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IS 14664 (2010): AUTOMOTIVE VEHICLES – PERFORMANCE REQUIREMENTS AND TESTING PROCEDURE FOR BRAKING SYSTEM OF TWO AND THREE WHEELED MOTOR VEHICLES [TED 4: Automotive Braking Systems]



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भारतीय मानक  
स्वचल वाहन — दुपहिया एवं तिपहिया मोटर वाहनों की ब्रेकिंग  
प्रणाली हेतु कार्यकारिता — अपेक्षाएँ तथा परीक्षण प्रक्रिया  
( पहला पुनरीक्षण )

*Indian Standard*  
AUTOMOTIVE VEHICLES — PERFORMANCE  
REQUIREMENTS AND TESTING PROCEDURE FOR  
BRAKING SYSTEM OF TWO AND THREE  
WHEELED MOTOR VEHICLES  
( *First Revision* )

ICS 43.040.40, 43.140

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**BUREAU OF INDIAN STANDARDS**  
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NEW DELHI 110002

## FOREWORD

This Indian Standard (First Revision) was adopted by Bureau of Indian Standards, after the draft finalized by the Automotive Braking Systems, Vehicle Testing and Performance Evaluation Sectional Committee and approved by the Transport Engineering Division Council.

This standard was first published in 1999. This revision has been taken up to align the standard with the Global Technical Regulation GTR3, formulated by UNECE, for which India has voted in favour of. The requirements of regenerative braking systems of battery-operated vehicles have also been added in line with AIS 049 and ECE Regulation R13H.

This standard specifies requirements of ABS for two wheeled motor vehicles (categories 3-1 and 3-3) only in line with GTR3. The standard needs a review when the systems as applied to two wheeled motor vehicles with side car and three wheeled vehicles (categories 3-2, 3-4 and 3-5) are to be tested.

This standard specifies deceleration requirements which have to be met on a test track having Peak Braking Coefficient (PBC) of 0.9. Such test tracks are under construction by National Automotive Testing and Research Infrastructure Project (NATRIP). This standard will, therefore, be applicable only after availability of such test tracks and after the revised standard is notified in *Central Motor Vehicle Rules (CMVR)* by Ministry of Shipping, Road Transport and Highways, till that time old version of this standard will remain in force.

Indian Standard for measurement of PBC is under preparation by Automotive Braking Systems, Vehicle Testing and Performance Evaluation Sectional Committee, till that time reference has been made to ASTM standard for measurement of PBC in this standard (*see 5.1.1.3*).

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard*

**AUTOMOTIVE VEHICLES — PERFORMANCE  
REQUIREMENTS AND TESTING PROCEDURE FOR  
BRAKING SYSTEM OF TWO AND THREE  
WHEELED MOTOR VEHICLES**

*( First Revision )*

**1 SCOPE**

**1.1** This standard specifies requirements for service brake systems and where applicable, associated parking brake systems of power driven vehicles with two or three wheels of category 3-1, 3-2, 3-3, 3-4 and 3-5, as defined in **3.28** to ensure safe braking performance under normal and emergency riding conditions. These categories do not include,

- a) vehicles with a  $V_{Max}$  of < 25 km/h; and
- b) vehicles equipped for disabled riders.

**1.2** This standard is also applicable to three wheeled vehicle designed to draw a semi-trailer. In case of three wheeled vehicles designed to draw a semi-trailer, the maximum weight to be considered shall be the maximum weight of the drawing vehicle (prime mover) in running order plus the maximum weight transferred to the drawing vehicle (prime mover) by the laden semi-trailer (in static condition).

**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:

<i>IS No.</i>	<i>Title</i>
9226 : 1979	Recommendations for load distribution for passenger cars
9237 : 1979	Symbols for controls, indicators and tell-tales for road vehicles
10278 : 2009/ ISO 7117 : 1995	Automotive vehicles — Maximum speed of two wheeler — Method of measurement ( <i>third revision</i> )
11827 : 2008	Automotive vehicles — Calibration of speedometers — Method of evaluation ( <i>second revision</i> )

<i>IS No.</i>	<i>Title</i>
13453 : 1994	Automotive vehicles — Braking systems — Method of test on brake dynamometer for two and three wheelers
IS/ISO/PAS 12158 : 2002	Road vehicles — Braking systems — Temperature measuring methods

**3 DEFINITIONS**

The following definitions apply for the purpose of interpreting this standard.

**3.1 Antilock Brake System (ABS)** — A system, which senses wheel slip and automatically modulates the pressure producing the braking forces at the wheel(s) to limit the degree of wheel slip.

**3.2 Baseline Test** — A stop or a series of stops carried out in order to confirm the performance of the brake prior to subjecting it to a further test such as the heating procedure or wet brake stop.

**3.3 Brake** — Those parts of the brake system where the forces opposing the movement of the vehicle are developed.

**3.4 Brake System** — The combination of parts consisting of the control, transmission, and brake, but excluding the engine, whose function is to progressively reduce the speed of a moving vehicle, bring it to a halt, and keep it stationary when halted.

**3.5 Combined Brake System (CBS)**

- a) *For vehicle categories 3-1 and 3-3*, a service brake system where at least two brakes on different wheels are actuated by the operation of a single control.
- b) *For vehicle categories 3-2 and 3-5*, a service brake system where the brakes on all wheels are actuated by the operation of a single control.
- c) *For vehicle category 3-4*, a service brake system where the brakes on at least the front

and rear wheels are actuated by the operation of a single control. (If the rear wheel and sidecar wheel are braked by the same brake system, this is regarded as the rear brake.)

**3.6 Control** — The part actuated directly by the rider in order to supply or control the energy required for braking the vehicle to the transmission.

**3.7 Engine Disconnected** — When the engine is no longer connected to the driving wheel(s).

**3.8 Initial Brake Temperature** — The temperature of the hottest brake before any brake application.

**3.9 Laden** — The gross vehicle mass.

**3.10 Lightly Loaded** — Mass in running order (*see 3.29*) plus 15 kg for test equipment, or the laden condition, whichever is less. In the case of ABS tests on a low friction surface (*see 5.9.4 to 5.9.7*), the mass for test equipment is increased to 30 kg to account for outriggers.

**3.11 Peak Braking Coefficient (PBC)** — The measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre.

**3.12 Power-Assisted Braking System** — A brake system in which the energy necessary to produce the braking force is supplied by the physical effort of the rider assisted by one or more energy supplying devices, for example vacuum assisted (with vacuum booster).

**3.13 Secondary Brake System** — The second service brake system on a vehicle equipped with a combined brake system.

**3.14 Service Brake System** — A brake system which is used for slowing the vehicle when in motion.

**3.15 Single Brake System** — A brake system which acts on only one axle.

**3.16 Split Service Brake System (SSBS)** — A brake system that operates the brakes on all wheels, consisting of two or more sub-systems actuated by a single control designed so that a single failure in any sub-system (such as a leakage type failure of a hydraulic sub-system) does not impair the operation of any other sub-system.

**3.17 Stopping Distance** — The distance travelled by the vehicle from the point the rider begins to actuate the brake control to the point at which the vehicle reaches full stop. For tests where simultaneous actuation of two controls is specified, the distance travelled is taken from the point the first control is actuated.

**3.18 Test Speed** — The vehicle speed measured the

moment the rider begins to actuate the brake control. For tests where simultaneous actuation of two controls is specified, the vehicle speed is taken from the moment the first control is actuated.

**3.19 Transmission** — The combination of components that provide the functional link between the control and the brake.

**3.20  $V_{Max}$**  — The speed measured on a 200 m length test strip, in accordance with IS 10278.

**3.21 Wheel Lock** — The condition that occurs when there is a slip ratio of 1.00.

**3.22 Electric Regenerative Braking System** — A braking system, which allows the use of the vehicle's drive motor(s) to convert the kinetic energy of the vehicle into electrical energy during deceleration. A braking system, which during deceleration, provides for the conversion of vehicle kinetic energy into electrical energy.

**3.23 Electric Regenerative Brake Control** — A device which modulates the action of the electric regenerative braking system

**3.24 Electric Regenerative Braking System of Category A** — An electric regenerative braking system, which is not part of the service braking system.

**3.25 Electric Regenerative Braking System of Category B** — An electric regenerative braking system, which is part of the service braking system.

**3.26 Electric State of Charge** — The instantaneous ratio of electric quantity of energy stored in the traction battery relative to the maximum quantity of electric energy, which could be stored in this battery.

**3.27 Traction Battery** — An assembly of accumulators constituting the storage of energy used for powering the traction motor(s) of the vehicle.

**3.28 Power Driven Vehicles with Two or Three Wheels**

**3.28.1 Category 3 vehicle** — A power driven vehicle with 2 or 3 wheels designed and constructed for the carriage of persons and/or goods.

**3.28.2 Category 3-1 vehicle: two-wheeled moped** — A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm<sup>3</sup> and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.

**3.28.3 Category 3-2 vehicle: three-wheeled moped** — A three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm<sup>3</sup> and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.

**3.28.4 Category 3-3 vehicle: two-wheeled motorcycle** — A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm<sup>3</sup> or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

**3.28.5 Category 3-4 vehicle: motorcycle with sidecar** — A vehicle with three wheels asymmetrically arranged in relation to the longitudinal median plane with an engine capacity in the case of thermic engine exceeding 50 cm<sup>3</sup> or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

**3.28.6 Category 3-5 vehicle: tricycle** — A vehicle with three wheels symmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm<sup>3</sup> or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

**3.29 Mass in Running Order** — The nominal mass of a vehicle as determined by the following criteria: Sum of unladen vehicle mass (*see* 3.29.1) and driver's mass (*see* 3.29.2). The driver's mass is applied in accordance with 7.1.

#### 3.29.1 Unladen Vehicle Mass

The nominal mass of a complete vehicle as determined by the following criteria:

- a) Mass of the vehicle with bodywork and all factory fitted equipment, electrical and auxiliary equipment for normal operation of vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks and spare wheel, if fitted.
- b) The fuel tank shall be filled in case of liquid fuel to at least 90 per cent of rated capacity and in case of LPG, CNG and other gaseous fuels to legally permitted capacity and the other liquid containing systems (except those for used water) to 100 per cent of the capacity specified by the manufacturer.

#### 3.29.2 Driver Mass

The nominal mass of a driver that shall be 75 kg (subdivided into 68 kg occupant mass at the seat and 7 kg luggage mass in accordance with IS 9226).

NOTE — The definitions given in 3.28 and 3.29 are identical to Special Resolution No.1 (Document TRANS/WP.29/1045 dated 15 September 2005).

## 4 GENERAL REQUIREMENTS

### 4.1 Brake System Requirements

**4.1.1** Each vehicle shall meet each of the tests specified for a vehicle of its category and for those brake features on the vehicle.

#### 4.1.2 Service Brake System Control Operation

Vehicles shall have configurations that enable a rider to actuate the service brake system control while seated in the normal driving position and with both hands on the steering control.

#### 4.1.3 Secondary Brake System Control Operation

Vehicles shall have configurations that enable a rider to actuate the secondary brake system control while seated in the normal driving position and with at least one hand on the steering control.

#### 4.1.4 Parking Brake System

If a parking brake system is fitted, it shall hold the vehicle stationary on the slope prescribed in 5.8.2.

The parking brake system shall,

- a) have a control which is separate from the service brake system controls; and
- b) be held in the locked position by solely mechanical means.

Vehicles shall have configurations that enable a rider to be able to actuate the parking brake system while seated in the normal driving position.

**4.1.5** Two-wheeled vehicles of categories 3-1 and 3-3 shall be equipped with either two separate service brake systems, or a split service brake system, with at least one brake operating on the front wheel and at least one brake operating on the rear wheel.

**4.1.6** Three-wheeled vehicles of vehicles category 3-4 shall comply with the brake system requirements set out in 4.1.5. A brake on the sidecar wheel is not required if the vehicle meets the performance requirements prescribed in 5.

**4.1.7** Three-wheeled vehicles of category 3-2 shall be equipped with a parking brake system plus one of the following service brake systems,

- a) Two separate service brake systems, except CBS, which, when applied together, operate the brakes on all wheels; or
- b) A split service brake system; or
- c) A CBS that operates the brakes on all wheels and a secondary brake system which may be the parking brake system.

**4.1.8** Category 3-5 vehicles shall be equipped with,

- a) a parking brake system; and
- b) a foot actuated service brake system which operates the brakes on all wheels, by way of either,
  - 1) a split service brake system; or



- 2) a CBS and a secondary brake system, which may be the parking brake system.

**4.1.9** In cases where two separate service brake systems are installed, the systems may share a common brake, if a failure in one system does not affect the performance of the other.

**4.1.10** For vehicles that use hydraulic fluid for brake force transmission, the master cylinder shall,

- a) have a sealed, covered, separate reservoir for each brake system. These may be in the form of one or more separate reservoirs located within the same container. Such containers may only have one sealed, covered filling cap;
- b) have a minimum reservoir capacity equivalent to 1.5 times the total fluid displacement required to satisfy the new to fully worn lining condition with the worst case brake adjustment condition; and
- c) have a reservoir where the fluid level is visible for checking without removal of the cover.

NOTE — Caps of such containers may have vent hole.

**4.1.11** All warning lamps shall be mounted in the rider's view.

**4.1.12** Vehicles that are equipped with a split service brake system shall be fitted with a red warning lamp (with identification as per **3.31** of IS 9237), which shall be activated,

- a) when there is a hydraulic failure on the application of a force of  $\leq 90$  N on the control; or
- b) without actuation of the brake control, when the brake fluid level in the master cylinder reservoir falls below the greater of,
  - 1) that which is specified by the manufacturer; and
  - 2) that which is less than or equal to half of the fluid reservoir capacity.

To permit function checking, the warning lamp shall be illuminated by the activation of the ignition switch and shall be extinguished when the check has been completed. This condition is satisfied if the warning lamp switches off after few second. The warning lamp shall remain on while a failure condition exists whenever the ignition switch is in the 'on' position.

**4.1.13** Vehicles that are equipped with an ABS system shall be fitted with a yellow warning lamp. The lamp shall be activated whenever there is a

malfunction that affects the generation or transmission of signals in the vehicle's ABS system.

To permit function checking, the warning lamp shall be illuminated by the activation of the ignition switch and extinguished when the check has been completed. This condition is satisfied, if the warning lamp switches off after few second. The warning lamp shall remain on while a failure condition exists whenever the ignition switch is in the 'on' position.

#### **4.1.14** *General Requirements of Electric Regenerative Braking Systems*

##### **4.1.14.1** *Vehicles fitted with electric regenerative braking system of category A*

The electric regenerative braking shall be only activated by accelerator control and/or the gear neutral position.

##### **4.1.14.2** *Vehicles fitted with electric regenerative braking system of category B*

**4.1.14.2.1** It shall not be possible to disconnect partially or totally one part of the service braking system other than by an automatic device.

**4.1.14.2.2** The service braking system control shall also actuate the action of the electric regenerative braking system simultaneously.

**4.1.14.2.3** The service braking system shall not be adversely affected by the disengagement of the motor(s) or gear ratio used, except during the short duration of operation of gear shifting.

**4.1.14.3** If the brake control (front or rear or combined) actuates the electric regenerative brake system (Category B), the prescribed performance requirements shall be complied with the use of the electric regenerative system.

**4.1.14.4** If so desired by the manufacturer the performance requirements may be verified without the use of the electric regenerative system by appropriately disconnecting the system. If, so this shall be recorded in the test report.

## **4.2** Durability

**4.2.1** Wear of the brakes shall be compensated for by means of a system of automatic or manual adjustment.

**4.2.2** The friction material thickness shall either be visible without disassembly of brakes, or where the friction material is not visible; wear shall be assessed by means of a device designed for that purpose.

**4.2.3** During all the tests in this standard and on their completion, there shall be no friction material detachment and no leakage of brake fluid.

### 4.3 Measurement of Dynamic Performance

The method used to measure performance is as specified in the respective tests in 5. There are three ways in which the service brake system performance may be measured:

#### 4.3.1 MFDD (Mean Fully Developed Deceleration)

Calculation of MFDD:

$$d_m = \frac{V_b^2 - V_e^2}{25.92(S_e - S_b)} \text{ m/s}^2$$

where

- $d_m$  = mean fully developed deceleration;
- $V_b$  = vehicle speed at 0.8  $V_1$ , in km/h;
- $V_e$  = vehicle speed at 0.1  $V_1$ , in km/h;
- $S_b$  = distance travelled between  $V_1$  and  $V_b$ , in m; and
- $S_e$  = distance travelled between  $V_1$  and  $V_e$ , in m.

#### 4.3.2 Stopping Distance

##### 4.3.2.1 Based on the basic equations of motion

$$S = 0.1 \cdot V + (X) \cdot V^2$$

where

- $S$  = stopping distance, in m;
- $V$  = vehicle speed, in km/h; and
- $X$  = variable based on the requirement for each test.

To calculate the corrected stopping distance using the actual vehicle test speed, the following formula is used:

$$S_s = 0.1V_s + (S_a - 0.1V_a) \cdot V_s^2/V_a^2$$

where

- $S_s$  = corrected stopping distance, in m;
- $V_s$  = specified vehicle test speed, in km/h;
- $S_a$  = actual stopping distance, in m; and
- $V_a$  = actual vehicle test speed, in km/h.

NOTE — This equation is only valid when the actual test speed ( $V_a$ ) is within  $\pm 5$  km/h of the specified test speed ( $V_s$ ).

##### 4.3.2.2 Based on the basic equations of motion

$$S = (X) V^2$$

where

- $S$  = stopping distance, in m;
- $V$  = vehicle speed, in km/h; and
- $X$  = variable based on the requirement for each test.

To calculate the corrected stopping distance using the actual vehicle test speed, the following formula is used:

$$S_s = S_a \cdot V_s^2/V_a^2$$

where

- $S_s$  = corrected stopping distance, in m;
- $V_s$  = specified vehicle test speed, in km/h;
- $S_a$  = actual stopping distance, in m; and
- $V_a$  = actual vehicle test speed, in km/h.

NOTE — This equation is only valid when the actual test speed ( $V_a$ ) is within  $\pm 5$  km/h of the specified test speed ( $V_s$ ).

#### 4.3.3 Continuous Deceleration Recording

For the burnishing procedure and tests such as the wet brake and heat fade – heating procedure, there is a continuous recording of the vehicle instantaneous deceleration from the moment a force is applied to the brake control until the end of the stop.

## 5 TEST CONDITIONS, PROCEDURES AND PERFORMANCE REQUIREMENTS

### 5.1 General

#### 5.1.1 Test Surfaces

##### 5.1.1.1 High-friction surface

- a) Applicable to all dynamic brake tests excluding the ABS tests where a low-friction surface is specified;
- b) The test area is a clean, dry and level surface, with a gradient  $\leq 1$  percent; and
- c) The surface has a nominal peak braking coefficient (PBC) of 0.9, unless otherwise specified.

##### 5.1.1.2 Low-friction surface

- a) Applicable to ABS tests where a low-friction surface is specified;
- b) The test area is a clean and level surface, with a gradient  $\leq 1$  percent; and
- c) The surface has a PBC  $\leq 0.45$ .

##### 5.1.1.3 Measurement of PBC

The PBC is measured as specified in national or regional legislation using the American Society for Testing and Materials (ASTM) E1136 standard reference test tyre, in accordance with ASTM Method E1337-90, at a speed of 64 km/h without water delivery.

##### 5.1.1.4 Parking brake system tests

The specified test slope has a clean and dry surface that does not deform under the weight of the vehicle.

##### 5.1.1.5 Test lane width

- a) For two-wheeled vehicles (vehicle categories 3-1 and 3-3) the test lane width is 2.5 m.
- b) For three-wheeled vehicles (vehicle

categories 3-2, 3-4 and 3-5) the test lane width is 2.5 m + the vehicle width.

**5.1.2 Ambient Temperature**

The ambient temperature is between 4 °C and 45 °C.

**5.1.3 Wind Speed**

The wind speed is not more than 5 m/s.

**5.1.4 Test Speed Tolerance**

- a) Test speed tolerance is ±5 km/h; and
- b) In the event of the actual test speed deviating from the specified test speed, the actual stopping distance is corrected using the formula as given in 4.3.2.

**5.1.5 Automatic Transmission**

Vehicles with automatic transmission shall complete all tests — whether they are for ‘engine connected’ or ‘engine disconnected’.

If an automatic transmission has a neutral position, the neutral position is selected for tests where engine disconnected is specified.

**5.1.6 Vehicle Position and Wheel Lock**

- a) Vehicle is positioned in the centre of the test lane for the beginning of each stop; and
- b) Stops are made without the vehicle wheels passing outside the applicable test lane and without wheel lock.

**5.1.7 Test Sequence**

Sl No. (1)	Test Order (2)	Clause (3)
i)	Dry stop — single brake control actuated	5.3
ii)	Dry stop — all service brake controls actuated	5.4
iii)	High speed	5.5
iv)	Wet brake	5.6
v)	Heat fade ( <i>see Note</i> )	5.7
vi)	If fitted:	
a)	Parking brake system	5.8
b)	ABS	5.9
c)	Partial failure, for split service brake systems	5.10
d)	Power-assisted braking system failure	5.11

NOTE — Heat fade is always the last test to be carried out.

**5.2 Preparation**

**5.2.1 Engine Idle Speed**

The engine idle speed is set to the manufacturer’s specification.

**5.2.2 Tyre Pressures**

The tyres are inflated to the manufacturer’s specification for the vehicle loading condition for the test.

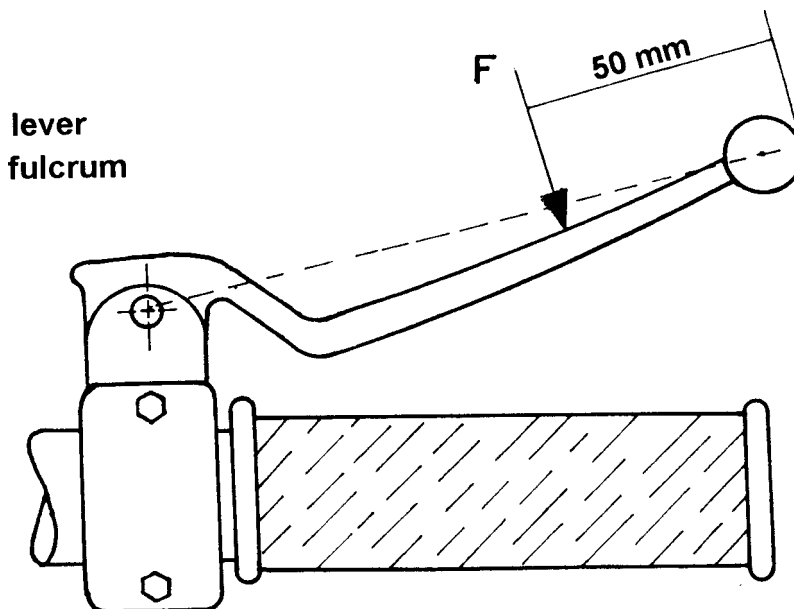


FIG. 1 CONTROL FORCE APPLICATION POINT AND DIRECTION

### 5.2.3 Control Application Points and Direction

For a hand control lever, the input force ( $F$ ) is applied on the control lever's forward surface perpendicular to the axis of the lever fulcrum and its outermost point on the plane along which the control lever rotates (see Fig. 1).

The input force is applied to a point located 50 mm from the outermost point of the control lever, measured along the axis between the central axis of the fulcrum of the lever and its outermost point.

For a foot control pedal, the input force is applied to the centre of, and at right angles to, the control pedal.

When the tests are to be conducted with actuation of both controls simultaneously, there shall be a device to establish time interval elapsed between actuation of two controls and time elapsed between actuation of these controls shall be less than 0.1s.

### 5.2.4 Brake Temperature Measurement

The brake temperature is measured on the approximate centre of the braking path of the disc or drum using a thermocouple that is embedded in the friction material (see 2.1 and Fig. B.2 and B.3 of IS/ISO/PAS 12158).

### 5.2.5 Burnishing Procedure

The vehicle brakes are burnished prior to evaluating performance. This procedure may be completed by the manufacturer.

- a) Vehicle lightly loaded;
- b) Engine disconnected;
- c) *Test speed*
  - 1) Initial speed: 50 km/h or  $0.8 V_{\text{Max}}$ , whichever is lower; and
  - 2) Final speed: 5 to 10 km/h.
- d) *Brake application*,  
Each service brake system control actuated separately.
- e) *Vehicle deceleration*,
  - 1) Single front brake system only; 3.0-3.5 m/s<sup>2</sup> for vehicle categories 3-3 and 3-4; 1.5-2.0 m/s<sup>2</sup> for vehicle categories 3-1 and 3-2; and
  - 2) Single rear brake system only: 1.5-2.0 m/s<sup>2</sup>; and
  - 3) CBS or split service brake system: 3.5-4.0 m/s<sup>2</sup>.
- f) Number of decelerations: 100 per brake system.
- g) Initial brake temperature before each brake application  $\leq 100$  °C; and

- h) For the first stop, accelerate the vehicle to the initial speed and then actuate the brake control under the conditions specified until the final speed is reached. Then reaccelerate to the initial speed and maintain that speed until the brake temperature falls to the specified initial value. When these conditions are met, reapply the brake as specified. Repeat this procedure for the number of specified decelerations. After burnishing, adjust the brakes in accordance with the manufacturer's recommendations.

## 5.3 Dry Stop Test — Single Brake Control Actuated

### 5.3.1 Vehicle Condition

- a) Test is applicable to all vehicle categories
- b) *Laden*  
For vehicles fitted with CBS and split service brake systems: the vehicle is tested in the lightly loaded condition in addition to the laden condition; and
- c) Engine disconnected.

### 5.3.2 Test Conditions and Procedure

- a) *Initial brake temperature*:  
 $\geq 55$ °C and  $\leq 100$  °C;
- b) *Test speed*
  - 1) Vehicle categories 3-1 and 3-2: 40 km/h or  $0.9 V_{\text{Max}}$ , whichever is lower; and
  - 2) Vehicle categories 3-3, 3-4 and 3-5: 60 km/h or  $0.9 V_{\text{Max}}$ , whichever is lower.
- c) *Brake application*:  
Each service brake system control actuated separately;
- d) *Brake actuation force*:
  - 1) Hand control:  $\leq 200$  N; and
  - 2) Foot control:  $\leq 350$  N for vehicle categories 3-1, 3-2, 3-3 and 3-4  $\leq 500$  N for vehicle category 3-5.
- e) Number of stops: Until the vehicle meets the performance requirements, with a maximum of 6 stops; and
- f) For each stop, accelerate the vehicle to the test speed and then actuate the brake control under the conditions specified in this paragraph.

### 5.3.3 Performance Requirements

When the brakes are tested in accordance with the test procedure set out in 5.3.2, the corrected stopping distance shall be as specified in col 2 or the MFDD shall be as specified in col 3 of Table 1.

**Table 1 Performance Requirements of Braking System**  
(Clauses 5.3.3, 5.4.3 and 5.9.8.2)

Sl No.	Vehicle Category	Stopping Distance ( $S$ ) (Where $V$ is the specified test speed in km/h and $S$ is the required stopping distance in metres)	MFDD
(1)	(2)	(3)	(4)
Single brake system, front wheel(s) braking only:			
i)	3-1	$S \leq 0.1 V + 0.011 1 V^2$	$\geq 3.4 \text{ m/s}^2$
ii)	3-2	$S \leq 0.1 V + 0.014 3 V^2$	$\geq 2.7 \text{ m/s}^2$
iii)	3-3	$S \leq 0.1 V + 0.008 7 V^2$	$\geq 4.4 \text{ m/s}^2$
iv)	3-4	$S \leq 0.1 V + 0.010 5 V^2$	$\geq 3.6 \text{ m/s}^2$
v)	3-5	Not applicable	Not applicable
Single brake system, rear wheel(s) braking only:			
vi)	3-1	$S \leq 0.1 V + 0.014 3 V^2$	$\geq 2.7 \text{ m/s}^2$
vii)	3-2	$S \leq 0.1 V + 0.014 3 V^2$	$\geq 2.7 \text{ m/s}^2$
viii)	3-3	$S \leq 0.1 V + 0.013 3 V^2$	$\geq 2.9 \text{ m/s}^2$
ix)	3-4	$S \leq 0.1 V + 0.010 5 V^2$	$\geq 3.6 \text{ m/s}^2$
x)	3-5	Not applicable	Not applicable
Vehicles with CBS or split service brake systems: for laden and lightly loaded conditions ( <i>see</i> Note)			
xi)	3-1 and 3-2	$S \leq 0.1 V + 0.008 7 V^2$	$\geq 4.4 \text{ m/s}^2$
xii)	3-3	$S \leq 0.1 V + 0.007 6 V^2$	$\geq 5.1 \text{ m/s}^2$
xiii)	3-4	$S \leq 0.1 V + 0.007 1 V^2$	$\geq 5.4 \text{ m/s}^2$
xiv)	3-5	$S \leq 0.1 V + 0.007 7 V^2$	$\geq 5.0 \text{ m/s}^2$
Vehicles with CBS — secondary service brake systems:			
xv)	ALL	$S = 0.1 V + 0.015 4 V^2$	$> 2.5 \text{ m/s}^2$
NOTE — If the stopping distance requirement for compliance with 5.4.3 is more stringent than requirement specified above, this test need not be carried out.			

#### 5.4 Dry Stop Test — All Service Brake Controls Actuated

##### 5.4.1 Vehicle Condition

- The test is applicable to vehicle categories 3-3, 3-4 and 3-5;
- Lightly loaded; and
- Engine disconnected.

##### 5.4.2 Test Conditions and Procedure

- Initial brake temperature:  $\geq 55 \text{ }^\circ\text{C}$  and  $\leq 100 \text{ }^\circ\text{C}$ ;
- Test speed: 100 km/h or  $0.9 V_{\text{Max}}$ , whichever is lower;
- Brake application:

Simultaneous actuation of both service brake system controls, if so equipped, or of the single service brake system control in the case of a service brake system that operates on all wheels;

##### d) Brake actuation force:

- Hand control:  $\leq 250 \text{ N}$ .
- Foot control:  $\leq 400 \text{ N}$  for vehicle categories 3-3 and 3-4,  $\leq 500 \text{ N}$  for vehicle category 3-5.

e) Number of stops: Until the vehicle meets the performance requirements, with a maximum of 6 stops; and

f) For each stop, accelerate the vehicle to the test speed and then actuate the brake controls under the conditions specified in this paragraph.

##### 5.4.3 Performance Requirements

When the brakes are tested in accordance with the test procedure set out in 5.4.2, the stopping distance ( $S$ ) shall be  $S \leq 0.006 0 V^2$  (where  $V$  is the specified test speed in km/h and  $S$  is the required stopping distance in metres).

For vehicles with CBS or split service brake systems for laden and lightly loaded conditions, if the stopping distance requirement for compliance with those specified in Table 1 is more stringent than requirement specified above, this test need not be carried out.

## 5.5 High Speed Test

### 5.5.1 Vehicle Condition

- The test is applicable to vehicle categories 3-3, 3-4 and 3-5;
- Test is not required for vehicles with  $V_{Max} \leq 125$  km/h;
- Lightly loaded; and
- Engine connected with the transmission in the highest gear.

NOTE — 'Highest gear' means the one with the lowest numerical reduction.

### 5.5.2 Test Conditions and Procedure

- Initial brake temperature:*  $\geq 55$  °C and  $\leq 100$  °C;
- Test speed:*  $0.8 V_{Max}$  for vehicles with  $V_{Max} > 125$  km/h and  $< 200$  km/h;  
 $160$  km/h for vehicles with  $V_{Max} \geq 200$  km/h;
- Brake application:*  
Simultaneous actuation of both service brake system controls, if so equipped, or of the single service brake system control in the case of a service brake system that operates on all wheels;
- Brake actuation force:*  
Hand control:  $\leq 200$  N  
Foot control:  $\leq 350$  N for vehicle categories 3-3, and 3-4  
 $\leq 500$  N for vehicle category 3-5;
- Number of stops:* Until the vehicle meets the performance requirements, with a maximum of 6 stops; and
- For each stop, accelerate the vehicle to the test speed and then actuate the brake control (s) under the conditions specified in this paragraph.

### 5.5.3 Performance Requirements

When the brakes are tested in accordance with the test procedure set out in 5.5.2.

- The stopping distance ( $S$ ) shall be  $\leq 0.1 V + 0.0067 V^2$   
(where  $V$  is the specified test speed in km/h and  $S$  is the required stopping distance in

metres); or

- The MFDD shall be  $\geq 5.8$  m/s<sup>2</sup>.

## 5.6 Wet Brake Test

### 5.6.1 General Information:

- The test is comprised of two parts that are carried out consecutively for each brake system:
  - a baseline test based on the dry stop test — single brake control actuated (see 5.3); and
  - a single wet brake stop using the same test parameters as in (1), but with the brake(s) being continuously sprayed with water while the test is conducted in order to measure the brakes' performance in wet conditions.
- The test is not applicable to parking brake systems unless it is the secondary brake.
- Drum brakes or fully enclosed disc brakes are exempt from this test unless ventilation or open inspection ports, through which water ingress into the brakes is possible, are present; and  
NOTE — Disc brakes with callipers covered by wheel rim are fully enclosed disc brakes.
- This test requires the vehicle to be fitted with instrumentation that gives a continuous recording of brake control force and vehicle deceleration. The MFDD and the stopping distance measurements are not appropriate in this case.

### 5.6.2 Vehicle Condition

- The test is applicable to all vehicle categories;
- Laden*  
For vehicles fitted with CBS and split service brake systems: the vehicle is tested in the lightly loaded condition in addition to the laden condition;
- Engine disconnected;
- Each brake is fitted with water spray equipment.
  - Disc brakes (see Fig. 2):

The disc brake water spray equipment is installed as follows:

- Water is sprayed onto each brake with a flow rate of 15 l/h. The water is equally distributed on each side of the rotor;
- If the surface of the rotor has any shielding, the spray is applied 45° prior

All dimensions are in mm

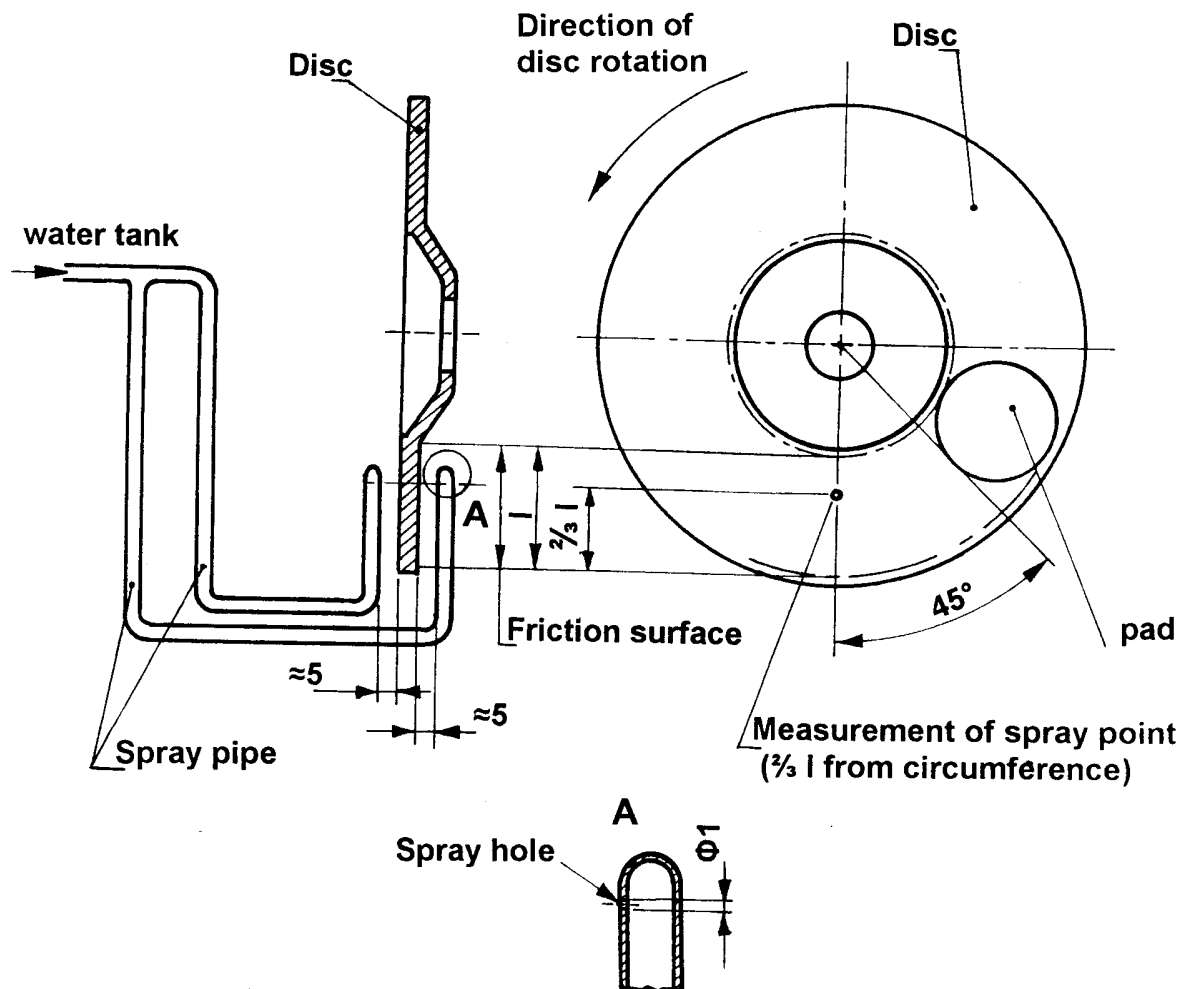


FIG. 2 DISC BRAKES: SKETCH OF WATER SPRAY EQUIPMENT

- to the shield; and
- iii) If it is not possible to locate the spray in the position shown on the sketch, or if the spray coincides with a brake ventilation hole or similar, the spray nozzle may be advanced by an additional 90° maximum from the edge of the pad, using the same radius.
- 2) Drum brakes with ventilation and open inspection ports:  
The water spray equipment is installed as follows:
  - i) Water is sprayed equally onto both sides of the drum brake assembly (on the stationary back plate and on the rotating drum) with a flow rate of 15 l/h;
  - ii) The spray nozzles are positioned two-thirds of the distance from the outer circumference of the rotating drum to the wheel hub centre; and

- iii) The nozzle position is > 15 ° from the edge of any opening in the drum back plate.

### 5.6.3 Baseline Test

#### 5.6.3.1 Test conditions and procedure

##### a) Dry stop test

Single brake control actuated (see 5.3) is carried out for each brake system but with the brake control force that results in a vehicle deceleration of 2.5 - 3.0 m/s<sup>2</sup>, and the following is determined:

- 1) The average brake control force measured when the vehicle is travelling between 80 percent and 10 percent of the specified test speed;
- 2) The average vehicle deceleration in the period 0.5 to 1.0 s after the point of actuation of the brake control; and

- 3) The maximum vehicle deceleration during the complete stop but excluding the final 0.5 s. (see 5.3), to measure the brake's performance after the heating procedure;
- b) Conduct 3 baseline stops and average the values obtained in 5.6.3.1(a) (1), (2), and (3).
- b) The test is applicable to vehicle categories 3-3, 3-4 and 3-5;

#### 5.6.4 Wet Brake Stop

##### 5.6.4.1 Test conditions and procedure

- a) The vehicle is ridden at the test speed used in the baseline test set out in 5.6.3 with the water spray equipment operating on the brake(s) to be tested and with no application of the brake system;
- b) After a distance of  $\geq 500$  m, apply the average brake control force determined in the baseline test for the brake system being tested;
- c) Measure the average vehicle deceleration in the period 0.5 to 1.0 s after the point of actuation of the brake control; and
- d) Measure the maximum vehicle deceleration during the complete stop but excluding the final 0.5 s.
- c) The test is not applicable to parking brake systems and secondary service brake systems;
- d) All stops are carried out with the vehicle laden; and
- e) The heating procedure requires the vehicle to be fitted with instrumentation that gives a continuous recording of brake control force and vehicle deceleration. The MFDD and stopping distance measurements are not appropriate for the heating procedure. The baseline test and the hot brake stop require the measurement of either MFDD or the stopping distance.

#### 5.7.2 Baseline Test

##### 5.7.2.1 Vehicle condition — Engine disconnected.

##### 5.7.2.2 Test conditions and procedure

#### 5.6.5 Performance Requirements

When the brakes are tested in accordance with the test procedure set out in 5.6.4.1 the wet brake deceleration performance shall be:

- a) The value measured in 5.6.4.1(c)  $\geq 60$  per cent of the average deceleration values recorded in the baseline test in 5.6.3.1(a)(2), that is in the period 0.5 to 1.0 s after the point of actuation of the brake control; and
- b) The value measured in 5.6.4.1 (d)  $\leq 120$  per cent of the average deceleration values recorded in the baseline test in 5.6.3.1(a)(3), that is during the complete stop but excluding the final 0.5 s.
- a) *Initial brake temperature:*  $\geq 55$  °C and  $\leq 100$  °C;
- b) *Test speed:* 60 km/h or  $0.9 V_{Max}$ , whichever is the lower;
- c) *Brake application:*  
Each service brake system control actuated separately;
- d) *Brake actuation force:*
  - 1) Hand control:  $\leq 200$  N
  - 2) Foot control:  $\leq 350$  N for vehicle categories 3-3 and 3-4  
 $\leq 500$  N for vehicle category 3-5; and
- e) Accelerate the vehicle to the test speed, actuate the brake control under the conditions specified and record the control force required to achieve the vehicle braking performance specified in Table 1.

### 5.7 Heat Fade Test

#### 5.7.1 General Information

- a) The test comprises three parts that are carried out consecutively for each brake system:
  - 1) A baseline test using the dry stop test — single brake control actuated (see 5.3);
  - 2) A heating procedure which consists of a series of repeated stops in order to heat the brake(s); and
  - 3) A hot brake stop using the dry stop test — single brake control actuated
- a) From the specified test speed to 50 percent specified test speed: connected, with the highest appropriate gear selected such that the engine speed remains above the manufacturer's specified idle speed;
- b) From 50 per cent specified test speed to standstill: disconnected; and

#### 5.7.3 Heating Procedure

##### 5.7.3.1 Vehicle condition — Engine transmission



- c) However, if the manufacturer request so, the test shall be carried out with the engine disconnected throughout the stop. This shall be recorded in the test report.

### 5.7.3.2 Test conditions and procedure

- a) Initial brake temperature prior to first stop only:  $\geq 55$  °C and  $\leq 100$  °C;
- b) *Test speed:*
- 1) Single brake system, front wheel braking only:  
100 km/h or  $0.7 V_{Max}$ , whichever is the lower.
  - 2) Single brake system, rear wheel braking only:  
80 km/h or  $0.7 V_{Max}$ , whichever is the lower.
  - 3) CBS or split service brake system:  
100 km/h or  $0.7 V_{Max}$ , whichever is the lower.
- c) *Brake application:*  
Each service brake system control actuated separately;
- d) *Brake actuation force:*
- 1) For the first stop:  
The constant control force that achieves a vehicle deceleration rate of 3.0-3.5 m/s<sup>2</sup> while the vehicle is decelerating between 80 percent and 10 percent of the specified speed;  
If the vehicle is unable to achieve the specified vehicle deceleration rate, this stop is carried out to meet the deceleration requirements specified in Table 1 (see 5.3.3);  
*For the remaining stops:*
    - i) The same constant brake control force as used for the first stop;
    - ii) Number of stops: 10; and
    - iii) Interval between stops: 1000 m.
- e) Carry out a stop to the conditions specified in this paragraph and then immediately use maximum acceleration to reach the specified speed and maintain that speed until the next stop is made.

### 5.7.4 Hot Brake Stop

#### 5.7.4.1 Test conditions and procedure

Perform a single stop under the conditions used in the baseline test (see 5.7.2) for the brake system that has been heated during the procedure in accordance with 5.7.3. This stop is carried out within 1 min of the completion of the procedure set out in 5.7.3 with

a brake control application force less than or equal to the force used during the test set out in 5.7.2.

### 5.7.5 Performance Requirements

When the brakes are tested in accordance with the test procedure set out in 5.7.4.1:

- a) *The stopping distance:*  $S_2 \leq 1.67 S_1 - 0.67 \times 0.1V$

where

$S_1$  = corrected stopping distance achieved in the baseline test set out in 5.7.2, in m ;

$S_2$  = corrected stopping distance achieved in the hot brake stop set out in 5.7.4.1, in m; and

$V$  = specified test speed in km/h.

or

- b) *The MFDD* = 60 per cent of the MFDD recorded in the test set out in 5.7.2.

### 5.8 Parking Brake System Test — For Vehicles Equipped with Parking Brakes

#### 5.8.1 Vehicle Condition

- a) The test is applicable to vehicle categories 3-2, 3-4 and 3-5;
- b) Laden [in the case of vehicle intended to be coupled with semi-trailer to Gross Combination Weight (GCW) recommended by the vehicle manufacturer]; and
- c) Engine disconnected.

#### 5.8.2 Test Conditions and Procedure

- a) *Initial brake temperature:*  $\leq 100$  °C;
- b) *Test surface gradient* = 18 percent. In the case of vehicle intended to be coupled with semi-trailer 12 percent;
- c) *Brake actuation force:*
  - 1) Hand control:  $\leq 400$  N
  - 2) Foot control:  $\leq 500$  N
- d) For the first part of the test, park the vehicle on the test surface gradient facing up the slope by applying the parking brake system under the conditions specified in this paragraph. If the vehicle remains stationary, start the measurement of the test period; and
- e) On completion of the test with vehicle facing up the gradient, repeat the same test procedure with the vehicle facing down the gradient.

#### 5.8.3 Performance Requirements

When tested in accordance with the test procedure set out in 5.8.2, the parking brake system shall hold

the vehicle stationary for 5 min when the vehicle is both facing up and facing down the gradient.

**5.8.3.1** In case the suitable gradient (18 percent or 12 percent as applicable) is not available, the test may be carried out on the nearest available gradient as per the following procedure.

**5.8.3.2** Carry out the test on the nearest higher gradient available, as per procedure given in 5.8.1 to 5.8.3, and if the vehicle meets the requirements of being held, the vehicle shall be deemed to comply with the requirements of this standard for parking brake.

**5.8.3.3** If nearest higher gradient is not available or the vehicle fails to meet the requirements with the nearest higher gradient with the specified weight, establish the maximum mass of vehicle which the parking brake is capable of holding the vehicle stationary.

The maximum mass of vehicle  $M_m$  that is capable of being held stationary by the parking brake on specified gradient shall be calculated as:

$$M_m = \frac{M_T (R \cos \theta_t + \sin \theta_t)}{(R \cos \theta_s + \sin \theta_s)}$$

where,

$M_m$  = maximum mass of vehicle capable of being held on the specified gradient (18 percent or 12 percent) (kg);

$M_T$  = maximum mass of vehicle that was held on the test gradient (kg);

$R$  = coefficient of rolling resistance = 0.02;

$\theta_t$  =  $\tan^{-1} (G_t/100)$ ;

$\theta_s$  =  $\tan^{-1} (G_s/100)$ ;

$G_t$  = percentage gradient on which the test was carried out; and

$G_s$  = specified gradient (18 percent or 12 percent as the case may be).

**5.8.3.4**  $M_m$  so calculated shall not be less than the GVW or GCW of the vehicle, as applicable.

## 5.9 ABS Tests

### 5.9.1 General

- The tests are only applicable to the ABS fitted on vehicle categories 3-1 and 3-3;
- The tests are to confirm the performance of brake systems equipped with ABS and their performance in the event of ABS electrical failure;
- 'Fully cycling' means that the anti-lock system is repeatedly modulating the brake force to prevent the directly controlled wheels from locking; and

- Wheel-lock is allowed as long as the stability of the vehicle is not affected to the extent that it requires the operator to release the control or causes a vehicle wheel to pass outside the test lane.

The test series comprises the following individual tests, which may be carried out in any order:

<i>ABS Tests</i>	<i>Clause</i>
a) Stops on a high friction surface — as specified in 5.1.1.1	<b>5.9.3</b>
b) Stops on a low friction surface — as specified in 5.1.1.2	<b>5.9.4</b>
c) Wheel lock checks on high and low friction surfaces	<b>5.9.5</b>
d) Wheel lock check — high to low friction surface transition	<b>5.9.6</b>
e) Wheel lock check — low to high friction surface transition	<b>5.9.7</b>
f) Stops with an ABS electrical failure	<b>5.9.8</b>

### 5.9.2 Vehicle Condition

- Lightly loaded; and
- Engine disconnected.

### 5.9.3 Stops on a High Friction Surface

#### 5.9.3.1 Test conditions and procedure

- Initial brake temperature:*  $\geq 55^\circ\text{C}$  and  $\leq 100^\circ\text{C}$ ;
- Test speed:* 60 km/h or  $0.9 V_{\text{Max}}$ , whichever is lower;
- Brake application:*  
Simultaneous actuation of both service brake system controls, if so equipped, or of the single service brake control in the case of a service brake system that operates on all wheels;
- Brake actuation force:*  
The force applied is that which is necessary to ensure that the ABS will cycle fully throughout each stop, down to 10 km/h;
- If one wheel is not equipped with ABS, the control for the service brake on that wheel is actuated with a force that is lower than the force that will cause the wheel to lock;
- Number of stops: Until the vehicle meets the performance requirements, with a maximum of 6 stops; and
- For each stop, accelerate the vehicle to the test speed and then actuate the brake control under the conditions specified in this paragraph.

**5.9.3.2 Performance requirements**

When the brakes are tested in accordance with the test procedures referred to in **5.9.3.1**:

- a) The stopping distance ( $S$ ) shall be  $\leq 0.0063V^2$  (where  $V$  is the specified test speed in km/h and  $S$  is the required stopping distance in metre) or the MFDD shall be  $\geq 6.17 \text{ m/s}^2$ ; and
- b) There shall be no wheel lock and the vehicle wheels shall stay within the test lane.

**5.9.4 Stops on a Low Friction Surface**

**5.9.4.1 Test conditions and procedure**

As set out in **5.9.3.1**, but using the low friction surface instead of the high friction one.

**5.9.4.2 Performance requirements**

When the brakes are tested in accordance with the test procedures set out in **5.9.4.1**,

- a) The stopping distance ( $S$ ) shall be  $\leq 0.0056 V^2/P$  (where  $V$  is the specified test speed in km/h,  $P$  is the peak braking coefficient and  $S$  is the required stopping distance in metre) or the MFDD shall be  $\geq 6.87 \times P$ , in  $\text{m/s}^2$ ; and
- b) There shall be no wheel lock and the vehicle wheels shall stay within the test lane.

**5.9.5 Wheel Lock Checks on High and Low Friction Surfaces**

**5.9.5.1 Test conditions and procedure**

- a) *Test surfaces*
  - 1) High friction; and
  - 2) Low friction.
- b) *Initial brake temperature*:  $\geq 55 \text{ }^\circ\text{C}$  and  $\leq 100 \text{ }^\circ\text{C}$
- c) *Test speed*
  - 1) On the high friction surface: 80 km/h or  $0.8 V_{\text{Max}}$ , whichever is lower; and
  - 2) On the low friction surface: 60 km/h or  $0.8 V_{\text{Max}}$ , whichever is lower.
- d) *Brake application*
  - 1) Each service brake system control actuated separately; and
  - 2) Where ABS is fitted to both brake systems, simultaneous actuation of both brake controls in addition to 1).
- e) *Brake actuation force*: The force applied is that which is necessary to ensure that the ABS will cycle fully throughout each stop, down to 10 km/h;

- f) *Brake application rate*:

The brake control actuation force is applied in 0.2 - 0.5s;

- g) *Number of stops*: Until the vehicle meets the performance requirements, with a maximum of 3 stops; and
- h) For each stop, accelerate the vehicle to the test speed and then actuate the brake control under the conditions specified in this paragraph.

**5.9.5.2 Performance requirements**

When the brakes are tested in accordance with the test procedures set out in **5.9.5.1**, there shall be no wheel lock and the vehicle wheels shall stay within the test lane.

**5.9.6 Wheel Lock Check**

High to low friction surface transition.

**5.9.6.1 Test conditions and procedure**

- a) *Test surfaces*: A high friction surface immediately followed by a low friction surface;
- b) *Initial brake temperature*:  $\geq 55 \text{ }^\circ\text{C}$  and  $\leq 100 \text{ }^\circ\text{C}$ ;
- c) *Test speed*: The speed that will result in 50 km/h or  $0.5 V_{\text{Max}}$ , whichever is the lower, at the point where the vehicle passes from the high friction to the low friction surface;
- d) *Brake application*:
  - 1) Each service brake system control actuated separately; and
  - 2) Where ABS is fitted to both brake systems, simultaneous actuation of both brake controls in addition to (1);
- e) *Brake actuation force*: The force applied is that which is necessary to ensure that the ABS will cycle fully throughout each stop, down to 10 km/h;
- f) *Number of stops*: until the vehicle meets the performance requirements, with a maximum of 3 stops; and
- g) For each stop, accelerate the vehicle to the test speed and then actuate the brake control before the vehicle reaches the transition from one friction surface to the other.

**5.9.6.2 Performance requirements**

When the brakes are tested in accordance with the test shall be no wheel lock and the vehicle wheels shall stay within the test lane.

**5.9.7 Wheel Lock Check**

Low to high friction surface transition.

**5.9.7.1 Test conditions and procedure**

- a) *Test surfaces*: A low friction surface immediately followed by a high friction surface with a PBC  $\geq 0.8$ ;
- b) *Initial brake temperature*:  $> 55\text{ }^{\circ}\text{C}$  and  $\leq 100\text{ }^{\circ}\text{C}$ ;
- c) *Test speed*: The speed that will result in 50 km/h or  $0.5 V_{\text{Max}}$ , whichever is the lower, at the point where the vehicle passes from the low friction to the high friction surface;
- d) *Brake application*:
  - 1) Each service brake system control applied separately; and
  - 2) Where ABS is fitted to both brake systems, simultaneous application of both brake controls in addition to (1).
- e) *Brake actuation force*: The force applied is that which is necessary to ensure that the ABS will cycle fully throughout each stop, down to 10 km/h;
- f) *Number of stops*: Until the vehicle meets the performance requirements, with a maximum of 3 stops;
- g) For each stop, accelerate the vehicle to the test speed and then actuate the brake control before the vehicle reaches the transition from one friction surface to the other; and
- h) Record the vehicle's continuous deceleration.

**5.9.7.2 Performance requirements**

When the brakes are tested in accordance with the test procedures set out in **5.9.7.1**:

- a) There shall be no wheel lock and the vehicle wheels shall stay within the test lane; and
- b) Within 1 s of the rear wheel passing the transition point between the low and high friction surfaces, the vehicle deceleration shall increase.

**5.9.8 Stops with an ABS Electrical Failure****5.9.8.1 Test conditions and procedure**

With the ABS electrical system disabled, carry out the test set out in **5.3** (dry stop test — single brake control actuated) applying the conditions relevant to the brake system and vehicle being tested.

**5.9.8.2 Performance requirements**

When the brakes are tested in accordance with the test procedure set out in **5.9.8.1**:

- a) The system shall comply with the failure warning requirements of **4.1.13**; and
- b) The minimum requirements for stopping distance or MFDD shall be as specified in col 3 or 4, respectively, under the heading "Single brake system, rear wheel(s) braking only" in Table 1.

**5.10 Partial Failure Test — For Split Service Brake Systems****5.10.1 General Information**

- a) Test is only applicable to vehicles that are equipped with split service brake systems; and
- b) Test is to confirm the performance of the remaining subsystem in the event of a hydraulic system leakage failure.

**5.10.2 Vehicle Condition**

- a) The test is applicable to vehicle categories 3-3, 3-4 and 3-5;
- b) Lightly loaded; and
- c) Engine disconnected.

**5.10.3 Test Conditions and Procedure**

- a) *Initial brake temperature*:  $\geq 55\text{ }^{\circ}\text{C}$  and  $\leq 100\text{ }^{\circ}\text{C}$ ;
- b) *Test speeds*: 50 km/h and 100 km/h or  $0.8 V_{\text{Max}}$ , whichever is lower;
- c) *Brake actuation force*:  
Hand control  $\leq 250\text{ N}$   
Foot control  $\leq 400\text{ N}$ ;
- d) *Number of stops*: Until the vehicle meets the performance requirements, with a maximum of 6 stops for each test speed;
- e) Alter the service brake system to induce a complete loss of braking in any one subsystem. Then, for each stop, accelerate the vehicle to the test speed and then actuate the brake control under the conditions specified in this paragraph; and
- f) Repeat the test for each subsystem.

**5.10.4 Performance Requirements**

When the brakes are tested in accordance with the test procedure set out in **5.10.3**:

- a) The system shall comply with the failure warning requirements set out in **4.1.12** and **4.1.13**; and
- b) The stopping distance ( $S$ ) shall be  $\leq 0.1V + 0.0117 V^2$  (where  $V$  is the specified test speed in km/h and  $S$  is the required stopping

distance in metre) or the MFDD shall be  $\geq 3.3 \text{ m/s}^2$ .

## 5.11 Power-Assisted Braking System Failure Test

### 5.11.1 General Information

- The test is not conducted when the vehicle is equipped with another separate service brake system; and
- The test is to confirm the performance of the service brake system in the event of failure of the power assistance.

### 5.11.2 Test Conditions and Procedure

Carry out the dry stop test — single brake control actuated set out in 5.3 for each service brake system with the power assistance disabled.

### 5.11.3 Performance Requirements

When the brakes are tested in accordance with the test procedure set out in 5.11.2, the stopping distance shall be as specified in col 3 or the MFDD shall be as specified in col 4 of Table 2.

## 5.12 Requirements of Electric Regenerative Braking Systems

**5.12.1** For vehicles powered completely or partially by an electric motor or motor(s), permanently connected to the wheels, all tests shall be carried out with these motor(s) connected.

**5.12.2** In the case of vehicles fitted with Category A type of regenerative braking system, any separate electric regenerative braking control which is provided, shall not be used during the following tests:

Test	Clause
Dry stop — single brake control actuated	5.3
Dry stop — all service brake controls actuated	5.4
High speed	5.5
Partial failure, for split service brake systems	5.10
Power-assisted braking system failure	5.11

**5.12.3** In the case of vehicles fitted with Category B type of regenerative braking system the contribution of the electric regenerative braking system to the braking force generated shall not exceed that minimum level guaranteed by the system design. This condition is deemed to be satisfied if the state of charge of the batteries is in one of the following conditions:

**5.12.3.1** At the maximum charge level recommended by the manufacturer, as listed in the vehicle specification.

**5.12.3.2** At a level not less than 95 percent of the full charge level, where the manufacturer has made no specific recommendation.

**5.12.3.3** At a maximum level resulting from automatic charge control on the vehicle (in case of hybrid vehicles).

**5.12.3.4** The state of charge of the traction batteries is determined by the method set out below:

**5.12.3.4.1** This procedure is applicable to vehicle batteries used for traction and regenerative braking.

**Table 2 Performance Requirements of Braking System**  
(Clause 5.11.3)

Sl No.	Vehicle Category	Stopping Distance (S) (Where V is the specified test speed in km/h and S is the required stopping distance in metre)	MFDD
(1)	(2)	(3)	(4)
	Single brake system		
i)	3-1	$S \leq 0.1 V + 0.014 3 V^2$	$\geq 2.7 \text{ m/s}^2$
ii)	3-2	$S \leq 0.1 V + 0.014 3 V^2$	$\geq 2.7 \text{ m/s}^2$
iii)	3-3	$S \leq 0.1 V + 0.013 3 V^2$	$\geq 2.9 \text{ m/s}^2$
iv)	3-4	$S \leq 0.1 V + 0.010 5 V^2$	$\geq 3.6 \text{ m/s}^2$
	Vehicles with CBS or SSBS		
	All	$S \leq 0.1 V + 0.015 4 V^2$	$\geq 2.5 \text{ m/s}^2$

NOTE — That if the power assistance may be activated by more than one control, the above performance shall be achieved when each control is actuated separately.

The procedure requires the use of a bi-directional dc watt-hour meter.

**5.12.3.4.2** If the batteries are new or have been subject to extended storage, they shall be cycled as recommended by the manufacturer. A minimum 8 h soak period at ambient temperature shall be allowed after completion of cycling. A full charge shall be established using the manufacturers recommended charging procedure.

**5.12.3.4.3** When the tests as per **5.3** and **5.4** are conducted the watt-hours consumed by the traction motors and supplied by the regenerative braking system shall be recorded as a running total which shall then be used to determine the state of charge existing at the beginning or end of a particular test.

**5.12.3.4.4** To replicate a level of state of charge in the batteries for comparative tests, the batteries shall be either recharged to that level or charged to above that level and discharged into a fixed load at approximately constant power until the required state of charge is reached. Alternatively, for vehicles with battery powered electric traction only, the state of charge may be adjusted by running the vehicle. Tests conducted with a battery partially charged at their start shall be commenced as soon as possible after the desired state of charge has been reached.

**5.12.3.4.5** State of charge assessment will not be required for vehicles, which have an on-board energy source for charging the traction batteries and the means for regulating their state of charge (for example hybrid vehicles).

**5.12.3.4.6** Conditions prescribed in **5.12.3** are not applicable if the desired performance is complied when tested without the use of the electric regenerative system by appropriately disconnecting the system as described in **4.1.14**.

## 6 PREPARATION OF THE VEHICLE

**6.1** The vehicle manufacturer before offering the vehicle shall ensure that vehicle is run-in.

**6.2** The brake system and free play of levers and pedal shall be adjusted as per manufacturer's recommendations to establish optimum braking performance.

**6.3** The weight of testing personnel seated on the vehicles while testing and the instrumentation carried on the vehicle shall form part of vehicle weight.

The additional loads, if any, shall be selected and mounted in normal operating condition in such a way that actual weight during testing shall not exceed specified laden or unladen weights by more than 25 kg.

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 weight exceed the gross vehicle weight, the actual weight on axle shall be in the same proportion of the ratios of the gross vehicle weight to the sum of maximum recommended axle weights.

Actual load condition shall be recorded in the report.

**6.4** The tyres shall be in good condition and shall be preferably run in along with the vehicle. Declaration of the vehicle manufacturer shall be accepted as compliance to this sub-clause

**6.5** At the start of the test, tyres shall be cold and shall be inflated to the pressure specified for respective load condition of the vehicle.

## 7 INSTRUMENTATION

**7.1** Fitment of instruments shall be as recommended by instrument manufacturer. All instruments shall be mounted in such a way that they do not affect the performance or stability of the vehicle and do not hamper the driver from normal driving of the vehicle and carrying out the test.

**7.2** Appropriate switches shall be fixed to control lever and pedal such that actuation of controls is signalled to the instruments. Alternatively, brake light switch of the vehicle may be used, if this is compatible with the instrument.

**7.3** Calibration of instruments shall be checked and adjusted as per instrument manufacturer's instructions before commencement of a test series.

**7.4** When the tests are to be conducted with actuation of both controls simultaneously, there shall be a device to establish time interval elapsed between actuation of two controls.

### 7.5 Instruments for Stopping Distance

Contact less electronic speed and distance measuring instruments or speed measuring system using an additional wheel when used, shall meet the following least count and accuracy requirements.

<i>Parameter</i>	<i>Least Count</i>	<i>Accuracy</i>
Speed	0.1km/h	± 1 percent at the prescribed speed for the test
Distance	0.1 m	
Time	0.01 s	–

### 7.6 Instruments for Deceleration

**7.6.1** Decelerometers shall be secured on test vehicle properly such that its position is not likely to be

### Typical vehicle stopping point

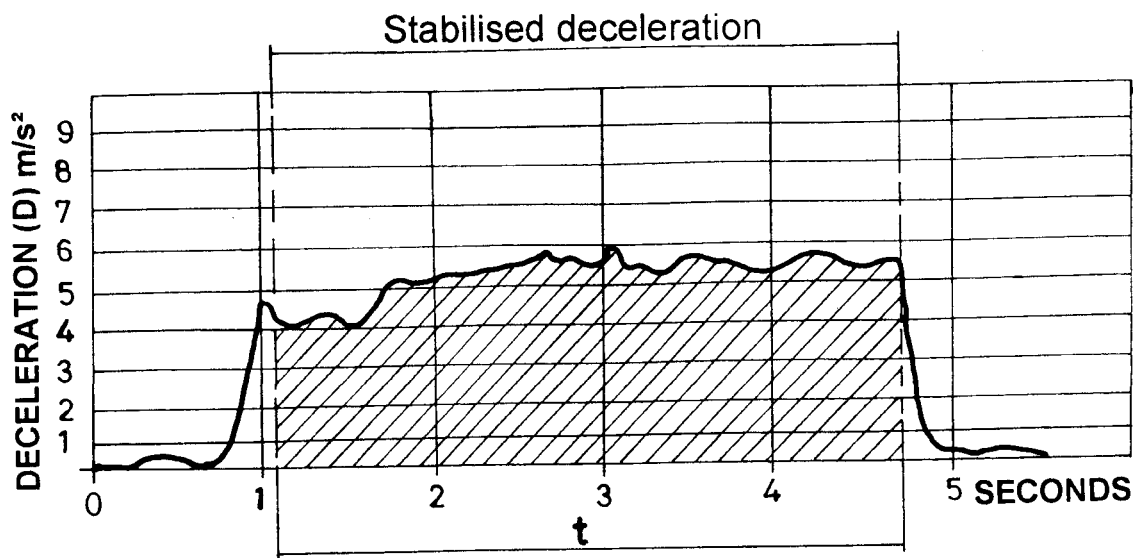


FIG. 3 ILLUSTRATION OF A TYPICAL VALID DECELERATION  $V_s$  TIME GRAPH

disturbed during tests. This shall be fitted as close to centre of gravity of vehicle as possible in longitudinal and lateral plane. Before commencement of each run, levelling of instrument within the limits prescribed by the instrument manufacturer shall be ensured.

The accuracy of the instrument for deceleration shall be within  $\pm 3$  percent.

**7.6.2** For calculating mean fully developed deceleration/mean deceleration, it is essential that graph of deceleration is fairly uniform. It is not possible to lay down norms for steady features of this graph as this is influenced by many testing factors, mainly response of the rider. Hence, general

engineering should be followed. The graph illustrated in Fig. 3 is typically valid graph and the graph illustrated in Fig. 4 shall be considered invalid. Methods of calculations of deceleration are also illustrated in Fig. 3.

#### 7.7 Instrument for Control Force

**7.7.1** Suitable load cells shall be used for this and recommended least count and accuracy are 10 N (1 kg) and 20 N (2 kg) respectively.

**7.7.2** Load cells shall be fixed to control in such a way that normal actuation of the brake control is not hampered. In view of practical difficulties in adapting load cell and for the driver to control maximum for force applied, suitable stoppers to limit the control

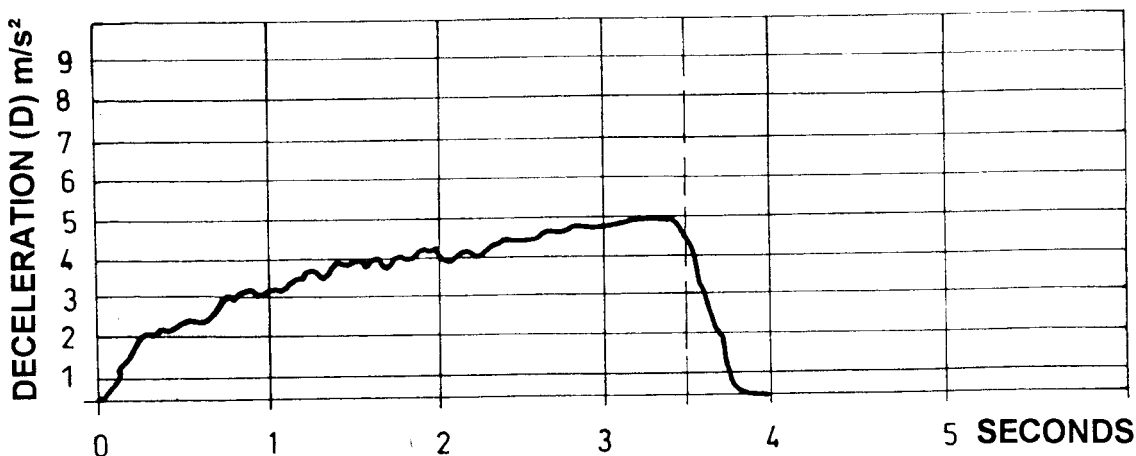


FIG. 4 ILLUSTRATION OF A TYPICAL INVALID DECELERATION  $V_s$  TIME GRAPH

travel or valves to limit the hydraulic pressure may be used during brake tests. In such cases, it will be sufficient to measure the control force in static condition, to bring the control to the stopper position or to achieve the limited hydraulic pressure.

## 7.8 Instrument for Speed Measurement

**7.8.1** While measuring stopping distance by instruments specified in 7.5, speed is also measured by these systems.

**7.8.2** While measuring deceleration, a speedometer may be used. This may be the one fitted on the vehicle. Appropriate temporary marking shall be made on the dial of speedometer in such a way that the actual speed of the vehicle, when the indicated speed is as per the marking, established as per the procedure given in IS 11827 is within +1 km/h of the specified initial speed. There shall be suitable markings for all necessary test speeds.

## 8 CORRECTIONS OF TEST RESULTS TO THE STANDARD TEST CONDITIONS

The test results of tests as per 5.3 to 5.7 shall be corrected to the specified conditions of initial speed and load condition.

**8.1** The stopping distance measured shall be corrected to the condition of specified initial speed by the appropriate formula prescribed in 4.3.2.1 or 4.3.2.2

**8.2** If the actual weight of the vehicle at the time of test is different from required values, the stopping distance or the MFDD shall be corrected to the condition of specified mass by the following formulae

$$S = (S_c - 0.1V_s) \times (M_s/M_m) + 0.1V_s$$

$$d = d_m \times M_m/M_s$$

where

$S$  = stopping distance corrected to the condition of specified initial speed and specified mass, m,

$M_s$  = specified mass, kg,

$M_m$  = actual mass at the test condition, g,

$d_m$  = measured MFDD m/s<sup>2</sup>, and

$d$  = measured MFDD corrected to the condition of specified mass, m/s<sup>2</sup>.

## 9 TECHNICAL SPECIFICATION OF VEHICLE

**9.1** Technical specifications of vehicle as relevant to brake system shall be declared by the vehicle manufacturer and shall contain at least the details given in Annex A.

NOTE — If the specifications submitted for complete type approval of a vehicle contain the details given in Annex A, there is no necessity of submitting this information again.

### 9.2 Modifications/Changes

In case test is conducted for verification of compliance to statutory requirements the following shall be carried out:

**9.2.1** Every functional modification pertaining to the information declared in accordance with 9.1 shall be intimated by the manufacturer to the certifying agency. The Testing Agency may then consider, whether,

- a) The model with the changed specifications still complies with provisions; or
- b) Any further verification is required to establish compliance.

**9.2.2** For considering whether any further verification is required or not, guidelines given in Annex B shall be used.

**9.2.3** In case of 9.2.1(b), tests for only those parameters which are affected by the modifications need to be carried out.

**9.2.4** In case of fulfillment of criterion of 9.2.1(a) or after results of further verification as per 9.2.1(b) are successful, the approval of compliance shall be extended for the changes carried out.



**ANNEX A**  
(Clause 9.1)

**PROFORMA FOR TECHNICAL SPECIFICATION OF VEHICLE**

<b>A-1</b>	<b>GENERAL</b>	
	Manufacturer's name	:
	Address	:
	Name of model and variants	:
	Category of vehicle (as per 3.28)	:
	Maximum design speed, km/h	:
<b>A-2</b>	<b>ENGINE</b>	
	Type	:
	Working principle (four/two stroke)	:
	Swept volume cc	:
	Bore (mm)	:
	Stroke (mm)	:
	No. and layout of cylinders	:
	Compression ratio	:
<b>A-3</b>	<b>TRANSMISSION</b>	
	Type (Manual/Automatic/Semi-automatic)	:
	Overall transmission ratio	:
	1st	:
	2nd	:
	3rd	:
	4th	:
	5th	:
	6th	:
	Over drive	:
<b>A-4</b>	<b>WEIGHTS, kg</b>	
	Weight in running order	:
	Front axle	:
	Rear axle	:
	Total	:
	Gross vehicle weight	:
	Maximum permissible axle weights	:
	Front axle	:
	Rear axle	:
	Gross combination weight	:
	(for vehicles with trailer/semi-trailer)	
	Maximum permissible axle weights	:
	(for vehicles with trailer/semi-trailer)	
	Front axle, tractor	:
	Rear axle, tractor	:
<b>A-5</b>	<b>VEHICLE DIMENSIONS, mm</b>	
	Length	:
	Width	:
	Height (Unladen)	:
	Wheel base	:
<b>A-6</b>	<b>SERVICE BRAKING SYSTEM</b>	
	Type (drum / disc/leading/trailing)	:

	Front	:
	Rear	:
	Other	:
	Make	:
	Front	:
	Rear	:
	Other	:
<b>A-7</b>	<b>SERVICE CONTROL SYSTEM (OPERATED BY HAND/FOOT)</b>	
	Front	:
	Rear	:
	Combined	:
	Free play of control, mm	
	Front	:
	Rear	:
	Combined	:
	Brake pedal ratio	
	Hand lever ratio	:
<b>A-8</b>	<b>SERVICE BRAKE — TRANSMISSION TYPE</b>	
	Mechanical/Hydraulic	
<b>A-9</b>	<b>SERVICE BRAKE-LINING/PAD</b>	
	Nominal dimensions (mm) (length × width × thickness)	:
	Front	:
	Rear	:
	Other	:
	Area per wheel (cm <sup>2</sup> )	
	Front	:
	Rear	:
	Other	:
	Make and material designation	
	Front	:
	Rear	:
	Other	:
<b>A-10</b>	<b>SERVICE BRAKE DRUM OR DISC EFFECTIVE DIA, mm</b>	
	Front	:
	Rear	:
	Other	:
	Material (if the braking surface is non-ferrous)	
	Front	:
	Rear	:
	Other	:
<b>A-11</b>	<b>NOMINAL SIZE OF MASTER CYLINDER, mm</b>	:
<b>A-12</b>	<b>NOMINAL SIZE OF WHEEL CYLINDER, mm</b>	
	Front	:
	Rear	:
	Other	:
<b>A-13</b>	<b>PARKING BRAKE</b>	
	Braking wheel	:
	Type	:
	Control (operated by hand/foot)	:

	Locking device	:
<b>A-14</b>	<b>TYRES</b>	
	Tyre size and ply rating	:
	Front wheel	:
	Rear wheel	:
	Other wheel	:
	Inflation pressure—Unladen (kg/cm <sup>2</sup> )	
	Front	:
	Rear	:
	Other wheel	:
	Inflation pressure—Laden (kg/cm <sup>2</sup> )	
	Front	:
	Rear	:
	Other wheel	:
<b>A-15</b>	<b>IN CASE OF VEHICLES FITTED WITH ELECTRICAL REGENERATIVE BRAKING SYSTEM</b>	:
	a) Type (Type A/Type B)	
	b) If Type A, is there a separate control for activating regenerative braking/	
<b>A-16</b>	<b>ANTI-LOCK BRAKING SYSTEM PROVIDED (YES/NO)</b>	
<b>A-16.1</b>	a) If yes, details of ABS	
<b>A-16.2</b>	b) Make	
<b>A-16.3</b>	c) Category of ABS	
<b>A-16.4</b>	d) Nos. of directly controlled wheel(s)	
<b>A-16.5</b>	e) Make of controlling unit ( ECU )	
<b>A-16.5.1</b>	1) Identification No. / Part No. of ECU	
<b>A-16.5.2</b>	2) Brief description of failure warning tell -tale	
<b>A-16.6</b>	f) Wheel speed sensors	
<b>A-16.6.1</b>	1) No. of sensors	
<b>A-16.6.2</b>	2) Make of sensors	
<b>A-16.6.3</b>	3) Type of sensors	
<b>A-16.7</b>	g) Modulator	
<b>A-16.7.1</b>	1) Nos. of modulators	
<b>A-16.7.2</b>	2) Make of modulators	
<b>A-16.7.3</b>	3) Identification No. / Part No. of modulator	
<b>A-16.7.4</b>	4) Brief description and features	
<b>A-16.8</b>	h) Controller	
<b>A-16.8.1</b>	1) Nos. of controller	
<b>A-16.8.2</b>	2) Make of controller	
<b>A-16.8.3</b>	3) Identification No. / Part No. of controller	
<b>A-16.8.4</b>	4) Brief description and features	
<b>A-16.9</b>	j) Height of center of gravity, in mm	
<b>A-16.9.1</b>	1) Unladen condition	
<b>A-16.9.2</b>	2) Laden condition	

## ANNEX B

(Clause 9.2.2)

### CRITERIA FOR EXTENSION OF APPROVAL

**B-1** This Annex gives factors to be considered while selecting a vehicle to represent a range of variants for testing the vehicle for type approval as per this standard and the extension of type approval certificate of one model to changes in technical specification/its variant (s).

**B-2** In general, when changes in technical specifications of vehicle do not affect the brake performance adversely, and it is still within the stipulated limits, the type approval certificate shall be extended. If the changes affect some of the performance parameter, test shall be carried out only for those parameters.

**B-3** The changes in parameters that affect the brake performance adversely and the test to be conducted, if, any, for extending the type approval are listed in Table 3.

In Table 3 'N' denotes that it is not necessary to carry out the test and 'Y' denotes that test is to be carried out and 'NA' denotes not applicable.

**B-4** If during the type approval test, Heat fade test has been carried out as per 5.7.3.1 (c) and the vehicle complies with the requirements stipulated for F test, then no additional tests are needed for change in engine and drive line transmission ratio.

**B-5** Increase in brake torque may be:

- Demonstrated by the design calculation submitted by the manufacturer; or
- By a comparative test on inertia dynamometer as per IS 13453; or
- By carrying out the tests as per 5.3 and 5.4.

**B-6** If the performance of brake lining for which type approval is to be extended, established on inertia dynamometer as per procedure given in IS 13453 is not less than that for the lining already type approved on vehicle trials as established on inertia

dynamometer by 15 percent, the type approval certificate shall be extended without any trials on vehicle.

**B-7** In the case of in an increase in GVW by less than 25 kg for 3-1 and 3-3 categories or by less than 10 percent for 3-2, 3-4 and 3-5 categories from the actual weight used for testing, the brake performance for tests as per 5.3, 5.4 and 5.5 shall be calculated from the test results of the tested model using the formulae given in 8.1 and 8.2. In the case of parking brake performance, the maximum weight which is possible to be held on the gradient for parking brake shall be calculated as per 5.8.3.3. If such calculated values are within the stipulated limits, no additional test need be carried out. Other wise tests as per 5.3, 5.4, 5.5 and 5.8, engine connected and disconnected, as applicable, shall be carried out.

**B-8** Changes such as increase in swept volume, increase in compression ratio, 2 stroke to 4 stroke, petrol to diesel etc. are considered to increase the engine braking effect.

**B-9** In case of vehicles fitted with regenerative braking system, if during the type approval test, tests as per 5.3, 5.4 and 5.5 has been carried out as per 4.1.14.4 with the regenerative braking system disconnected, and the vehicle complies with the requirements stipulated, then no additional tests are needed for changes in the characteristics of traction motor, electronic controller, battery charge levels, regenerative control systems, etc.

**B-10** Criteria for extension of approval of changes for power assisted and ABS system shall be as agreed between certifying agency and manufacturer.

**Table 3 Parameters for Deciding Tests for Extension of Type Approval**  
(Clause B-3)

Sl No.	Parameter	Necessity for Test				
		Engine Disconnected Tests (see 5.3, 5.4 and 5.10)	Engine Connected Tests (see 5.10)	Heat Fade Tests (see 5.7)	Wet Brake Test (see 5.6)	Parking Brake Test (see 5.8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Decrease in maximum speed	N	N	N	N	N
ii)	Change of category 3-1 to 3-3	Y	Y	Y	Y	NA
iii)	Change of category 3-3 to 3-1	N	N	N	N	N
iv)	Increase in maximum speed which does not cause the initial speed tests as per 5.3 to 5.5, 5.7 and 5.10 to be increased by not more than 10 percent of the initial speed used in the testing	N	N	N	N	N
v)	Increase in maximum speed which causes the initial speed for tests as per 5.3 to 5.5, 5.7 and 5.10 to be increased	Y	Y	Y	Y	N

Table 3 (Concluded)

Sl No.	Parameter	Necessity for Test				
		Engine Disconnected Tests (see 5.3, 5.4 and 5.10)	Engine Connected Tests (see 5.10)	Heat Fade Tests (see 5.7)	Wet Brake Test (see 5.6)	Parking Brake Test (see 5.8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	by more than 10 percent of the initial speed used in the testing					
vi)	Any decrease within 10 percent or any increase in wheel base	N	N	N	N	N
vii)	Any decrease by more than 10 percent	Y	Y	N	N	N
viii)	Decrease in GVW	N	N	N	N	N
ix)	In case of 3-1 and 3-3 categories increase in GVW by less than 25 kg from the actual weight used for testing	See B-7	See B-7	N	N	NA
x)	In case of 3-2, 3-4 and 3-5 categories increase in GVW by less than 10 percent of the actual weight used for testing	See B-7	See B-7	N	N	See B-7
xi)	Increase in GVW other than 9 and 10	Y	Y	Y	Y	Y (for 3-2 and 3-5 category)
xii)	Increase in GVW other than 10					
xiii)	Changes in engine which increase or does not reduce the engine braking effect (see B-8)	N	Y	N	N	N
xiv)	Changes which reduces the engine braking effect	N	N	See B-4	N	N
xv)	A change in drive line ratio that increases engine rpm corresponding to gear and the initial speed for engine connected tests	N	N	N	N	N
xvi)	A change in drive line ratio that decreases engine rpm corresponding to gear and the initial speed for engine connected tests	N	Y	See B-4	N	N
xvii)	Change of type of transmission from manual or automatic with a manual disengagement provision to fully automatic	N	N	N	N	N
xviii)	Change of type of transmission from fully automatic to manual or automatic with a manual disengagement provision	Y	Y	Y	N	N
xix)	Changes in brakes which cause a increase in brake torque	See B-5	See B-5	N	N	See B-5
xx)	Changes in brakes which cause a decrease in brake torque	Y	Y	Y	N	Y
xxi)	Changes in configuration such as disc type to drum type or vice versa	Y	Y	Y	Y	Y
xxii)	Fully enclosed disc brakes to partially or not enclosed disc brakes	N	N	N	Y	N
xxiii)	Brake lining material	See B-6	See B-6	See B-6	See B-6	See B-6
xxiv)	Change in tyre size designation which causes an increase in dynamic rolling radius of tyre by 6 percent or more	Y	Y	Y	Y	Y
xxv)	In case of vehicles fitted with electrical regenerative braking system, changes in the performance characteristics of battery, traction motor and electronic controller	See B-9	N	See B-10	N	N

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