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Indian Standard

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

ICS 19.060; 43.020

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 3

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Vehicle Testing and Performance Evaluation Sectional Committee had been approved by the Transport Engineering Division Council.

The 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.

Indian Standard

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

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 $F = a+bv^2$, 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*
9211 : 1979	Denomination and definitions of weights of road vehicles
11422 : 1986	Terms and definitions of weights of two wheeled motor vehicles

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.

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 as 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 as per 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.

Parameter	*Least Count*	*Accuracy*
Speed	0.1 km/h	0.1 km/h
Distance	0.1 m	0.1 m
Time	0.01 s	0.01 s

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:

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

where

d_t = air density at test site expressed in kg/m^3,
d_o = airdensityatreference conditions = 1.168 kg/m^3,
P_t = atmospheric pressure at test site kPa,
P_o = atmospheric pressure at reference conditions = 100 kPa,
T_o = ambient temperature at test site K, and
T_t = ambient temperature at reference conditions = 300 K.

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 '$v + \delta v$' to speed '$v - \delta v$', when the transmission is in neutral. From the values of 'F' at different speeds, values of constants 'a' and 'b' in equation $F = a + bv^2$ 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 '$v + \delta v$' to '$v - \delta v$' 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

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 'δv' 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 minimun 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 ($v + \delta v$) and shift the transmission of vehicle in neutral. Measure time (t_1) up to 2 decimal places required for the speed to reduce from '$v + \delta v$' to '$v - \delta v$' 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.

8.2.9 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 = $\dfrac{\sqrt{\Sigma (F_{mean} - F_{av})^2}}{\sqrt{(10-1)}}$,

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

F_{av} = average of 10 readings of 'F_{mean}'.

NOTE — It may be necessary to select a different set of 10 readings if 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 :

$$F = a + bv^2$$

where

F = road load, in Newton;

a and b = road load constants; and

v = test speed, in km/h.

9.2 Curve Fitting

9.2.1 From the values of F_{av} at atleast 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.

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

Curve fitting error =

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

where

n = number of test speeds,

F_{curve} = $a + bv^2$, and

F_{obs} = F_{av} given in **8.2.10**.

NOTE — For finding values of a and b and error in curve fitting, standard software packages such as 'Regression Analysis' may be used.

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 Vehicle Testing and Performance Evaluation Sectional Committee, TED 8

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Kasturi Bai Nagar
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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 323 01 31, 323 94 02, 323 33 75

Telegrams: Manaksanstha
(Common to all offices)

Regional Offices:	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	323 76 17, 323 38 41
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola, CALCUTTA 700054	337 84 99, 337 85 61, 337 86 26, 337 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43, 60 20 25
Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600113	235 02 16, 235 04 42, 235 15 19, 235 23 15
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