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BUREAU OF INDIAN STANDARDS

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भारतीय मानक **मसौदा**

ऑटोमोटिव वाहन — सड़क का निर्धारण — कोस्ट डाउन टेस्ट विधि द्वारा स्थिरांक लोड

(*पहला पुनरीक्षण*)

Draft *Indian Standard*

AUTOMOTIVE VEHICLES — DETERMINATION OF ROAD LOAD CONSTANTS BY COAST DOWN TEST METHOD

(*First Revision*)

ICS 43.040

Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee, TED 04	**Last date for receipt of comments is 09/07/2024**

FOREWORD

(Formal Clause to be added later)

This standard was first published in 2000. In this road-load constants of an automotive vehicle are needed for evaluation of the performance of an automotive vehicle such as fuel consumption, emission, etc. on a chassis dynamometer. These constants are used to determine the load on the chassis dynamometer to simulate the power needed to propel the vehicle at different speeds as per the appropriate driving cycle.

This standard has been prepared with a view to have a uniform procedure to be followed by the automobile manufacturers as well as the testing laboratories who at present in the absence of this standard have evolved their own practices for evaluating these constants.

The composition of the Committee responsible for formulating this standard is given in Annex A (Will be added later)

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2: 2022 'Rules for rounding off numerical values (*second revision*)'. This shall be given in standards on methods of test, Sampling, code of practice, etc.

Draft *Indian Standard*

AUTOMOTIVE VEHICLES —DETERMINATION OF ROAD—LOAD CONSTANTS BY COAST DOWN TEST METHOD

(first revision)

(Part -1)

ROAD TESTS OF L2-CATEGORY VEHICLES EQUIPPED WITH ONE WHEEL ON THE DRIVEN AXLE OR WITH TWINNED WHEELS FOR THE DETERMINATION OF TEST BENCH SETTINGS.

1 SCOPE

This part is applicable to motor vehicles of category L_2 as defined in IS 14272 as amended from time to time, equipped with positive ignition engines, compression ignition engines including hybrids electric vehicles for Bharat Stage VI.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 10278 : 2018	Under revision as draft TED 4 (10235) W of Oct, 2016 - Motorcycles – Method of measurement of maximum speed
IS 11422 : 2006	Terms and definitions of weights of Two wheeled motor vehicles
IS 14272 : 2011	Automotive Vehicles — Types — Terminology (*First Revision*)
AIS-000:2013	Administrative Procedure to deal with Corrigendum, Amendments or Revisions to AIS, TAP 115 /116, CMVR Notifications, IS and ISO standards, which are notified under CMVR
AIS-017:2000	Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules.

3 DEFINITIONS

3.1 'Axle' means the common axis of rotation of two or more wheels whether power driven or freely rotating, and whether in one or more segments located in the same plane perpendicular to the longitudinal centre-line of the vehicle;

3.2 'Compression Ignition engine' or 'CI engine' means a combustion engine working according to the principles of the 'Diesel' cycle;

3.3 'Fuel tank' means a type of energy storage system that stores the fuel;

3.4 'Sensor' means a converter that measures a physical quantity or state and converts it into an electric signal that is used as input to a control unit;

3.5 'Reference mass' means the mass in running order/unladen mass as determined in accordance with IS 11422 as amended by time to time, increased with the mass of the rider (75 kg) and if applicable plus the mass of the propulsion battery.

4 SPECIFICATION

4.1 General requirements This part establishes the administrative and technical requirements for the type-approval of new types of vehicles, systems, components and separate technical units referred to in clause 1 of this part.

4.2 However, the test requirements are not applicable in petrol mode for a vehicle in the scope of this part that is designed primarily for permanent running on gaseous fuel, having a petrol system, with a petrol fuel tank capacity not exceeding two liters in the case of vehicles of L_2 category, intended for emergency purposes or starting only or limp home mode.

4.3 L_2 category of vehicles shall be manufactured to comply with the requirements specified in the notification throughout the useful life specified therein when maintained as per the recommendations of the vehicle manufacturer. This requirement shall be deemed to be satisfied when the vehicles are tested for specified tests as per the procedures mentioned in this part.

4.4 For the purpose of classification of vehicle for deciding the applicable test cycle and weighting factors as defined in the notification, the maximum speed shall be taken as the maximum speed declared by the manufacturer. However, in case of border line cases, testing agencies may decide to measure the maximum speed which shall be, when tested as per IS 10278 as amended from time to time, within the tolerance specified in the standard.

Note: Till such time the standard is finalized, test shall be carried out as per IS: 10278-2009 and measured max speed shall be within + 5%.

5 REQUIREMENT FOR THE ROAD AND AMBIENT CONDITIONS

5.1 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 of the surface shall not exceed 0.5 percent between any two points at least 2m apart.

5.2 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 coast-down is representative.

5.3 The ambient conditions shall be within the following limits:

a) maximum wind speed: 3 m/s;
b) maximum wind speed for gusts: 5 m/s;
c) average wind speed, parallel: 3 m/s;
d) average wind speed, perpendicular: 2 m/s;
e) maximum relative humidity: 95 percent; and
f) air temperature: 278.2 K to 308.2 K.

5.4 Standard ambient conditions shall be as follows:

a) pressure, P_0: 100 kPa;
b) temperature, T_o: 293.2 k;
c) relative air density, D_o: 0.9197; and
d) air volumetric mass, ρ_o: 1.189 kg/m^3

The relative air density, d_T shall be calculated using the following formula:

Equation 1:

$$d_T = \frac{d_o . P_t . T_o}{P_o . T_t}$$

where:

D_o is the reference relative air density at reference conditions (1.189 kg/m^3)
P_t is the mean ambient pressure during the test, in kPa;
P_o is the reference ambient pressure (101.3 kPa);
T_t is the mean ambient temperature during test, in K; and
T_o is the reference ambient temperature 293.20 K/20˚C

6 REQUIREMENTS FOR THE RIDER

6.1 The rider shall wear a well-fitting (one-piece) suit or similar clothing and a protective helmet, eye protection, boots and gloves.

6.2 The rider, dressed and equipped as described in **1.1** of this part, shall have a mass of 75 kg ± 5 kg and be 1.75 ± 0.05 m tall.

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

7 CONDITION OF TEST VEHICLE

7.1 Running-in

The test vehicle shall be in normal running order and adjustment after having been run in for at least 300 km. The tyres shall be run in at the same time as the vehicle or shall have a tread depth within 90 and 50 percent of the initial tread depth, the same to be declared by the manufacturer**.**

7.2 Checks

The following checks shall be made in accordance with the manufacturer's specifications for the use considered: wheels, wheel rims, tyres (make, type and pressure), front axle geometry, brake adjustment (elimination of parasitic drag), lubrication of front and rear axles, adjustment of the suspension and vehicle ground clearance, etc. Check that during freewheeling, there is no electrical braking.

7.3 Preparation for the test

7.3.1 The test vehicle shall be loaded to its test mass including rider and measurement equipment, spread in a uniform way in the loading areas.

7.3.2 The windows of the vehicle shall be closed. Any covers for air conditioning systems, headlamps, etc. shall be closed.

7.3.3 The test vehicle shall be clean, properly maintained and used.

7.3.4 Immediately before the test, the vehicle shall be brought to the normal running temperature in an appropriate manner.

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

8 SPECIFIED COAST-DOWN SPEEDS

8.1 The coast-down times must be measured between V_1 and V_2 as specified in Table 1 of this part, depending on the vehicle class.

8.1.1 The test can be executed at V_1 ± 5 km/h, provided that the coast-down time accuracy referred in 8.1.2 is ensured.

8.1.2 Measurement accuracies: Measurements shall be taken using equipment that full fills the accuracy requirements.

Required Accuracy of Measurements

Sl.No	Measurement Items	At measured values	Resolution
(1)	(2)	(3)	(4)
i)	a) Running Resistance force, F	+ 2 Percent	—

ii)	b) Vehicle Speed (V_1,V_2)	± 1 Percent	0.2 km/h
iii)	c) Coast-down speed interval $2\Delta v = (V_1 - V_2)$	± 1 Percent	0.2 km/h
iv)	d) Coast-down time Δt	± 0.5 Percent	0.01 s
v)	e) Total vehicle mass ($m_{ref} + m_{rid}$)	± 0.5 Percent	1.0 kg
vi)	f) Wind speed	± 10 Percent	0.1 m/s
vii)	g) Wind direction	—	5 deg.
viii)	h) Temperatures	± 1 k	1 k
ix)	i) Barometric pressure	—	0.2 kPa
x)	j) Distance	± 0.1 Percent	1 m
xi)	k) Time	± 0.1 s	0.1 s

Table 1 Coast-down time measurement beginning speed and ending speed 45 km/h < maximum design speed ≤ 130 km/h and > 130 km/h

(*Clause* 8.1)

Sl.No	**Specified target vehicle speed** (V_1, km/h)	V_1 in km/h	V_2 in Km/h
(1)	(2)	(3)	(4)
i)	120	130*/	110
ii)	100	110*/	90
iii)	80	90*/	70
iv)	60	70	50
v)	40	45	35
vi)	20	25	15

9 MEASUREMENT OF COAST-DOWN TIME

9.1 After a warm-up period, the vehicle shall be accelerated to the coast-down starting speed, at which point the coast- down measurement procedure shall be started.

9.2 Since shifting the transmission to neutral can be dangerous and complicated by the construction of the vehicle, the coasting may be performed solely with the clutch disengaged. Vehicles that have no means of cutting the transmitted engine power off prior to coasting may be towed until they reach the coast-down starting speed. When the coast down test is reproduced on the chassis dynamometer, the drive train and clutch shall be in the same condition as during the road test.

9.3 The vehicle steering shall be altered as little as possible and the brakes shall not be operated until the end of the coast-down measurement period.

9.4 The first coast-down time Δ_{tai} measured in seconds corresponding to the specified speed v_j shall be measured as the time taken for the vehicle to decelerate from $v_j+\Delta$ v to $v_j-\Delta v$.

9.5 The procedure described in clauses **5.1** to **5.4** of this part shall be repeated in the opposite direction to measure the second coast-down time Δ_{tbi}

9.6 The average Δ_{ti} of the two coast-down times Δ_{tai} and Δ_{tbi} shall be calculated using the following equation:

Equation 2

$$\Delta_{ti} = \frac{\Delta_{tai} + \Delta_{tbi}}{2}$$

9.7 At least four (consecutive valid) tests shall be performed and the average coast-down time $\Delta\ t_j$ calculated using the following equation:

Equation 3

$$\Delta t_j = \frac{1}{n} * \sum_{i=1}^{n} \Delta t_i$$

9.8 Tests shall be performed until the statistical accuracy P is equal to or less than 3 percent (P ≤3 percent). The statistical accuracy P (as a percentage) is calculated using the following equation:

Equation 4

$$p = \frac{t*s}{\sqrt{n}} * \frac{100}{\Delta t_j}$$

where:

t is the coefficient given in Table 2 of this part; and
s is the standard deviation given by the following formula:

Equation 5

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

where:

n is the number of tests.

Table 2 Coefficients for statistical accuracy
(*Clause* 9.8)

Sl.No	n	t	$\frac{t}{\sqrt{n}}$
(1)	(2)	(3)	(4)
i)	4	3.2	1.6
ii)	5	2.8	1.25
iii)	6	2.6	1.06
iv)	7	2.5	0.94
v)	8	2.4	0.85
vi)	9	2.3	0.77
vii)	10	2.2	0.73
viii)	11	2.2	0.66
ix)	12	2.2	0.64
x)	13	2.2	0.61
xi)	14	2.2	0.59
xii)	15	2.2	0.57

9.9 In repeating the test, care shall be taken to start the coast-down after observing the same warm-up procedure and at the same coast-down starting speed.

9.10 The coast-down times for multiple specified speeds may be measured in a continuous coast-down. In this case, the coast-down shall be repeated after observing the same warm-up procedure and at the same coast-down starting speed.

9.11 The coast-down time shall be recorded. A specimen record form is given in the Regulation for administrative requirements.

10 DATA PROCESSING

10.1 Calculation of running resistance force

10.1.1 The running resistance force F_j, in Newton, at the specified speed V_1 shall be calculated using the following equation:

Equation 6

$$F_j = \frac{1}{3.6} * m_{ref} * \frac{2*\Delta v}{\Delta t}$$

where:

m_{ref} = reference mass (kg);
Δv = vehicle speed deviation (km/h); and
Δt = calculated coast down time difference (s)

10.1.2 The running resistance force F_j shall be corrected in accordance with **10.2** of this part.

10.2 Running resistance curve fitting

The running resistance force, F, shall be calculated as follows:

10.2.1 The following equation shall be fitted to the data set of F_j and v_j obtained in **4** and **6.1** of this Annex respectively by least squares statistical regression analysis to determine the coefficients F_0 and F_2

Equation 7

$$F = F_0 + F_2 * v^2$$

10.2.2 The coefficients F_0 and F_2 thus determined shall be corrected to the standard ambient conditions using the following equations:

Equation 8

$$F^*_0 = F_0 = [1 + K_0(T_T - T_0)]$$

Equation 9

$$F^*_0 = F_2 * \frac{T_T}{T_o} * \frac{P_o}{P_T}$$

K_0 shall be determined on the basis of the empirical data for the particular vehicle and tyre tests or shall be assumed as follows, if the information is not available:

$$K_0 = 6 * 10^{-3} K^{-1}$$

10.3 Target running resistance force F* for chassis dynamometer setting

The target running resistance force $F^*(V_0)$ on the chassis dynamometer at the reference vehicle speed v_0, in Newton, is determined using the following equation:

Equation 10

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

(Part 2)

RESISTANCE TO PROGRESS OF A VEHICLE MEASUREMENT METHOD ON THE ROAD-SIMULATION ON A CHASSIS DYNAMOMETER

1 SCOPE

This part of the standard is applicable for three wheeled motor vehicles of category L_5 as defined in AIS-053 / IS 14272 as amended from time to time, equipped with positive ignition engines, compression ignition engines including hybrids electric vehicles for Bharat Stage VI.

This Chapter describes the methods to measure the resistance to the progress of a vehicle at stabilized speeds on the road and to simulate this resistance on a chassis dynamometer with adjustable load curves.

2 REFERENCE STANDARDS

IS No.	*Title*
IS 9211:2003	Specification for Terms and Definitions of Weights of Road Vehicles
IS 14272 : 2011	Automotive Vehicles — Types — Terminology (*First Revision*)
IS 14785: 2000	Automotive Vehicles - Determination of Road-load Constants by Coast down Test Method
AIS-053:2005	Automotive Vehicles – Types – Terminology.
AIS-000:2013	Administrative Procedure to deal with Corrigendum, Amendments or Revisions to AIS, TAP 115 /116, CMVR Notifications, IS and ISO standards, which are notified under CMVR.
AIS-017:2000	Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules
AIS-102 (Part 1)	CMVR Type Approval for Hybrid Electric Vehicles

3 DEFINITIONS

3.1 'Compression Ignition engine' or 'CI engine' means a combustion engine working according to the principles of the 'Diesel' cycle;

3.2 'Driving cycle' means a test type I cycle consisting of engine key-on, driving mode where a malfunction would be detected if present, and engine key -off;

3.3 'Drive train' means the part of the powertrain downstream of the output of the propulsion unit(s) that consists if applicable of the torque converter clutches, the transmission and its control, either a drive shaft or belt drive or chain drive, the differentials, the final drive, and the driven wheel tyre (radius);

3.4 'Fuel tank' means a type of energy storage system that stores the fuel;

3.5 'Propulsion' means a combustion engine, an electric motor, any hybrid application or a combination of those engine types or any other engine type;

3.6 'Reference mass' means the mass in running order /unladen mass as determined in accordance with IS 11422 as amended by time to time, increased with the mass of the rider (75 kg) and if applicable plus the mass of the propulsion battery; and

3.7 'Unladen mass (kerb mass)' means the mass of the vehicle in running order without crew, passengers or load, but with the fuel tank 90 percent full and the usual set of tools and spare wheel on board where applicable. In the case of 3 wheeled tractors, designed for coupling to a
semi-trailer, the unladen mass will be that of the drawing vehicle**.**

4 REQUIREMENTS

4.1 This part of the standard establishes the administrative and technical requirements for the type-approval of new types of vehicles, systems, components and separate technical units referred to in above clause 1 of this part.

4.2 However, the test requirements are not applicable in petrol mode for a vehicle in the scope of this part that is designed primarily for permanent running on gaseous fuel, having a petrol system, with a petrol fuel tank capacity not exceeding three liters in the case of vehicles of L_5 category, intended for emergency purposes or starting only or limp home mode.

4.3 The vehicles shall be manufactured to comply with the requirements specified in BSVI emission norms throughout the useful life specified therein when maintained as per the recommendations of the vehicle manufacturer. This requirement shall be deemed to be satisfied when the vehicles are tested for specified tests as per the procedures mentioned in this part.

5 DEFINITION OF THE ROAD

5.1 The road shall be level and sufficiently long to enable the measurements specified below to be made. The longitudinal slope shall not exceed 1.5 percent and shall be constant within ± 0.1 percent over the measuring strip.

5.2 Atmospheric conditions

5.2.1 *Wind* — Testing shall be limited to wind speeds averaging less than 3 m/s with peak speeds less than 5 m/s. In addition, the vector component of the wind speed across the test road shall be less than 2 m/s. Wind velocity should be measured 0.7 m above the road surface.

5.2.2 *Humidity* — The road shall be dry**.**

5.2.3 *Pressure-Temperature* — Air density at the time of the test shall not deviate by more than ± 7.5 percent from the reference conditions:

P = 100 kPa & T = 293.2 K (20°C)

6 VEHICLE PREPARATION:

6.1 Verifications — The following verifications shall be made in accordance with the manufacturer's specifications for the use considered:

a) wheel, wheel rims, tyres (make, type, pressure);
b) front axle geometry;
c) brake adjustment (elimination of parasitic drag);
d) lubrication of front and rear axles; and
e) adjustment of the suspension and vehicle level, etc.

6.1.1 *Run-in*

The vehicle shall be presented in good mechanical condition, properly maintained and used. It shall have been run in and driven at least 1000 km before the test. The engine, drive train and vehicle shall be properly run in, in accordance with the manufacturer’s requirements.

Note: If the manufacturer has carried out the run-in on a chassis dynamometer where the odometer does not get operated, a declaration by the manufacturer will be sufficient for the compliance to this clause. However, the test agency may seek for log data by the manufacturer.

6.2 Preparation for the test – The vehicle shall be loaded to its reference mass. The level of the vehicle shall be that obtained when the centre of gravity of the load is situated midway between the "R" points of the front outer seats and on a straight line passing through those points.

6.2.1 In case of road tests, the windows of the vehicle shall be closed. Any covers of air acclimatization systems, headlamps, etc., shall be in the non-operating position.

6.2.2 The vehicle shall be clean.

6.2.3 Immediately prior to the test the vehicle shall be brought to normal running temperature in an appropriate manner.

7 METHODS FOR CHASSIS DYNAMOMETER WITH ADJUSTABLE LOAD CURVE

7.1 Energy variation during coast-down method:

7.1.1 On the road

7.1.1.1 Accuracies of test equipment Time shall be measured accurate to within 0.1 second. Speed shall be measured accurate to within 2 percent.

7.1.1.2 *Test procedure*

7.1.1.2.1 Accelerate the vehicle to a speed of 10 km/h greater than the chosen test speed, V.

7.1.1.2.2 Place the gear box in "neutral" position.

7.1.1.3 Measure the time taken (t_1) for the vehicle to decelerate from V_2= V + ΔV km/h to V_1 = V - ΔV km/h with 3 ≤ V 5 km/h.

7.1.1.4 Perform the same test in the opposite direction t_2

7.1.1.5 Take the arithmetic mean T, of the two times t_1 and t_2 Refer Equation 1 of this Annex for Average T.

7.1.1.6 Repeat these tests several times such that the statistical accuracy (p) of the arithmetic Mean is not more than 2 Percent (p ≤ 2 percent)

$$T=\frac{1}{n}\sum_{i=1}^{n} t_1$$

The statistical accuracy (p) is defined by:

$$P = \frac{t*s}{\sqrt{n}} * \frac{100}{T}$$

where,

t = coefficient given by the table below `

s = standard deviation

$$\sqrt{\sum \frac{(T_i - T)^2}{n-1}}$$

n = number of tests

n	4	5	6	7	8	9	10	11	12	13	14	15
T	3.2	2.8	2.6	2.5	2.4	2.3	2.2	2.2	2.2	2.2	2.2	2.2
$\frac{t}{\sqrt{n}}$	1.6	1.25	1.06	0.94	0.85	0.77	0.73	0.66	0.64	0.61	0.59	0.57

7.1.1.7 Calculate the power by the formula:

$$P = \frac{m * V * \Delta V}{500 * T}$$

where,

P is expressed in kW
V = speed of the test in m/s
ΔV = speed deviation from speed V, in m/s
m = reference mass in kg
T = time in seconds

7.1.2 *On the chassis dynamometer:*

7.1.2.1 Measurement equipment and accuracy: The equipment shall be identical to that used on the road.

7.1.2.2 *Test procedure*

7.1.2.2.1 Install the vehicle on the test dynamometer.

7.1.2.2.2 Adjust the tyre pressure (cold) of the driving wheels as required by the chassis dynamometer.

7.1.2.2.3 Adjust the equivalent inertia of the chassis dynamometer.

7.1.2.2.4 Bring the vehicle and chassis dynamometer to operating temperature in a suitable manner.

7.1.2.2.5 Carry out the following operations specified in **7.1.1.2** of this Annex with the exception of **7.1.1.2.4** and **7.1.1.2.5** of the Annex and with changing m by I in the formula of **7.1.1.2.7** of this Annex above.

7.1.2.2.6 Adjust the chassis dynamometer such that It shall be possible to measure and read the indicated load to an accuracy of ± 5 percent.

7.2 Torque measurements method at constant speed

7.2.1 On the road

7.2.1.1 *Measurement equipment and error*

Torque measurement shall be carried out with an appropriate measuring device, accurate to within 2 percent. Speed measurement shall be accurate to within 2 percent.

7.2.1.2 *Test procedure*

7.2.1.2.1 Bring the vehicle to the chosen stabilized speed, V.

7.2.1.2.2 Record the torque C(t) and speed over a period t (of at least 10s) by means of class 1000 instrumentation meeting [ISO standard No. 970], over small intervals of time t.

7.2.1.2.3 Differences in torque C(t), and speed relative to time shall not exceed 5percent for each second of the measurement period. The torque C is the average torque derived from the following formula:

$$C_{t1} = \frac{1}{\Delta t} \int_{t}^{t+\Delta t} C(t)\, dt$$

7.2.1.2.4 Carry out the test in the opposite direction and find out the average torque i.e. C_t.

7.2.1.2.5 Determine the average of these torques C_{t1} and C_{t2} i.e. C_t

7.2.2 On the chassis dynamometer

7.2.2.1 *Measurement equipment and error* — The equipment shall be identical to that used on the road.

7.2.2.2 *Test procedure*

7.2.2 On the chassis dynamometer

7.2.2.1 *Measurement equipment and error* — The equipment shall be identical to that used on the road.

7.2.2.2 *Test procedure*

7.2.2.2.1 Perform the operations specified in clauses **7.1.2.2.1** to **7.1.2.2.4** of this Annex above.

7.2.2.2.2 Adjust the chassis dynamometer such that It shall be possible to measure and read the indicated load to an accuracy of ± 5 percent.

7.3 Integrated torque over vehicle driving pattern

7.3.1 This method is a non-obligatory complement to the constant speed method described in **4.2** above.

7.3.2 In this dynamic procedure the mean torque value M is determined. This is accomplished by integrating the actual torque values, M (t), with respect to time during operation of the test vehicle with a defined driving cycle. The integrated torque is then divided by the time difference $t_2 - t_1$

The result is:

$$\bar{M} = \frac{1}{t_1 - t_2} \int_{t_2}^{t_1} M(t)dt - - - - (\text{with M(t)} > 0)$$

M is calculated from 6 sets of results.

It is recommended that the sampling rate of $\bar{M}$ be not less than two samples per second.

7.3.3 *Dynamometer setting* - The dynamometer load is set by the method described in **4.2** above. If M (dynamometer) does not match M (road) then the inertia setting shall be adjusted until the values are equal within ± 5 percent.

Note: This method can only be used for dynamometers with electrical inertia simulation or fine adjustment.

7.3.3.1 *Acceptance criteria*

Standard deviation of 6 measurements shall be less than or equal to 2 percent of the mean value.

7.4 Method by deceleration measurement by gyroscopic platform

7.4.1 *On the road*

7.4.1.1 Measurement equipment and accuracy:

a) Speed shall be measured with accuracy better than 2 percent;
b) Deceleration shall be measured with accuracy better than 1 percent;
c) The slope of the road shall be measured with accuracy better than 1percent;
d) Time shall be measured with accuracy better than 0.1 s; and
e) The level of the vehicle is measured on a reference horizontal ground: as an alternative, it is possible to correct for the slope of the road (a1).

7.4.1.2 *Test procedure*

7.4.1.2.1 Accelerate the vehicle to a speed 5 km/h greater than the chosen test speed V.

7.4.1.2.2 Record the deceleration between V + 0.5 km/h and V - 0.5 km/h.

7.4.1.2.3 Calculate the average deceleration attributed to the speed V by the formula:

$$\overline{Y_1} = \frac{1}{t} \int_0^t Y_1(t)dt - (g.sina_1)$$

where:

Y_1 = average deceleration value at the speed V in one direction of the road
t = time between V + 0.5 km/h and V - 0.5 km/h
$Y_1(t)$ = deceleration recorded with the time
g = 9.81 m/s².

7.4.1.2.4 Perform the same test in the other direction Y_2

7.4.1.2.5 Calculate the average deceleration i.e.

$$Y_1 = \frac{Y_1 - Y_2}{2}$$ ------- for Test I

7.4.1.2.6 Perform a sufficient number of tests as specified in clause **7.1.1.2.6** of this Annex replacing T by γ where

$$\gamma = \frac{1}{n}\sum_{i=1}^{n} Y_t$$

7.4.1.2.7 Calculate the average force absorbed

$$F = m*\gamma,$$

Where,

m = vehicle reference mass in kg.
γ = average deceleration calculated as above.

7.4.2. On the chassis dynamometer

7.4.2.1 Measuring equipment and accuracy. The measurement instrumentation of the chassis dynamometer itself shall be used as defined in clause **7.1.2.1** of this Annex.

7.4.2.2 Test procedure Adjustment of the force on the rim under steady speed. On chassis dynamometer, the total resistance is of the type:

$$F_{Total} = F_{indicated} + \text{axle rolling with}$$

$$F_{Total} = F_{road}$$

$$F_{indicated} = F_{road} \text{ axle rolling}$$

Where:

$F_{indicated}$ is the force indicated on the force indicating device of the chassis dynamometer. $F_{(road)}$ is known.

33F driving axle rolling can be measured on chassis dynamometer driving axle rolling able to work as generator. The test vehicle, gear box in neutral position, is driven by the dynamometer at the test speed; the rolling resistance, RR, of the driving axle is then measured on the force indicating device of the chassis dynamometer.

Determination on chassis dynamometer unable to work as a generator.

For the two-roller chassis dynamometer, the RR value is the one which is determined before on the road.

For the single-roller chassis dynamometer, the RR value is the one which is determined on the road multiplied by a coefficient R which is equal to the ratio between the driving axle mass and the vehicle total mass.

Note: R_R is obtained from the curve F = f (V).

7.4.2.2.1 Calibrate the force indicator for the chosen speed of the roller bench as defined in Annex 3 of this chapter.

7.4.2.2.2 Perform the same operation as in clauses **7.1.2.2.1** to **7.1.2.2.4** of this Annex above.

7.4.2.2.3 Set the force, FA = F - FR on the indicator for the speed chosen.

7.4.2.2.4 Carry out a sufficient number of tests as indicated in clause **7.1.1.2.6** of this Annex above, replacing T by FA.

7.5 Deceleration method applying coast-down technique

7.5.1 *On the Road*

7.5.1.1 *Accuracies of test equipment* – Time shall be measured accurate to within 0.1 second. Speed shall be measured accurate to within 2 percent.

7.5.1.2 Drive the vehicle at a constant speed of about 10 km/h more than the chosen test speed, Vkm/h, along a straight line.

7.5.1.3 After this speed is held steady for a distance of at least 100 m, disconnect the engine from the drive line by bringing the gear to neutral or by other means in the case of vehicle where manual shifting to neutral is not possible.

7.5.1.4 Measure the time taken ($t_1$sec) for the speed to drop from V + ΔV km/h to V – ΔVkm/h.

The value of ΔV shall not be less than 1 km/h or more than 5 km/h. However, same value of ΔV shall be used for all the tests.

7.5.1.5 Repeat the test in the opposite direction and record the time (12 sec.)

7.5.1.6 Repeat the test 10 times such that the statistical error of the time t_1 (arithmetic average of t_1 and 12) is equal to or less than 2 percent.

7.5.1.7 The statistical error 'p' is calculated as –

Equation 9

$$p = \frac{24.24*(t_1 - t_m)^2}{t_m}$$

Where
t = average time for each consecutive set of reading, $(t_1 + t_2)/2$
t_m = Arithmetic average of 10 such t_1

7.5.1.8 The basic equation of motion to calculate the road load resistance force, F, is

Equation 10

$$F = \frac{(W+W_2)*V}{(3.6*t_m*g)}$$

Where

F - in N

W — the weight of the test vehicle in N
W_2— equivalent inertia weight of rotating axle (0.035 x mass of the test vehicle) in N
V — vehicle speed difference during the coast down, in km/h
t_m— coast down time, in seconds
g — Acceleration due to gravity, 9.81 m/s².

7.5.1.9 Using least square curve fitting method and values of F and V, the coefficient of rolling and aerodynamic resistance of the vehicle viz. a and b respectively are found from the following equation:

$$F = a + b^{*}V^{2}$$

7.5.2 *Chassis Dynamometer Setting* — The values of a and b are set on the dynamometer.

7.5.3 *Validity of the equation*

7.5.3.1 The above road-load equation can be extrapolated up to speeds 20 percent above the highest speed at which test has been conducted.

7.5.3.2 If the value of 'a' so obtained can be extrapolated for load conditions other than the test load, this can be done for loads up to + 10 percent of the test load with following correction:

$$a_{desired} = a_{tested} \times \frac{\text{Test Load}_{\text{desired}}}{\text{Test load}_{\text{tested}}}$$

7.6 Alternative method

With the manufacturer's agreement, Power absorption table method provided in Annex 5 of This chapter may be used. The brake is adjusted so as to absorb the load exerted at the driving wheels at constant speed of 50 km/h in accordance with table I of Annex 5 of this chapter.

(Part 3)

MEASUREMENT OF VEHICLE ROAD LOAD RESISTANCE TO PROGRESS OF A VEHICLE MEASUREMENT METHOD ON THE ROAD SIMULATION ON A CHASSIS DYNAMOMETER.

1 Scope

1.1 This part applies to the emission of vehicles equipped with positive-ignition engines including hybrids and compression - ignition engines including hybrids for all M and N category vehicles with GVW up to 3 500 kg for Bharat Stage VI.

1.2 It shall apply to vehicles of categories M1, M2, N1 and N2 with a reference mass not exceeding 2 610 kg. At the manufacturer's request, type approval granted under this Part maybe extended from vehicles mentioned above to M1, M2, N1 and N2 vehicles with a reference mass not exceeding 2 840 kg and which meet the conditions laid down in this Part.

1.3 The object of the methods defined below is to measure the resistance to progress of a vehicle at stabilized speeds on the road and to simulate this resistance on a dynamometer.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS/ISO No.	*Title*
ISO 28580:2018	Passenger car, truck and bus tyre rolling resistance measurement method Single point test and correlation of measurement results
AIS-142: 2019	Evaluation of Tyres with Regard to Rolling Sound Emissions and/or to Adhesion on Wet Surfaces and/or to Rolling Resistance

2 DEFINITIONS

2.1 Road – The road shall be level and sufficiently long to enable the measurements specified in this Annex to be made. The longitudinal slope shall be constant to within ± 0.1% and shall not exceed 1.5%.

2.2 Reference mass – means the "unladen mass" of the vehicle increased by a uniform figure of 150 kg.

2.3 Unladen mass – means the mass of the vehicle in running order without the uniform mass of the driver of 75 kg, passengers or load, but with the fuel tank 90 % full and the usual set of tools and spare wheel on board, where applicable;

2.4 Gross Vehicle Weight (GVW) – means the technically permissible maximum weight declared by the vehicle manufacturer.

3 ATMOSPHERIC CONDITIONS

3.1 Wind

Testing shall be limited to wind speeds averaging less than 3 m/s with peak speeds of less than 5 m/s. In addition, the vector component of the wind speed across the test road shall be less than 2 m/s as average. Wind velocity shall be measured 0.7 m above the road surface.

3.2 Humidity

The road shall be dry.

3.3 Pressure and Temperature

Air density at the time of the test shall not deviate by more than ±7.5% from the reference conditions, P = 100 kPa and T = 293.2 K.

4 VEHICLE PREPARATION

4.1 Selection of the test vehicle

If not all variants of a vehicle type are measured, the following criteria for the selection of the test vehicle shall be used.

4.1.1 *Body*

If there are different types of body, the test shall be performed on the least aerodynamic body. The manufacturer shall provide the necessary data for the selection (Physical test / CAE data).

4.1.2 *Tyres*

The choice of tyres shall be based on the rolling resistance. The tyres with the highest rolling resistance shall be chosen, measured according to ISO 28580 or AIS-142 or UN R117.

If there are more than three tyre rolling resistances, the tyre with the second highest rolling resistance shall be chosen.

The rolling resistance characteristics of the tyres fitted to production vehicles shall reflect those of the tyres used for type approval.

4.1.3 *Testing mass*

The testing mass shall be the reference mass of the vehicle with the highest inertia range.

4.1.4 *Engine*

The test vehicle shall have the largest heat exchanger(s).

4.1.5 *Transmission*

A test shall be carried out with each type of the following transmission:

a) Front-wheel drive;
b) Rear-wheel drive;
c) Full-time 4 x 4;
d) Part-time 4 x 4;
e) Automatic gearbox, and
f) Manual gearbox.

4.2 Running-in

The vehicle shall be in normal running order and adjustment after having been run-in for at least 3,000 km. The tyres shall be run-in at the same time as the vehicle or have a tread depth within 90 and 50% of the initial tread depth.

4.3 Verifications

The following checks shall be made in accordance with the manufacturer's specifications for the use considered:

Wheels, wheel trims, tyres (make, type, pressure), front axle geometry, brake adjustment (elimination of parasitic drag), lubrication of front and rear axles, adjustment of the suspension and vehicle level, etc.

4.4 Preparation for the test

4.4.1 The vehicle shall be loaded to its reference mass. The level of the vehicle shall be that Obtained when the centre of gravity of the load is situated midway between the "R" points of the front outer seats and on a straight line passing through those points.

4.4.2 In the case of road tests, the windows of the vehicle shall be closed. Any covers of air climatisation systems, headlamps, etc. shall be in the non-operating position.

4.4.3 The vehicle shall be clean.

4.4.4 Immediately prior to the test, the vehicle shall be brought to normal running temperature In an appropriate manner.

5 METHODS

5.1 Energy variation during coast-down method

5.1.1 *On the road*

5.1.1.1 *Test equipment and error*

Time shall be measured to an error lower than ± 0.1 s. Speed shall be measured to an error lower than ± 2%.

During the test, elapsed time and vehicle speed shall be measured and recorded at a minimum frequency of 1Hz

5.1.1.2 *Test procedure*

5.1.1.2.1 Accelerate the vehicle to a speed 10 km/h higher than the chosen test speed V.

5.1.1.2.2 Place the gearbox in "neutral" position.

5.1.1.2.3 For each reference speed Point V_j, measure the time taken (ΔT_{aj}) for the vehicle to decelerate from speed.

$$V_2 = V_j + \Delta \text{ km/h to } V_1 = V_j - \Delta \text{ km/h}$$

where

Δv is equal to 5 km/h

V_j is each of the reference speed [km/h] points as indicated in the following table:

20	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**

5.1.1.2.4 Perform the same test in the opposite direction: ΔT_{bj}

5.1.1.2.5 These measurements shall be carried out in opposite directions until, for each reference speed v_j a minimum of three consecutive pairs of measurements have been obtained which satisfy the statistical accuracy p_j in per cent, as defined below.

$$P_j = \frac{h.s_j}{\sqrt{n}} * \frac{100}{\Delta T_j} \leq 3\%$$

where:

P_j is the statistical accuracy of the measurements performed at reference speed v_j;

n is the number of pairs of measurements;

ΔT_j is the mean coast down time at reference speed v_j in seconds, given by the equation:

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

where

ΔT_{ji} is the harmonic mean coast down time of the i_{th} pair of measurements at velocity v_j, seconds [s], given by the equation:

$$\Delta T_{ji} = \frac{2}{\left(\frac{1}{\Delta T_{aji}}\right) + \left(\frac{1}{\Delta T_{bji}}\right)}$$

where

ΔT_{aji} and ΔT_{bji} are the coast down times of the i_{th} measurement at reference Speed v_j, in seconds [s], in opposite directions a and b, respectively; S_j is the Standard deviation, in seconds [s], defined by:

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

h = is a coefficient given in the following table

Coefficient *h* as function of *n*

Sl. No	*n*	*h*	*n*	*h*	*n*	*h*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	3	4.3	13	2.2	23	2.1
ii)	4	3.2	14	2.2	24	2.1
iii)	5	2.8	15	2.2	25	2.1
iv)	6	2.6	16	2.1	26	2.1
v)	7	2.5	17	2.1	27	2.1
vi)	8	2.4	18	2.1	28	2.1
vii)	9	2.3	19	2.1	29	2.0
viii)	10	2.3	20	2.1	30	2.0
ix)	11	2.2	21	2.1		
x)	12	2.2	22	2.1		

5.1.1.2.6 If during a measurement in one direction any external factor or driver action occurs Which influences the road load test, that measurement and the corresponding measurement in the opposite direction shall be rejected.

5.1.1.2.7 The total resistances, F_{aj} and F_{bj}, at reference speed V_j in directions a and b, are determined by the equations:

$$F_{aj} = \frac{1}{3.6} * M * \frac{2 * \Delta V}{\Delta T_{aj}}$$

and

$$F_{bj} = \frac{1}{3.6} * M * \frac{2 * \Delta V}{\Delta T_{bj}}$$

5.1.1.2.8 The following equation shall be used to compute the average total resistance:

$$F_j = \left(\frac{(F_{aj} + F_{bj})}{2}\right)$$

5.1.1.2.9 For each reference speed V_j calculate the power (P_j), [kW], by the formula:

$$P_j = (F_j . V_j)/1{,}000$$

where:

F_j is the average resistance at reference speed, j, [N];
V_j is the reference speed, j, [m/s], defined in **5.1.1.2.3** of this Annex.

5.1.1.2.10 The complete power curve (P), [kW], as a function of speed, [km/h], shall be calculated with a least squares statistical regression analysis.

Final results shall be recorded as regression coefficients of force equation in the form either –

$$F = F_0 + (F_1 * V) + (F_2 * V^2) \text{ or}$$

$$F = F_0 + (F_2 * V^2)$$

where,

F_0, F_1, F_2 are regression coefficients

5.1.1.2.11 The power (P) determined on the track shall be corrected to the reference ambient conditions as follows:

$$P_{Corrected} = K.P_{Measured}$$

$$K = \frac{R_R}{R_r}.[1 + K_R(t - t_0)] + \frac{R_{AERO}}{R_T}.\frac{(\rho_o)}{\rho}$$

Where:

R_R = Rolling resistance at speed V,
R_{AERO} = aerodynamic drag at speed V,
R_T = Total driving resistance = $R_R + R_{AERO}$,
K_R = Temperature correction factor of rolling resistance, taken to be equal to 8.64 x 10^{-3}/°C, or the manufacturer's correction factor that is approved by the Test Agency
t = Road test ambient temperature in °C,
t_0 = Reference ambient temperature = 20° C,
ρ = Air density at the test conditions
ρ_o = Air density at the reference conditions (20° C, 100 kPa)

The ratios R_R/R_T and R_{AERO}/R_T shall be specified by the vehicle manufacturer based on the data normally available to the company.

If these values are not available, subject to the agreement of the manufacturer and the Test Agency concerned, the figures for the rolling/total resistance given by the following formula may be used:

$$\frac{R_R}{R_T} = a.M + b$$

Where:

M = Vehicle mass in kg and for each speed the coefficients a and b are shown in the following table:

Sl.No	Km/h	a	b
(1)	(2)	(3)	(4)
i)	120	1.57E-04	0.14
ii)	110	1.60E-04	0.16
iii)	100	1.63E-04	0.18
iv)	90	1.71E-04	0.21
v)	80	1.85E-04	0.23
vi)	70	1.91E-04	0.28
vii)	60	1.96E-04	0.33

viii)	50	1.86E-04	0.42
ix)	40	1.59E-04	0.54
x)	30	1.25E-04	0.67
xi)	20	1.24E-05	0.82

5.1.2 On the dynamometer

5.1.2.1 *Measurement equipment and accuracy* — The equipment shall be identical to that used on the road.

5.1.2.2 *Test procedure*

5.1.2.2.1 Install the vehicle on the test dynamometer.

5.1.2.2.2 Adjust the tyre pressure (cold) of the driving wheels as required by the dynamometer.

5.1.2.2.3 Adjust the equivalent inertia of the dynamometer.

5.1.2.2.4 Bring the vehicle and dynamometer to operating temperature in a suitable manner.

5.1.2.2.5 Carry out the operations specified in **5.1.1.2** of this Annex (with the exception of **5.1.1.2.4**. replacing M by I in the formula set out in **5.1.1.2.7** of this Annex.

5.1.2.2.6 Adjust the brake to reproduce the corrected power (**5.1.1.2.11** of this Annex) and to take into account the difference between the vehicle mass (M) on the track and the equivalent inertia test mass (I) to be used. This may be done by calculating the mean corrected road coast down time from V_2 to V_1 and reproducing the same time on the dynamometer by the following relationship:

$$T_{Corrected} = \frac{T_{measured}}{K} \cdot \frac{I}{M}$$

K = value specified in **5.1.1.2.11** of this Annex.

5.1.2.2.7 The power P_a to be absorbed by the dynamometer shall be determined in order to enable the same power (**5.1.1.2.11** of this Annex) to be reproduced for the same vehicle on different days.

5.2 Torque measurements method at constant speed

5.2.1 On the road

5.2.1.1 *Measurement equipment and error*

Torque measurement shall be carried out with an appropriate measuring device accurate to within ±2%. Speed measurement shall be accurate to within ±2%

5.2.1.2 *Test procedure*

5.2.1.2.1 Bring the vehicle to the chosen stabilized speed V.

5.2.1.2.2 Record the torque C_t and speed over a period of at least 20 seconds. The accuracy of the data recording system shall be at least ±1 Nm for the torque and ±0.2 km/h for the speed.

5.2.1.2.3 Differences in torque C_t and speed relative to time shall not exceed 5% for each second of the measurement period.

5.2.1.2.4 The torque C_{t1} is the average torque derived from the following formula:

$$C_{t1} = \frac{1}{\Delta t} \int_t^{t+\Delta t} C(t)dt$$

5.2.1.2.5 The test shall be carried out three times in each direction. Determine the average torque from these six measurements for the reference speed. If the average speed deviates by more than 1 km/h from the reference speed, a linear regression shall be used for calculating the average torque.

5.2.1.2.6 Determine the average of these two torques C_{t1} and C_{t2}, i.e. C_t

5.2.1.2.7 The average torque C_t determined on the track shall be corrected to the reference ambient conditions as follows:

$$C_{Tcorrected} = K.\ C_{Tmeasured}$$

Where,

K has the value specified in **5.1.1.2.11** of this Annex

5.2.5 *On the dynamometer*

5.2.2.1 *Measurement equipment and error* — The equipment shall be identical to that used on the road.

5.2.2.2 *Test procedure*

5.2.2.2.1 Perform the operations specified in clauses **5.1.2.2.1** to **5.1.2.2.4** of this Annex.

5.2.2.2.2 Perform the operations specified in clauses **5.2.1.2.1** to **5.2.1.2.4** of this Annex. Adjust the power absorption unit to reproduce the corrected total track torque indicated in clause **5.2.1.2.7** of this Annex.

5.2.2.2.4 Proceed with the same operations as in clause **5.1.2.2.7** of this Annex, for the same purpose.

(Part 4)

AUTOMOTIVE VEHICLES -DETERMINATION OF ROAD-LOAD CONSTANTS BY COAST DOWN TEST METHOD EXCEEDING 3500 Kg.

1 SCOPE

1.1 This standard specifies the procedure for determining the equation of road-load resistance of vehicle, including the aerodynamic and rolling resistance by coast down technique. This data is primarily intended for the road-load simulation on variable load curve chassis dynamometer.

This equation is expressed as $F = u + b_{v^2}$, where factors a and b are the constants.

1.2 However, it may be borne in mind that use of each of these constants independently may not be accurate. For example, the coefficient of rolling resistance 'a' will not be accurate enough to use as a comparison of rolling resistance of tyre.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 9211 : 2003	Terms and definitions of weights of road vehicles other than 2 and 3 wheelers (*Second Revision*)
IS 11422 : 2001	Terms and definitions of weights of two wheeled motor vehicles (*First Revision*)

3 DEFINITIONS

3.1 Laden Vehicle

A vehicle loaded to the condition of weight required for-establishing the road-load.

Note — The load condition of the vehicle for which the road-load equation is to be determined, depends on the end use of this equation. For example, for emission measurement for statutory purposes, the load condition is the 'Reference Mass', whereas for design verification tests, it may be the 'Gross Vehicle Weight'.

3.2 Unladen Vehicle

A vehicle in the condition of kerb weight as per the relevant Indian Standard, given in 2 above.

4 VEHICLE PREPARATION

4.1 The vehicle shall be clean and complete in all respects, representative of production series.

4.2 Vehicle shall be run-in as per manufacturer's recommendation.

4.3 The wheels of vehicle shall be free and without any parasitic drag. For vehicles with rear chain drive, it shall be-ensured that there is no chain rubbing.

4.4 The weight of testing personnel riding the vehicle and instrumentation carried on the vehicle shall be part of vehicle weight (*see* **8.2.1**). Additional loads may be added to bring the actual weight during testing to be within ±2 percent of specified weight. The distribution of weight among axles shall be as close as possible to the values recommended by the manufacturer. However, if sum of maximum recommended axle weights exceeds the gross vehicle weight, the actual weight on the axle shall be in the same proportion of the ratios of the gross vehicle weight to the sum of maximum recommended axle weights. The actual load condition and wheel reactions shall be recorded in the report.

4.5 Tyres which have covered only 10 percent or less of their expected life shall be fitted on the vehicle. The tread depth measurement method or tread wear indicators on the tyre may be used to assess tyre life. At the start of the test, tyres shall be cold and shall be inflated to pressure specified for respective load condition of the vehicle.

Sl No.	Parameter	Least Count	Accuracy
(1)	(2)	(3)	(4)
i)	Speed	0.1 km/h	0.1 km/h
ii)	Distance	0.1 m	0.1 m
iii)	Time	0.01 s	0.01 s

4.6 The grade, quality, quantity of lubricants for various moving parts, adjustments of brake, clutch, idling speed, etc. shall conform to the manufacturer's recommendation. The vehicle may be serviced before the test was per the procedure recommended by manufacturer.

5 FEATURES OF TEST TRACK

The test shall be conducted on a dry, level test track with a coefficient of adhesion not less than 0.8, particularly in region where the test is to be conducted. If test surface is of tar, it shall not be traffic smooth and surface shall not have become soft due to heat. Longitudinal slope of the track shall-not exceed 0.5 percent and shall be constant within ±0.1 percent over the measuring strip. The track shall have sufficient length and width for achieving the test speed and carrying out the test safely.

6 INSTRUMENTATION

6.1 Fitment of instruments shall be as recommended by instrument manufacturer. All instruments and the additional weights, if any, shall be mounted in such a way that they do not affect the performance or stability of the vehicle and do not hamper rider/driver from normal driving of vehicle and carrying out tests. The instrument shall be positioned on the vehicle such that it does not significantly affect the aerodynamics of the vehicle.

6.2 Calibration of instrument shall be checked and adjusted asper instrument manufacturer's instructions before commencement of test.

6.3 Automatic speed and distance measuring instruments meeting following least count and accuracy requirements shall be used.

7 TEST REQUIREMENTS

7.1 The test shall be conducted when wind speed is less than 3 m/s with gusts less than 5 m/s. In addition, the vector component across the test-road shall not be more than 2 m/s. The wind velocity measurement shall be done at a height of 0.7 m above the road surface. The ambient temperature shall be preferably between 15° to 40°C and relative humidity shall preferably be less than 75 percent.

Note - For proper consistency of test results, it is preferred that the tests are done with wind velocity less than 0.5 m/s.

7.2 Air density when calculated as described below shall not differ by more than **7.5** percent from the air density under reference condition

$$d_t = \frac{d_o . P_t . T_o}{P_o . T_t}$$

Where

d_1 = air density at test site expressed in kg/m',
d_0= air density at reference conditions = 1.168 kg/m),
P_t = atmospheric pressure at test site kPa,

P_o = atmospheric pressure at reference conditions = 100 kPa,
T_0 = ambient temperature at test site K, and
T_t = ambient temperature at reference conditions = 300K.

8 COAST DOWN TEST

8.1 General

8.1.1 Coast down test for a specific test speed (v) is basically to establish the road-load 'F' from the deceleration by measuring time elapsed from speed 'v +δ_v' to speed 'v - δ_v', when the transmission is in neutral. From the values of 'F' at different speeds, values of constants 'a' and 'b' in equation $F = a + b_v^2$ are determined by best curve fit method.

8.1.2 In the case of two wheelers, the recommended height of rider shall be 1.7 ± 0.05 m and the rider shall wear helmet and proper riding gear. He shall be seated upright on the seat provided for the rider, his feet upon the pedals or foot rests. This position shall, nevertheless, allow the rider at all times to have proper control of the vehicle during the test.

8.1.3 While carrying out the test, the portion of the test track where the vehicle is decelerated from 'v + δ_v' to 'v - δ_v' shall be kept approximately same in both directions to reduce the effect of track variation. This shall be followed for each test speed.

8.1.4 For improving the consistency of the test results, it is preferable that:

a) the test at all speeds is conducted by the same rider/ driver;
b) the test at each speed shall be done continuously without intermediate stoppage.

8.2 Testing Procedure

8.2.1 The test shall be conducted with the load condition given in **3.1**.

8.2.2 *Test Speeds*

a) The test shall be conducted at least at 5 speeds. Difference between each test speed shall not be less than 10 km/h;

b) The lowest speed at which test is done shall not be less than 20 km/h;

c) However in case of vehicle with maximum speed attainable under the test load and track condition is not exceeding 60 km/h;

1) The interval between test speeds (a) above may be reduced to the extent particularly needed, but not less than 5 km/h; and

2) The lowest speed (b) above may be reduced to 10 km/h.

d) The highest speed shall be more than or equal to speed at which road load equation is intended to be used. However, the highest test speed shall not be more than 80 percent of the maximum speed achievable by the vehicle under the test load and test track condition.

8.2.3 The value of 'δ_v' shall not be less than 3 km/h and not more than 5 km/h

8.2.4 Mount the instrumentation on the vehicle and make necessary connections.

8.2.5 During the test, the windows and other ventilating passages shall be kept closed. They may be kept open to the minimum extent needed for installing the instruments.

8.2.6 The vehicle shall be warmed up by running the vehicle for at least 15 km, at test speed prior to test. The test shall begin immediately after completion of warming up. Warming up shall be repeated before tests for each speed.

8.2.7 The vehicle shall be driven along a straight line during the test.

8.2.8 Attain a speed of about 5 to 10 km/h above 'v + δ_v' and shift the transmission of vehicle in neutral. Measure time (t,) up to 2 decimal places required for the speed to reduce from 'v + δ_v' to 'v - δ_v' in one direction. In case the vehicle has transmission without manual control, the test shall be done by towing/ pushing the vehicle to achieve required speed and releasing the towing/pushing arrangement. In case of electric vehicles, if the regenerative braking system can be electrically switched off, disconnecting the drive from the wheels may be done by switching off the same and the power supply to the motor. If it is not possible to do so, the motor should be decoupled before the test and the test shall be done by towing/ pushing the vehicle to achieve required speed and releasing the towing/pushing arrangement. The towing/ pushing shall be done in such a way that it does not affect the test.

8.2.8 Repeat the test immediately in the opposite direction and note the time (t_2) as explained in **8.2.8**. Take arithmetic average (t) of t_1, and t_2 from the value of t, calculate the deceleration force (F_{mean}) as:

$$F_{mean}=\frac{(\text{Test load}).(\delta_v).(\beta)}{1.8.t}\ \text{Newton}$$

Where

Test load = weight of test vehicle, in kg, as per 3.1;

β = (A factor to take into account the inertia of rotating parts), that is, 1 for 2 and 3 wheelers and 1.035 for other vehicles; and

$'t'$ = time, in seconds.

8.2.10 Repeat the tests (**8.2.8** and **8.2.9**) sufficient number of times to enable to select the lowest 10 statistically consistent readings of (F_{mean}), at each speed. The reading shall be considered as statistically consistent when the statistical error (P) calculated as per formula given below is within 2 percent:

$$P=\frac{K.s.100}{F_{av}.\sqrt{10}}=24.24\times\frac{\sqrt{\Sigma(F_{mean}-F_{av})2}}{F_{av}}$$

where

K= 2.3 for n =10

S = standard deviation $=\frac{\sqrt{\Sigma(F_{mean}-F_{av})2}}{\sqrt{(10-1)}}$

F_{mean} = average of force in both directions, and

F_{av} = average of 10n readings of $'F_{mean}'$

Note – It may be necessary to select a different set of 10 readings of the condition given in 9.2 is not satisfied

8.2.11 Repeat the test for all the desired test speeds (*see* **8.2.2**). Depending on consistent length of test track available, the tests may be carried out for more than one speed in the same run. In such cases, as the condition of **8.2.3** would not be satisfied, it shall be ensured that the variation of the track does not affect the test results.

9 CALCULATION

9.1 The road load is calculated as: $F = a + b_v^2$

Where

F = road load, in Newton;

a and b = road load constant; and

v = test speed, in km/h

9.2 Curve fitting

9.2.1 From the values of *F*, at least five test speeds, the values of coefficients *a* and *b* shall be calculated using following formulae. The curve fitting error should be within 2-percent.

$$a = \frac{\sum F_{av} - b\sum v^2}{n}, \quad b = \frac{n\sum v^2 F - \sum v^2 \sum F}{n\sum v^4 - (\sum v^2)^2}$$

Curve fitting error =

$$\left[\frac{\sum[(F_{curve} - F_{obs})/F_{curve}]^2}{n}\right]^{1/2} 100$$

where

n = number of test speeds
$F_{curve} = a + b_v{}^2$, and
$F_{obs} = F_{av}$ given in 8.2.10

10 VALIDITY OF THE EQUATION

10.1 The above road-load equation can be extrapolated up to speeds 20 percent -above the highest speed at which test has been conducted.

10.2 If the value of 'a' so obtained can be extrapolated for load conditions other than the test load,this can be done for loads up to + 10 percent of the test load with following correction:

$$a_{\text{desired}} = a_{\text{tested}} \times \frac{\text{Test load}_{\text{desired}}}{\text{Test load}_{\text{tested}}}$$

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee, TED 04

Will be added later