and minimum points) shall be wider than the reference speed range with sufficient margin on either side. This margin should be at least Δv as defined in 7.2.1.

5.3 The speed points shall be distributed with sufficiently small intervals, no greater than 20 km/h.

5.4 Each reference speed shall correspond to one of these speed points.

6 Preparation for road test

6.1 Vehicle preparation

6.1.1 Vehicle condition

Unless any particular purpose is intended, the vehicle shall be in normal vehicle condition as specified in annex B.

6.1.2 Installation of instruments

When installing the measuring instruments on the test vehicle, care shall be taken to minimize their adverse effect on the distribution of the total vehicle mass between the road wheels. When installing the speed sensor outside the vehicle, care shall be taken to minimize additional air resistance. If satisfactory data is available, this additional air and rolling resistance may be used to correct the road load.

6.2 Vehicle preconditioning

6.2.1 Prior to the test, the vehicle shall be preconditioned appropriately until normal vehicle operating temperatures, for the prevailing atmospheric conditions, have been reached. It is recommended that the vehicle should be driven at the most appropriate reference speed for a period of 30 min.

6.2.2 During this preconditioning period, the vehicle speed shall not exceed the highest reference speed.

7 Measurement of total resistance by coastdown method

7.1 Vehicle coastdown

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

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

7.1.3 Repeat the test, taking care to begin the coastdown at the same speed and preconditioning.

7.2 Determination of total resistance by coastdown time measurement

7.2.1 Measure the coastdown time corresponding to speed v_j as the elapsed time from the vehicle speed $v_j + \Delta v$ to $v_j - \Delta v$, where Δv is as follows:

$\Delta v = 5$ km/h for $v_j \leqslant 60$ km/h;

$\Delta v = 10$ km/h for $v_j > 60$ km/h.

7.2.2 Carry out these measurements in both directions until a minimum of four consecutive pairs of figures (but see 7.2.3) have been obtained which satisfy the statistical accuracy P, in percent, defined below:

$$P = \frac{ts}{\sqrt{n}} \times \frac{100}{\Delta T_j} \leqslant 3\ \%$$

where

n is the number of pairs of measurements;

ΔT_j is the mean coastdown time at speed v_j, in seconds, given by the formula:

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

in which

ΔT_{ji} is the average coastdown time of the ith pair of measurements at speed v_j, in seconds, given by the formula:

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

and in which

ΔT_{jai} and ΔT_{jbi} are the coastdown time of ith measurement at speed v_j in each direction respectively, in seconds;

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

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

t is the coefficient given in table 1.

Table 1

n	t	$\frac{t}{\sqrt{n}}$
2	12,7	8,98
3	4,3	2,48
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

7.2.3 If during a measurement in one direction, the vehicle operator is forced to change the vehicle direction sharply in the interests of track safety or to avoid damaging the vehicle, then this measurement and the paired measurement in the opposite direction may be discounted.

7.2.4 The measurement of coastdown times for multiple speed points may be made in succession by a continuous coastdown.

7.2.5 The total resistance, F_j, at speed v_j, in newtons, is determined by the formula:

$$F_j = \frac{1}{2} (F_{ja} + F_{jb})$$

where

F_{ja} and F_{jb} are the total resistances at speed v_j, in newtons, in each direction respectively, given by the formulae:

$$F_{ja} = \frac{1}{3,6} (m + m_r) \frac{2\Delta v}{\Delta T_{ja}}$$

$$F_{jb} = \frac{1}{3,6} (m + m_r) \frac{2\Delta v}{\Delta T_{jb}}$$

in which

m is the vehicle mass including driver and instruments as tested, in kilograms;

m_r is the equivalent effective mass of all the wheels and vehicle components rotating with the wheels during coastdown on the road, in kilograms. m_r should be measured or calculated by an appropriate technique. As an alternative, m_r may be estimated as 3 % of the unladen vehicle mass;

ΔT_{ja} and ΔT_{jb} are the mean coastdown times in each direction respectively corresponding to speed v_j, in seconds, given by the formulae:

$$\Delta T_{ja} = \frac{1}{n} \sum_{i=1}^{n} \Delta T_{jai}$$

$$\Delta T_{jb} = \frac{1}{n} \sum_{i=1}^{n} \Delta T_{jbi}$$

7.3 Determination of total resistance by average deceleration measurement

As an alternative to the determination in 7.2, the total resistance may also be determined by the procedure described in 7.3.1 to 7.3.5.

7.3.1 Record the speed versus time data during coastdown from vehicle speed $v_j + \Delta v$ to $v_j - \Delta v$, where Δv is greater than 10 km/h and the data sampling interval is no greater than 0,1 s.

7.3.2 Fit the following function 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 vehicle speed;

t is the time;

A_0, A_1, A_2 and A_3 are the coefficients.

7.3.3 Determine the deceleration, γ_j, at the speed v_j, in metres per second squared, as follows:

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

where t_j is the time at which the vehicle speed given by the function in 7.3.2 is equal to v_j.

7.3.4 Repeat the measurements in both directions until a minimum of four consecutive pairs of the data have been obtained which satisfy the statistical accuracy P, in percent, below (but see 7.2.3):

$$\mathrm{P} = \frac{ts}{\sqrt{n}} \times \frac{100}{\Gamma_j} \leqslant 3\ \%$$

where

n is the number of pairs of measurements;

Γ_j is the mean average deceleration at speed v_j, in metres per second squared, given by the formula:

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

in which

$$\Gamma_{ji} = \frac{1}{2} (\gamma_{jai} + \gamma_{jbi})$$

and in which

γ_{jai} and γ_{jbi} are the decelerations of the ith measurement at speed v_j defined in 7.3.3 for each direction respectively, in metres per second squared;

s is the standard deviation, in metres per second squared, defined by the formula:

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (\Gamma_{ji} - \Gamma_j)^2}$$

t is the coefficient given by table 1.

7.3.5 Determine the total resistance F_j, at the speed v_j by the following formula using m and m_r defined in 7.2.5:

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

7.4 Total resistance curve determination

When the total resistance curve is considered useful, fit the following regression curve to the data sets (v_j, F_j) corresponding to all the speed points v_j (j = 1, 2, etc.) described in clause 5 to determine f_0, f_1 and f_2:

$$F = f_0 + f_1 v + f_2 v^2$$

where

F is the total resistance, in newtons;

f_0 is the constant term, in newtons;

f_1 is the coefficient of the first order term, in newtons hour per kilometre. f_1 may be assumed to be zero, if the value of $f_1 v$ is no greater than 3 % of F at the reference speed(s). In this case the function $F = f_0 + f_2 v^2$ shall be recalculated to determine the coefficients f_0 and f_2;

f_2 is the coefficient of the second order term, in newtons square hour per kilometre squared;

v is the vehicle speed, in kilometres per hour.

8 Measurement of running resistance by torquemeter method

As an alternative to the coastdown method, the torquemeter method may also be used, in which the running resistance is determined by measuring the torque as described in 8.1 to 8.3.

8.1 Installation of torquemeter

The torquemeter(s) shall be installed in the drive-train of the test vehicle.

It is preferable to have wheel torquemeters in each driven wheel.

8.2 Vehicle running and data sampling

8.2.1 Following preconditioning and stabilization of the vehicle at a speed v_j, where the running resistance is to be measured, the data collection may be started.

8.2.2 Record at least 10 data pairs of speed, torque and time over a period of at least 5 s.

8.2.3 The speed deviation from the mean speed shall be within the values in table 2.

Table 2

Time period s	Speed deviation km/h
5	± 0,2
10	± 0,4
15	± 0,6
20	± 0,8
25	± 1
30	± 1,2

8.3 Calculation of mean speed and mean torque

8.3.1 Calculate the mean speed v_{jm}, in kilometres per hour, and mean torque C_{jm}, in newton metres, over a time period as follows:

$$v_{jm} = \frac{1}{k} \sum_{i=1}^{k} v_{ji}$$

and

$$C_{jm} = \frac{1}{k} \sum_{i=1}^{k} C_{ji} - C_{js}$$

where

v_{ji} is the vehicle speed of ith data set, in kilometres per hour;

k is the number of data sets;

and

C_{ji} is the torque of ith data set, in newton metres;

C_{js} is the compensation term for the speed drift, in newton metres, which is given by the following formula. C_{js} shall be no greater than 5 % of the mean torque before compensation, and may be neglected if α_j is no greater than ± 0,005 m/s^2.

$$C_{js} = (m + m_r)\alpha_j r_j$$

in which

m and m_r are the test vehicle mass and the equivalent effective mass respectively, both in kilograms, defined in 7.2.5;

r_j is the dynamic radius of the tyre, in metres, given by the formula:

$$r_j = \frac{1}{3,6} \frac{v_{jm}}{2\pi N}$$

and in which

N is the rotational frequency of the driven tyre, in revolutions per second;

α_j is the mean acceleration, in metres per second squared, which shall be calculated by the formula:

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

and in which t_i is the time at which the ith data set was sampled, in seconds.

8.3.2 Carry out these measurements in both directions until a minimum of four consecutive figures have been obtained which satisfy the statistical accuracy P, in percent, below (but see 7.2.3):

$$P = \frac{ts}{\sqrt{n}} \times \frac{100}{\overline{C_j}} \leqslant 3\ \%$$

where

n is the number of pairs of measurement;

$\overline{C_j}$ is the running resistance at speed v_j, in newton metres, given by the formula:

$$\overline{C_j} = \frac{1}{n} \sum_{i=1}^{n} C_{jmi}$$

in which

C_{jmi} is the average torque of the ith pair of measurements at speed v_j, in newton metres, given by the formula:

$$C_{jmi} = \frac{1}{2} (C_{jmai} + C_{jmbi})$$

and in which

C_{jmai} and C_{jmbi} are the mean torques of the ith pair of measurements at speed v_j determined in 8.3.1 for each direction respectively, in newton metres;

s is the standard deviation, in newton metres, defined by the formula:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(C_{jmi} - \overline{C_j})^2}$$

t is the coefficient given by table 1.

8.3.3 The average speed, v_{jmi}, shall not deviate by more than $\pm$ 2 km/h from its mean, $\overline{v_j}$. v_{jmi} and $\overline{v_j}$ shall be calculated as follows:

$$\overline{v_j} = \frac{1}{n}\sum_{i=1}^{n} v_{jmi}$$

and

$$v_{jmi} = \frac{1}{2}(v_{jmai} + v_{jmbi})$$

where v_{jmai} and v_{jmbi} are the mean speeds of the ith pair of measurements at speed v_j determined in 8.3.1 for each direction respectively, in kilometres per hour.

8.4 Running resistance curve determination

The following regression curve shall be fitted to all the data pairs (v_{jm}, C_{jm}) for both directions at all speed points v_j (j = 1, 2, etc.) described in clause 5 to determine c_0, c_1 and c_2:

$$C = c_0 + c_1 v + c_2 v^2$$

where

c_0 is the constant term, in newton metres;

c_1 is the coefficient of the first order term, in newton metres hour per kilometre. c_1 may be assumed to be zero, if the value of $c_1 v$ is no greater than 3 % of C at the reference speed(s). In this case the function $C = c_0 + c_2 v^2$ shall be recalculated to determine the coefficients c_0 and c_2;

c_2 is the coefficient of the second order term, in newton metres hour squared per kilometre squared;

v is the vehicle speed, in kilometres per hour.

9 Correction to standard atmospheric conditions

9.1 Correction factors

9.1.1 Determine the correction factor for air resistance K_2 as follows:

$$K_2 = \frac{T}{293} \times \frac{100}{p}$$

where

T is the mean atmospheric temperature, in kelvins;

p is the mean atmospheric pressure, in kilopascals.

9.1.2 The correction factor, K_0, for rolling resistance, in reciprocal kelvins, may be determined based on the empirical data for the particular vehicle and tyre tests, or may be assumed as follows:

$$K_0 = 6 \times 10^{-3}\ \mathrm{K}^{-1}$$

9.2 Road load curve correction

9.2.1 Correct the coefficient of the fitting curve determined in 7.4 or 8.4 to reference conditions as follows:

$$f_0^* = f_0\{1 + K_0(T - 293)\}$$

$$f_1^* = f_1\{1 + K_0(T - 293)\}$$

$$f_2^* = K_2 f_2$$

or

$$c_0^* = c_0\{1 + K_0(T - 293)\}$$

$$c_1^* = c_1\{1 + K_0(T - 293)\}$$

$$c_2^* = K_2 c_2$$

where

f_0^* is the corrected constant term, in newtons;

f_1^* is the corrected coefficient of the first order term, in newtons hour per kilometre;

f_2^* is the corrected coefficient of the second order term, in newtons hour squared per kilometre squared;

c_0^* is the corrected constant term, in newton metres;

c_1^* is the corrected coefficient of the first order term, in newton metres hour per kilometre;

c_2^* is the corrected coefficient of the second order term, in newton metres hour squared per kilometre squared.

9.2.2 Determine the corrected road load as follows:

$$F_j^* = f_0^* + f_1^* v_j + f_2^* v_j^2$$

$$C_j^* = c_0^* + c_1^* v_j + c_2^* v_j^2$$

where

F_j^* is the corrected total resistance at speed v_j, in newtons;

C_j^* is the corrected running resistance at speed v_j, in newton metres.

9.3 Alternative correction method

As an alternative to the road load curve correction described in 9.2, the following formula may be used for the correction of total resistance at speed v_j when air resistance data are available:

$$F_j^* = K_2 R_{aj} + (F_j - R_{aj})\{1 + K_0(T - 293)\}$$

where R_{aj} is the air resistance at speed v_j, in newtons, measured in a wind tunnel.

This correction method shall not be applied to the torquemeter method.

10 Preparations for dynamometer test

10.1 Equipment and laboratory atmospheric conditions

10.1.1 The instrumentation for the speed and time measurements shall have the accuracy specified in 4.1. In the case of the torquemeter method, the torquemeter(s) shall be identical with that used on the road. In the case of chassis dynamometers with multiple rolls, the dynamometers shall be run in the same coupled or uncoupled state as the subsequent emission test, fuel economy test, etc., and the vehicle speed shall be measured from the roll coupled to the power absorption unit.

10.1.2 The chassis dynamometer rolls shall be clean, dry and free from anything which might cause tyre slippage.

10.1.3 The laboratory atmospheric temperature shall be within 293 K to 303 K inclusive.

10.2 Inertia mass setting

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

10.3 Preconditioning of chassis dynamometer

Precondition the chassis dynamometer in accordance with the manufacturer's recommendations or as appropriate. Usually 30 min at the highest reference speed is sufficient.

10.4 Tyre pressure adjustment

The tyre pressures shall be adjusted to that for the test. They shall correspond to those recommended for the range of vehicle speeds encountered during the subsequent emission test, fuel consumption test, etc. in conjunction with the roller geometry of the chassis dynamometer to be used. It is recommended that tyre pressures of 300 kPa be used with roller diameters of less than 500 mm.

10.5 Vehicle preconditioning

Prior to the test, the vehicle shall be driven on the chassis dynamometer for 15 min or until normal vehicle operating temperatures have been reached, under the prevailing laboratory ambient conditions. During this preconditioning, the vehicle speed shall not exceed the highest reference speed.

10.6 Target road load for dynamometer setting

The power absorption unit of the dynamometer shall be adjusted so that the corrected road loads obtained in 9.2.2 or 9.3 at all reference speeds are reproduced on the dynamometer.

11 Dynamometer setting by coastdown method

11.1 Initial setting of dynamometer

The dynamometer shall be set to an initial condition as appropriate. Some efficient procedures for the initial setting are described in annex C.

11.2 Verification

11.2.1 Immediately after the initial setting, measure the coastdown time on the dynamometer corresponding to all the reference speeds by the procedure in 7.1.1 to 7.2.3 omitting that in 7.2.2.

11.2.2 Repeat the measurement at least three times until the variation of coastdown time from the mean is less than 2 %.

11.2.3 Calculate the mean total resistance on the chassis dynamometer, F_c, in newtons, using the following formula:

$$F_c = \frac{1}{3,6}(m_i + m_d)\frac{2\Delta v}{\Delta T_c}$$

where

ΔT_c is the mean coastdown time, in seconds;

m_i is the equivalent inertia mass of the chassis dynamometer, in kilograms;

m_d is the equivalent effective mass of the wheels and vehicle component rotating with the wheels during coastdown on the chassis dynamometer, in kilograms. m_d may be measured or calculated by an appropriate technique. As an alternative m_d may be estimated as 1,5 % of the unladen vehicle mass.

11.2.4 The setting error, ε, in percent, is calculated as follows:

$$\varepsilon = \frac{F_c - F^*}{F^*} \times 100$$

where F^* is the corrected total resistance at each reference speed obtained in 9.2.2 or 9.3, in newtons.

11.2.5 Readjust the power absorption unit until the setting errors at all the reference speeds satisfy the criteria of the emission and fuel consumption test requirements. As an alternative, the following setting error criteria may be used:

$\varepsilon \leqslant 3$ % for $v_0 \geqslant 50$ km/h

$\varepsilon \leqslant 5$ % for 20 km/h $< v_0 < 50$ km/h

$\varepsilon \leqslant 10$ % for $v_0 \leqslant 20$ km/h

where v_0 is the reference speed, in kilometres per hour.

12 Dynamometer setting by torquemeter method

12.1 Initial setting of dynamometer

Following preconditioning, stabilize the vehicle on the dynamometer at the reference speed and adjust the power absorption unit so that the corrected running resistance is reproduced. Carry out this procedure at all reference speeds. In case of the dynamometer with coefficient control, an example of this procedure is described in annex D.

12.2 Verification

12.2.1 Immediately after the initial setting, drive the vehicle on the dynamometer at the reference speed and carry out the measurement with the procedure in 8.2.1 to 8.2.3, but using table 3 instead of table 2.

Table 3

Time period s	Speed deviation km/h
5	± 0,1
10	± 0,2
15	± 0,3
20	± 0,4
25	± 0,5
30	± 0,6

12.2.2 Determine the running resistance at the reference speed by the procedure in 8.3.1.

12.2.3 Repeat the measurement at least three times until the variation of torque from the mean is less than 2 %.

12.2.4 Calculate the setting error, ε, in percent, as follows:

$$\varepsilon = \frac{C_c - C^*}{C^*} \times 100$$

where

C_c is the mean running resistance measured on the dynamometer, in newton metres;

C^* is the corrected running resistance at the reference speed determined in 9.2.2 or 9.3, in newton metres.

12.2.5 Readjust the power absorption unit until the setting errors at all the reference speeds satisfy the criteria of the emission and fuel consumption tests. As an alternative, the following setting error criteria may be used:

$\varepsilon \leqslant 3$ % for $v_0 \geqslant 50$ km/h

$\varepsilon \leqslant 5$ % for 20 km/h $< v_0 < 50$ km/h

$\varepsilon \leqslant 10$ % for $v_0 \leqslant 20$ km/h

where v_0 is the reference speed, in kilometres per hour.

NOTE 2 Taking account of the difference in the dynamic tyre radius between on the road and on the dynamometer, this setting error criteria may not be identical to that in the coastdown method.