

GLOBAL TECHNICAL REGULATION ON MOTORCYCLE BRAKE SYSTEMS.

2nd FINAL DRAFT – Prepared 2005 – 10 – 28

28-GTRBR-05

Changes to 1st Final Draft (12-GTRBR-05) shown in red
Remaining Issues in yellow

1. SCOPE

This **global technical regulation (gtr)** ~~GTR~~ specifies requirements for service brake and, where applicable, associated parking brake systems.

Its purpose is to ensure safe braking performance under normal and emergency riding conditions.

The **gtr** applies to power driven vehicles* with 2 **or** 3 wheels as follows*:

"Category 3 vehicle" means a power driven vehicle with 2 or 3 wheels designed and constructed for the carriage of persons and/or goods.

"Category 3-1 vehicle: two-wheeled moped" means a two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm³ and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.

"Category 3-2 vehicle: three-wheeled moped" means a three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm³ and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.

"Category 3-3 vehicle: two-wheeled motorcycle" means a two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

"Category 3-4 vehicle: tricycle" means 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 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

"Category 3-5 vehicle: motorcycle with sidecar" means a vehicle with three wheels asymmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

These categories do not include:

- a. vehicles with a V max. of < 25 km/h
- b. vehicles equipped for disabled drivers
- ~~the categories include vehicles with electric power.~~

CATEGORY	DESCRIPTION
3-1	2 wheels, engine < 50cc and max speed < 50 km/h
3-2	3 wheels, engine < 50cc and max speed < 50 km/h
3-3	2 wheels, engine > 50 cc or max speed > 50 km/h
3-4	3 wheels — symmetrical, engine > 50 cc or max speed > 50 km/h.
3-5	3 wheels — asymmetric, engine > 50 cc or max speed > 50 km/h (motorcycle ≠ sidecar)

2. DEFINITIONS

The following definitions apply for the purpose of interpreting this gtr and have, where appropriate, been taken from SPECIAL RESOLUTION No. 1: CONCERNING THE COMMON DEFINITIONS OF VEHICLE CATEGORIES, MASSES AND DIMENSIONS (SR1) and indicated in the gtr by *.

2.1 *ABS (Antilock Brake System)* means 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.

2.2 *Baseline test* means 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 eg: **such as the** Heating Procedure or Wet Brake Stop.

2.3 *Brake* means ~~the~~ **those** parts of the brake system ~~in which~~ **where** the forces opposing the movement of the vehicle are developed. (~~per ISO 8710~~)

2.4 *Brake system* means the combination of parts consisting of the Control, Transmission, and Brake, but excluding the engine, whose function it is to progressively to reduce the speed of a moving vehicle, bring it to a halt, and keep it stationary ~~if already~~ **when** halted.

2.5 *Combined Brakes System (CBS)* means:

For **vehicle** categories 3-1 & 3-~~2~~: a **service** brake system where at least two brakes on different axles are ~~actuated~~ **activated** by the operation of a single control.

For **vehicle** categories 3-2 & 3-4: a **service** brake system where the brakes on all axles are **activated** by the operation of a single control.

For **vehicle** category 3-5: a **service** brake system where the brakes on at least the front and rear axles are **activated** by the operation of a single control. (~~Where~~ **If** the rear wheel and sidecar wheel are braked ~~simultaneously~~ **by the same brake system**, this is regarded as the rear brake.)

2.6 *Control* means the part actuated directly by the rider in order to supply the energy **required for braking the vehicle to the** transmission.

~~**2.7** *Controller* means the component designed to evaluate and operate on data transmitted by a sensor and transmit signals to the modulator~~

2.7 Driver mass means 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).

2.8 Engine disconnected means when the engine is no longer connected to the driving wheels.

2.9 Initial Brake Temperature means the temperature of the hottest brake ~~0.32 km~~ before any brake application.

2.10 Laden* means **the** “gross vehicle mass”, **which** is the maximum mass of the fully laden solo vehicle based on its construction and design performances, as declared by the manufacturer. This shall be less than or equal to the sum of the maximum axles’ (group of axles) capacity.

2.11 Lightly loaded means mass in running order plus 15 kgs for test equipment including outriggers, or the laden condition, whichever is less.

2.12 Mass in running order* means the sum of the unladen* vehicle mass and driver mass

~~2.13 Modulator means the component designed to vary braking force in accordance with the signal received from the controller~~

2.13 Peak Friction Coefficient (PFC) means ~~the friction of the test surface~~ **the measure of tire to road surface friction based on the maximum deceleration of a rolling tire, measured in accordance with the method specified in national legislation.**

2.14 Power assisted braking system means a braking system in which the energy necessary to produce the braking force is supplied by the physical effort of the driver assisted by one or more energy supplying devices, for example vacuum assisted (with vacuum booster)

2.15 Secondary brake system means the second service brake system on a vehicle equipped with a combined brake system.

~~2.17 Sensor means a component designed to identify the condition of rotation of the wheel(s) or other dynamic conditions of the vehicle and transmit them to the controller.~~

2.16 Service brake system means the brake systems which are used for slowing the vehicle when in motion.

2.17 Single brake system means a brake system which acts on only one axle.

2.18 Split service braking system means a brake system consisting of two or more subsystems **activated** by a single control designed so that a single failure in any

subsystem (such as a leakage type failure of a hydraulic subsystem) does not impair the operation of any other subsystem.

2.19 Stopping distance means **the** distance travelled by the vehicle from the point of application of the control to the point at which the vehicle reaches a full stop.

2.20 Test speed means **the** vehicle speed measured at the moment **of application of the brake control(s)**

2.21 Transmission means the combination of components that provide the functional link between the control and the brake.

Unladen means “mass in running order”, taken from SR1:

~~This is the nominal mass of the vehicle as determined by the following criteria:~~

~~Sum of unladen vehicle mass and driver’s mass. The driver’s mass is applied in accordance with paragraph 6.1 below:~~

~~In the case of 1-2 vehicles, additional crewmembers for which seating positions are provided shall be included, their mass being equal to, and incorporated in the same way as, that of the driver.~~

~~The weight of test equipment including outriggers, if fitted, will be included in the unladen weight.~~

2.22 V_{max} means the ~~maximum~~ speed attainable by accelerating at a maximum rate from a standing start for a distance of 1.6 km on a level surface, with the vehicle **lightly loaded**. ~~unladen. The vehicle manufacturer may supply this information.~~

3. GENERAL REQUIREMENTS

3.1 Brake system requirements

3.1.1 Each vehicle must meet each of the tests specified for that vehicle category and for those brake features on the vehicle.

3.1.2 Service brake control operation

Vehicles shall have configurations that enable a driver to operate the brake control whilst seated in the normal driving position and with both hands on the steering control.

3.1.3 Parking brake system

If ~~where~~ a parking brake system is fitted, it **shall** ~~must be capable of~~ holding the vehicle stationary on the prescribed slope.

The parking brake shall:

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

Vehicles shall have configurations that enable a driver to be able to **activate** the parking brake whilst seated in the normal driving position.

3.1.4 Two-wheeled vehicles (**vehicle** 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.

3.1.5 Category 3-5 vehicles shall **comply with** the brake system requirements **set out** in **paragraph** 3.1.4 above. A brake on the sidecar wheel is not required **if** the vehicle meets the performance requirements **prescribed** in **section** 4. ~~of this gtr.~~

3.1.6 Three-wheeled vehicles of categories 3-2 and 3-4 shall be equipped with a parking brake system plus one of the following service brake system **options**:

3.1.6.1 two separate service brake systems (**or a split braking system**) which, when applied together, activate the brakes on all wheels, or

3.1.6.2 a service brake system that **activates** the brakes on all wheels and a secondary brake system which may be the parking brake.

3.1.7 Category 3-4 vehicles shall be equipped with a foot operated service brake system which operates on all wheels and a secondary brake system, which may be the parking brake system.

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

3.1.9 For vehicles with a hydraulic transmission, the master cylinder shall:

- a.** have a separate reservoir for each brake system; ~~with its own cover, seal and retention;~~
- 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 ~~easily~~ visible for checking without removal of the cover.

3.1.10 Vehicles that are equipped with a split service brake system shall be fitted with a red warning lamp, that is mounted in clear view of the rider and which shall be activated:

a when ~~if~~ there is a hydraulic failure **on the application of a force** ~~maximum of~~ $\leq 90\text{ N}$ **to the control; and**

b without activation of the brake control, when the brake fluid level in the master cylinder reservoir falls below **the greater of:**

- (1)** the level specified by the manufacturer **and**
- (2)** **the level less than or equal to half** ≤ 0.5 of the fluid reservoir capacity.

To permit function checking, the warning lamp shall be ~~turned on briefly~~ **illuminated by the activation of the ignition switch and shall be extinguished when the check has been completed.**

The warning lamp shall remain on whilst a failure condition exists **whenever the ignition switch is in the “on” position.**

3.1.11 Vehicles that are equipped with an ABS system shall be fitted with an ~~amber~~ **yellow** warning lamp that is mounted in clear view of the rider. The lamp shall be activated whenever there is a malfunction that affects the generation or transmission of response or ~~control~~ signals in the vehicle's ABS system.

For function checking, the warning lamp shall be ~~turned on briefly~~ **illuminated by the activation of the ignition switch and extinguished once the check has been completed.**

The warning lamp shall remain on whilst a failure condition exists **whenever the ignition switch is in the “on” position.**

3.1.12 Brake friction material shall not contain asbestos.

3.2 ~~Brake system, general operation~~

~~3.2.1 Service brake system~~

~~The service brake system shall progressively reduce the speed of the moving vehicle, bring it to a halt, and keep it stationary. The rider shall achieve this whilst seated in the normal driving position and with both hands on the steering control.~~

~~3.2.2 Secondary brake system~~

~~Where a secondary brake system is fitted, it shall progressively reduce the speed of the moving vehicle to a halt in the event of a failure of the service brake system. The rider shall achieve this whilst seated in the normal driving position and with at least one hand on the steering control.~~

3.2 Durability

3.2.1 – Wear of the service brakes shall be compensated for by means of a system of automatic or manual adjustment.

~~The brake system shall take account of friction material wear automatically or by manual means~~

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

3.2.3 - During **all** the tests **in this gtr** and on their completion, there shall be no ~~lining~~ **friction material** detachment and no leakage of brake fluid.

3.3 Measurement of Dynamic performance

The method utilized to measure performance shall be as specified in the respective tests in **section 4**. There are three ways in which the **service brake system** performance may be measured:

3.3.1: MFDD (Mean Fully Developed Deceleration)

Calculation of MFDD :

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

Where :

d_m = mean fully developed deceleration

V_1 = vehicle speed when rider **activates** control

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 traveled between V_1 and V_b in metres

S_e = distance traveled between V_1 and V_e in metres

3.3.2: Stopping distance:

Based on the basic equations of motion:

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

Where:

S = stopping distance in metres

V = vehicle speed in km/h

X = a 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:

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

Where:

S_s = corrected stopping distance in metres

V_s = specified vehicle test speed in km/h

S_a = actual stopping distance in metres

V_a = actual vehicle test speed in km/h

Note: This equation is only valid when the actual test speed (V_a) is within ± 5 km/h of the specified test speed (V_s)

3.3.3 Continuous Deceleration Recording:

For tests such as the Wet Brake and Heat Fade – Heating Procedure, there shall be a continuous recording of the vehicle deceleration from the point where the brake control is applied until the end of the stop.

4. TEST CONDITIONS, PROCEDURES AND PERFORMANCE REQUIREMENTS.

4.1 General

4.1.1 Test surfaces:

4.1.1.1 Dynamic brake tests (excluding low friction ABS tests):

The test area shall have a clean, dry and level surface, with a gradient $\leq 1\%$

The surface shall have a nominal peak friction coefficient (PFC) of **0.9 or less**, unless otherwise specified.

4.1.1.2 Low friction ABS tests:

Vehicles with ABS shall also be tested on a **clean and level** surface, **with a gradient $\leq 1\%$** , with a peak friction coefficient of ≤ 0.45 .

4.1.1.3 Parking brake tests:

The **specified test slope** shall have a clean and dry ~~solid~~ surface **that does not deform under the weight of the vehicle.**

4.1.1.4 **Test** lane width:

For 2 wheeled vehicles (**vehicle** categories 3-1 and 3-3) the **test** lane width shall be 2.5m.

For 3 wheeled vehicles (**vehicle** categories 3-2, 3-4 and 3-5) the **test** lane width shall be 2.5m + the vehicle width.

4.1.2 Ambient temperature:

The ambient temperature shall be between 4°C and ~~38~~ **45°C** .

4.1.3 Wind speed:

The wind speed shall be not more than 5 m/s

4.1.4 Test speed tolerance:

The test speed tolerance shall be ± 5 km/h.

In the event of the actual test speed deviating from the specified test speed, the actual stopping distance shall be corrected using the formula in paragraph 3.3.2

~~[4.1.4 Tolerances:~~

~~Unless otherwise specified, a general tolerance of $\pm 10\%$ shall be applied to all test parameters.]~~

4.1.5 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 shall be selected for tests where “engine disconnected” is specified.

4.1.6 Vehicle position and wheel lock:

- The vehicle shall be positioned in the centre of the test lane for the beginning of each stop.
- Stops shall be made without the vehicle wheels passing outside the **applicable** test lane and without wheel lock.

4.1.7 Test sequence

TEST ORDER	SECTION
1. Dry Stop - single brake control activated	4.3
2. Dry Stop - all service brake controls activated	4.4
3. High Speed	4.5
4. Wet Brake	4.6
5. Heat Fade (1)	4.7
6. If fitted:	
6.1 Parking Brake	4.8
6.2 ABS	4.9
6.3 Partial failure, for split service brake systems	4.10
6.4 Servo Power-assisted braking system failure	4.11

Note (1): Heat Fade shall always be the last test carried out

4.2 Preparation

4.2.1 Engine idle speed:

The engine idle speed shall be set to the manufacturer's specification.

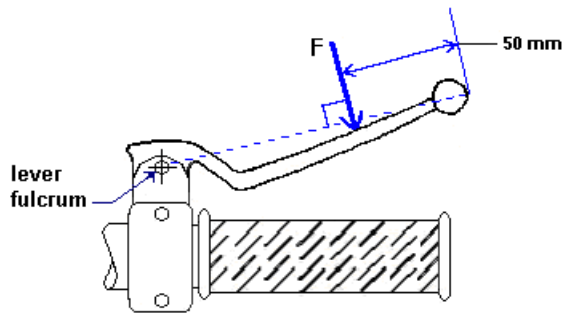
4.2.2 Tyre pressures:

The tyres shall be inflated to the manufacturer's specification for the vehicle loading condition for the test.

4.2.3 Control lever application points and direction:

For **a** hand control lever, the input force (F) shall be 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 figure below).

The input force shall be **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 shall be applied to the centre of the pedal and at right angles to the **control** pedal.

4.2.4 Brake temperature measurement:

The brake temperature shall be measured on the approximate centre of the braking path of the disc or drum using:

- a rubbing thermocouple that is in contact with the surface of the disc or drum or
- a thermocouple that is embedded in the friction material

Contracting parties may specify which method is acceptable **for the purpose of** establishing **conformity compliance with** these requirements.

4.2.5 Burnishing procedure:

[The following procedure shall be used, unless the manufacturer supplies the vehicle for testing with the brakes already burnished.]

OR

The following procedure shall be used. However, if the certification is based on type approval, the manufacturer may supply the vehicle for testing with the brakes already burnished.]

- Vehicle **lightly loaded.** ~~unladen.~~
- Engine disconnected
- Test speed:
 - Initial speed: ≥ 50 km/h **for vehicle category 3-3, 3-4, 3-5**
 - : $\geq 0.8 V_{max}$, for vehicle category 3-1, 3-2**
 - Final speed 5 to 10 km/h
- Brake application:
 - Each brake control applied separately.

- Vehicle deceleration:

Front wheel braking only:

3.0-3.5 m/s² **for vehicle category 3-3, 3-4, 3-5**

1.5-2.0 m/s² for vehicle category 3-1, 3-2

Rear wheel braking only: 1.5-2.0 m/s²

CBS or split service brake system: 3.5-4.0m/s²

- Number of decelerations: 100 per brake system

- Initial brake temperature before each brake application $\leq 100^{\circ}$ C.

- For the first stop, accelerate the vehicle to the ~~test~~ **initial** speed and then activate the brake control under the conditions specified above **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 control **as specified.**~~above~~ Repeat **this procedure** for the number of specified decelerations.

4.3 Dry Stop Test – single brake control activated

4.3.1 Vehicle condition.

- **The test is applicable to all vehicle categories.**
- Laden
For vehicles fitted with CBS **and split service brake systems: the vehicle is also tested in the lightly loaded** ~~unladen~~ **condition.**
- Engine disconnected

4.3.2 Test conditions and procedure

- Initial brake temperature: $\geq 55^{\circ}$ C and $\leq 100^{\circ}$ C
- Test speed :
Vehicle categories 3-1 & 3-2: 40 km/h or 0.9 Vmax, whichever is the lower
Vehicle categories 3-3, 3-4 & 3-5: 60 km/h or 0.9 Vmax, whichever is the lower
- Brake application:
Each brake control separately.
- Brake actuation force:
Hand control: ≤ 200 N
Foot control: ≤ 350 N for **vehicle categories** 3-1, 3-2, 3-3, 3-5

≤500N for **vehicle category** 3-4

- Number of stops : until the vehicle meets the performance requirements, with a maximum of 6 stops
- For each stop, accelerate the vehicle to the test speed and then activate the brake control under the conditions specified above

4.3.3 Performance requirements

When the brakes **are** ~~have been~~ tested in accordance with the test procedure **set out in paragraph** 4.3.2, the stopping distance shall be as specified in column 2 **or** the MFDD shall be as specified in column 3 of the following table:

column 2		column 3	
Vehicle Category	STOPPING DISTANCE (S) (Where V is the specified test speed in km/h and S is the required stopping distance in metres)	Θ R	MFDD
Single front brake system only:			
3-1	$S \leq 0.1 V + 0.011V^2$		$\geq 3.4\text{m/s}^2$
3-2	$S \leq 0.1 V + 0.014V^2$		$\geq 2.7\text{m/s}^2$
3-3	$S \leq 0.1 V + 0.0087V^2$		$\geq 4.4\text{m/s}^2$
3-4			
3-5	$S \leq 0.1 V + 0.011V^2$		$\geq 3.6\text{m/s}^2$
Single rear brake system only			
3-1	$S \leq 0.1 V + 0.014V^2$		$\geq 2.7 \text{ m/s}^2$
3-2	$S \leq 0.1 V + 0.014V^2$		$\geq 2.7\text{m/s}^2$
3-3	$S \leq 0.1 V + 0.013V^2$		$\geq 2.9\text{m/s}^2$
3-4			
3-5	$S \leq 0.1 V + 0.010V^2$		$\geq 3.6\text{m/s}^2$
Vehicles with CBS or Split Service Brake Systems: laden or unladen lightly loaded.			
3-1 + 3-2	$S \leq 0.1 V + 0.0087V^2$		$\geq 4.4\text{m/s}^2$
3-3	$S \leq 0.1 V + 0.0076V^2$		$\geq 5.1\text{m/s}^2$
3-4	$S \leq 0.1 V + 0.0077V^2$		$\geq 5.0\text{m/s}^2$
3-5	$S \leq 0.1 V + 0.0071V^2$		$\geq 5.4\text{m/s}^2$
Vehicles with CBS – secondary brake only			
ALL	$S \leq 0.1 V + 0.015V^2$		$\geq 2.5 \text{ m/s}^2$

4.4 Dry Stop Test – all service brake controls activated

4.4.1 Vehicle condition.

- The test is applicable to vehicle categories 3-3, 3-4, 3-5.

~~—Unladen~~ **Lightly loaded.**

- Engine disconnected

4.4.2 Test conditions and procedure

- Initial brake temperature : $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$.
- Test speed: 100 km/h or 0.9 V_{max} , whichever is the lower.
- Brake application:
Simultaneous ~~application~~ **actuation** of both brake controls, if so equipped, or of the single brake control in the case of a service brake system that operates on all wheels.
- Brake actuation force:
Hand control: $\leq 250\text{N}$
Foot control: $\leq 400\text{N}$
 $\leq 500\text{N}$ for **vehicle category** 3-4
- Number of stops : until the vehicle meets the performance requirements, with a maximum of 6 stops
- For each stop, accelerate the vehicle to the test speed and then apply the brakes under the conditions specified above

4.4.3 Performance requirements

When the brakes ~~have been~~ **are** tested in accordance with the test procedure **set out in paragraph** 4.4.2, the stopping distance (S) shall be:

a. For test speeds $< 80.5\text{ km/h}$, $S \leq 0.0055 V^2$

b. For test speeds $\geq 80.5\text{ km/h}$, $S \leq 0.0060 V^2$

(where V is the specified test speed in km/h and S is the required stopping distance in metres)

4.5 High Speed Test

4.5.1 Vehicle condition

- The test is applicable to vehicle categories 3-3, 3-4 **and** 3-5
- Test is not required for vehicles with $V_{\text{max}} \leq 125\text{ km/h}$

~~—Unladen~~ **Lightly loaded.**

- Engine connected **with the transmission in the highest gear**

4.5.2 Test conditions and procedure

- Initial brake temperature : $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$
- Test speed: $0.8 V_{\text{max}}$ for vehicles with $V_{\text{max}} > 125\text{ km/h}$ and $< 200\text{ km/h}$.
 160 km/h for vehicles with $V_{\text{max}} \geq 200\text{ km/h}$ ~~V_{max}~~
- Brake application:
~~Both brake controls shall be activated at the same moment~~
Simultaneous application of both brake controls, if so equipped, or of the single brake control in the case of a service brake system that operates on all wheels
- Brake actuation force:
Hand control $\leq 200\text{N}$
Foot control $\leq 350\text{N}$ for **vehicle categories** 3-3, and 3-5
 $\leq 500\text{N}$ for **vehicle category** 3-4
- Number of stops : until the vehicle meets the performance requirements, with a maximum of **4 6** stops
- For each stop, accelerate the vehicle to the test speed and then activate the brake control under the conditions specified ~~above~~

4.5.3 Performance requirements

When the brakes **are** tested in accordance with the test procedure **set out in paragraph 4.5.2**:

- The stopping distance (S) shall be $\leq 0.1 V + 0.00671V^2$
(where V is the specified test speed in km/h and S is the required stopping distance in metres)
or the MFDD shall be $\geq 5.8\text{m/s}^2$

4.6 Wet Brake Test

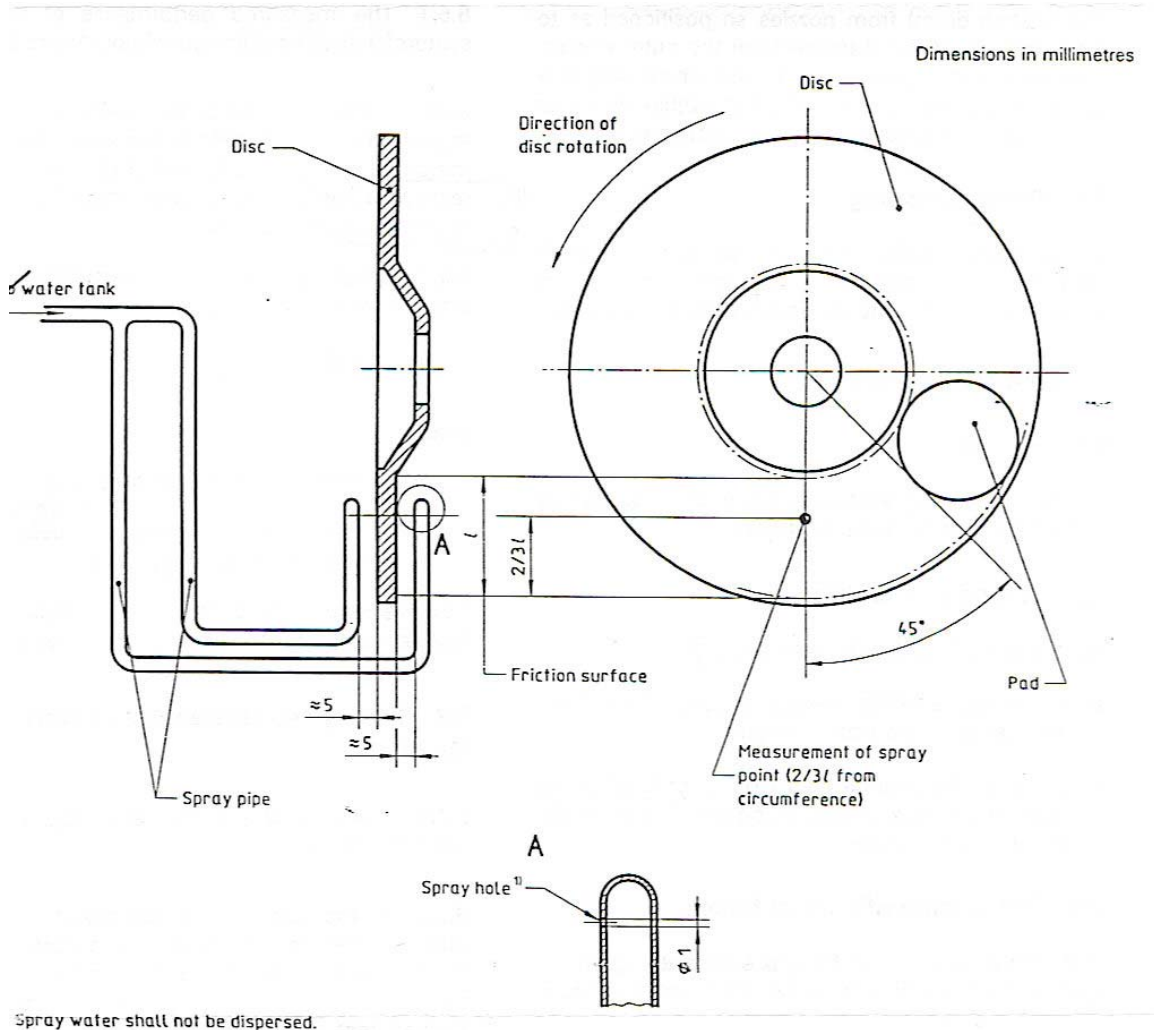
4.6.1 General information:

- The test comprises two parts that shall be carried out consecutively for each brake system:
 - a. A **baseline** test based on the Dry Stop Test - single brake control activated (**paragraph 4.3**).
 - b. A single **wet brake** stop using the same test parameters as in a. above but with the brake(s) being continuously sprayed with water **while the test is conducted** in order to assess the effect of riding in wet conditions.
- The test is not applicable to parking brakes
- Drum brakes or fully enclosed disc brakes are exempt from this test unless ventilation or open inspection ports are present.
- 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.

4.6.2 Vehicle condition.

- The test is applicable to all vehicle categories
- Laden
For vehicles fitted with CBS **and split service brake systems: the vehicle is also tested in the lightly loaded** ~~unladen~~ **condition.**
- Engine disconnected
- Each brake shall be fitted with water spray equipment

a. Disc Brakes : Sketch of water spray equipment:



The disc brake water spray equipment **shall be installed as follows:**

- Water shall be sprayed onto each brake with a flow rate of 15 litres/hr. The water shall be equally distributed on each side of the rotor.
- If the surface of the rotor has any shielding, the spray shall be applied 45° prior to the shield.
- If it is not ~~feasible~~ **possible** to position the spray at 45° as shown on the sketch, or if the spray coincides with a brake ventilation hole or similar, the spray may be moved 90° max prior to this position.

b. Drum Brakes with ventilation and open inspection ports:

The water spray equipment shall be installed as follows:

- **Water shall be 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 litres/hr.**

- **The spray nozzles shall be positioned two thirds of the distance from the outer circumference of the rotating drum to the wheel hub centre.**
- The nozzle **position** shall be $> 15^\circ$ from the edge of any opening in the drum back plate.

4.6.3 Baseline Test:

- **Carry out the test in ~~section~~ paragraph 4.3 (Dry Stop Test - single brake control activated) for each brake system but with the brake control force that results in a vehicle deceleration of $2.5 - 3.0 \text{ m/s}^2$, and determine the following:**
 - The average brake control force measured when the vehicle is travelling between 80% and 10% of the specified test speed.**
 - The average vehicle deceleration in the period 0.5 to 1.0 seconds after the point of application of the brake control.**
 - The maximum vehicle deceleration during the complete stop but excluding the final 0.5 seconds.**
 - To ensure repeatability, 3 baseline stops are performed and the average values of a, b, and c are calculated.**

~~To ensure repeatability:~~

- ~~3 baseline stops shall be performed~~
- ~~For each baseline stop, the brake control force and vehicle deceleration shall be recorded. The average brake control force shall be determined for the period between 80 and 10% of the specified test speed.~~
- ~~The average of these 3 control force values shall be used for the subsequent Wet Brake Stop.~~

4.6.4 Wet Brake Stop:

4.6.4.1 Test conditions and procedure

- The vehicle **is** ridden at the test speed used in the baseline test **set out in paragraph 4.6.3** with the water spray equipment operating on the brake(s) to be tested and with no activation of the brake system.
- After a distance of $\geq 500 \text{ m}$, apply ~~the control for the brake system being tested with the average input force~~ **the average brake control force determined in baseline test 4.6.3a** for the brake system being tested.
- Measure the average vehicle deceleration in the period 0.5 to 1.0 seconds after **the point of application of the** brake control.
- Measure the maximum vehicle deceleration during the complete stop but excluding the final 0.5 seconds.**

4.6.5. Performance requirements

When tested in accordance with **paragraph 4.6.4.1**, the wet brake deceleration performance shall be:

$\geq 60\%$ of the **average** deceleration value recorded in the baseline test **4.6.3b** (in the period **of 0.5 to 1.0 seconds** after **the point of application of the** brake control)

$\leq 120\%$ of the deceleration **average** value recorded in the baseline test **4.6.3c** (during the complete stop **but excluding the final 0.5 seconds**)

4.7 Heat Fade Test

4.7.1 General information:

- The test is comprised of three parts that shall be carried out consecutively for each brake system:
 - a A **baseline** test ~~based on~~ **using** the Dry Stop Test - single brake control activated (**paragraph 4.3**).
 - b A **heating procedure** which ~~includes~~ **consists of** a series of repeated stops in order to heat the brake(s)
 - c. A **hot brake** stop ~~based on~~ **using** the Dry Stop Test - single brake control activated (**paragraph 4.3**), to measure the brake's performance after the heating procedure.
- The test is applicable to vehicle categories 3-3, 3-4 **and** 3-5.
- The test is not applicable to parking brakes ~~or~~ **and** secondary brakes.
- All stops **shall be carried out** with the vehicle laden
- 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 and hot brake stops require the measurement of either MFDD or the stopping distance.

4.7.2 Baseline Test:

4.7.2.1 Vehicle condition.

- Engine disconnected

4.7.2.2 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 Vmax, whichever is the lower.**
- Brake application:
Separate test using each brake control.
- Brake actuation force:
Hand control $\leq 200\text{N}$
Foot control $\leq 350\text{N}$ for **vehicle categories** 3-3 and 3-5
 $\leq 500\text{N}$ for **vehicle category** 3-4
- Accelerate the vehicle to the test speed, activate the brake control under the conditions specified and record the control force **required** to achieve the vehicle braking performance specified in the table **to paragraph** 4.3.3

4.7.3 Heating Procedure

4.7.3.1 Test conditions and procedure

- Initial brake temperature prior to first stop only: $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$
- **Specified** Test speed:
Front brakes(s): 100 km/h or 0.7V max, whichever is the lower.
Rear brake(s): 80 km/h or 0.7V max, whichever is the lower.
CBS: 100 km/h or 0.7V max, whichever is the lower.
- Brake application:
Separate **application** test for each brake control.
- Brake actuation force:
For the first stop:
The a constant control force that achieves a vehicle deceleration rate of $3.0 - 3.5\text{ m/s}^2$ ~~for the duration of the first stop.~~ for the period **when the vehicle is travelling** between 80% and 10% of the **specified** test speed.
~~Record the brake control force and vehicle deceleration for the duration of the stop. Determine the constant brake control force~~
For the remaining stops:
The average **constant** brake control input force used for the first stop is repeated for each of the remaining stops.
Note that if the vehicle is unable to achieve the specified vehicle deceleration rate, these stops shall be carried out at the maximum achievable value.
- Number of stops: 10

- Interval between stops: 1000 m.
- Engine transmission:
 - a. From the ~~test~~ **specified** speed to 50% ~~test~~ **specified** speed: connected, with the highest **appropriate** gear selected **such that the engine speed remains above the manufacturer's specified idle speed.**
 - b. From 50% ~~test~~ **specified** speed to standstill: disconnected.
- Carry out a stop to the conditions specified above and then immediately use maximum acceleration to reach the ~~test~~ **specified** speed and maintain that speed until the next stop is made.

4.7.4 Hot Brake Stop:

4.7.4.1 Test conditions and procedure

Perform a single stop under the conditions used in the baseline test (**paragraph 4.7.2**) for the brake system that has been heated during **testing in accordance with paragraph 4.7.3**. This stop **is** carried out within one minute of the completion of the test **set out in paragraph 4.7.3** with a ~~an average~~ brake actuation force **less than or equal to** \leq the ~~average~~ force used **during the test set out in paragraph 4.7.2**.

4.7.5 Performance Requirements

When the brakes have been tested in accordance with **paragraph 4.7.4.1**, **their** performance shall be:

If based on MFDD, $\geq 60\%$ of the MFDD recorded in the test **set out in paragraph 4.7.2 or**

If based on stopping distance, $S_2 \leq 1.67 S_1 - 0.67 \times 0.1V$

Where:

S_1 = stopping distance in metres achieved in **the** baseline test **set out in paragraph 4.7.2**

S_2 = stopping distance in metres achieved in **the** hot brake stop **set out in paragraph 4.7.4.1**

V = test speed in km/h.

4.8 Parking Brake Test – for vehicles equipped with parking brakes

4.8.1 Vehicle condition.

- **The test is applicable to vehicle categories 3-2, 3-4 and 3-5.**
- Laden
- Engine disconnected

4.8.2 Test conditions and procedure

- Initial brake temperature: $\leq 100^{\circ}\text{C}$
- Test surface gradient = 18%
- Brake actuation force:
Hand control $\leq 400\text{ N}$.
Foot control $\leq 500\text{ N}$.
- For the first part of the test, park the vehicle on the test surface gradient facing up the slope by activating the brake system under the conditions specified above. If the vehicle remains stationary, start the measurement of **the test period**.~~time~~.
- On completion of the test with vehicle facing up **the gradient**, repeat the same test procedure with the vehicle facing down the gradient.

4.8.3 Performance requirements

When tested in accordance with the test procedure **set out in paragraph** 4.8.2, the parking brake system shall hold the vehicle stationary for 5 minutes **when the vehicle is both facing up and facing down** ~~in both forward and reverse directions on~~ the gradient.

4.9 ABS Tests

4.9.1 General information:

- 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 including the performance in the event of ABS electrical failure.**

- **“Wheel lock” means the condition that occurs when there is a slip ratio of 1.00. However, in practice, wheel lock is judged to have occurred when a vehicle’s speed exceeds 15 km/h while its wheel speed falls below 5 km/h. at the tyre to road interface (as defined in ISO 12364 – Two-wheeled motorcycles – Antilock braking systems (ABS) – Tests and measurement methods)**
- **"Fully cycling" means that the anti-lock system is repeatedly modulating the brake force to prevent the directly controlled wheels from locking. Brake applications where modulation only occurs once during the stop shall not be considered to meet this definition (as defined in annex 6 of ECE Regulation No. 13H)**
- The test series comprises the following individual tests, which may be carried out in any order:

ABS TESTS	SECTION PARAGRAPH
a. Stops on a high friction surface - as used for tests set out in paragraph 4.3 specified in paragraph 4.1.1.1	4.9.3
b. Stops on a low friction surface - ≤0.45 as specified in paragraph 4.1.1.2	4.9.4
c. Wheel lock checks on high and low friction surfaces.	4.9.5
d. Wheel lock check - high to low friction surface transition.	4.9.6
e. Wheel lock check - low to high friction surface transition.	4.9.7
f. Stops with an ABS electrical failure.	4.9.8

4.9.2 Vehicle condition

- ~~Unladen~~ **Lightly loaded.**
- Engine disconnected

4.9.3 Stops on a high friction surface:

4.9.3.1 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 Vmax, whichever is lower.
- Brake application:

Each brake control separately.

- Brake actuation force:
Hand control = 200N ± **20%**
Foot control = 350N ± **20%**
These forces may be increased in order to ensure that the ABS is **fully** cycling during the stop.
For systems where the brake actuation force fluctuates due to ABS operation, the nominal brake actuation force shall be the mean value applied for the duration of the stop.
- Number of stops: until the vehicle meets the performance requirements, with a maximum of 6 stops.
- For each stop, accelerate the vehicle to the test speed and then activate the brake control under the conditions specified above.

—Record wheel rotation

[4.9.3.2 Performance requirements

When the vehicle **is** tested in accordance with the test procedures **referred to in paragraph 4.9.3.1**, there shall be no wheel lock and the vehicle wheels shall stay within the test lane.]

Note: Until further data has been collected, the measurement of stopping distance or MFDD is not required.

~~The stopping distance shall be as specified in column 2 or the MFDD shall be as specified in column of the following table (based on 0.7 x the performance requirements specified in paragraph 4.3.3 — Dry Stop Test — single brake control activated):~~

Category	STOPPING DISTANCE (S) (Where V is the specified test speed in km/h and S is the required stopping distance in metres)	OR	MFDD
For single front brakes only:			
3-1	$S \leq 0.1 V + V^2/64$		$\geq 2.4 \text{m/s}^2$
3-3	$S \leq 0.1 V + V^2/81$		$\geq 3.1 \text{m/s}^2$
For single rear brakes only			
3-1	$S \leq 0.1 V + V^2/49$		$\geq 1.9 \text{m/s}^2$
3-3	$S \leq 0.1 V + V^2/52$		$\geq 2.0 \text{m/s}^2$
For CBS:			
3-1	$S \leq 0.1 V + V^2/81$		$\geq 3.1 \text{m/s}^2$
3-3	$S \leq 0.1 V + V^2/93$		$\geq 3.6 \text{m/s}^2$

4.9.4 Stops on a low friction surface:

4.9.4.1 Test conditions and procedure:

As set out in paragraph 4.9.3.1 but using the low friction surface instead of the high friction one.

4.9.4.2 Performance requirements

[When the vehicle **is** tested in accordance with the test procedures **referred to in paragraph 4.9.4.1**, there shall be no wheel lock and the vehicle wheels shall stay within the test lane.]

Note: Until further data has been collected, the measurement of stopping distance or MFDD is not required.

4.9.5 Wheel lock checks on high and low friction surfaces.

4.9.5.1 Test conditions and procedure

- Test surfaces:
 - a. High friction **and**
 - b. Low friction
- Initial brake temperature : $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$
- Test speed:
 - a. **On high friction surface:** 80 km/h or 0.8 Vmax, whichever is lower.
 - b. **On low friction surface:** 60 km/h or 0.8 Vmax, whichever is lower.
- Brake application:
 - a. Each brake control separately **and**:
 - b. Where ABS is fitted to both brake systems, both controls **are** activated at the same moment.
- Brake actuation force:
 - Hand control = 200N \pm **20%**
 - Foot control = 350N \pm **20%**
 - These forces may be increased in order to ensure that the ABS is **fully** cycling during the stop.

For systems where the brake actuation force fluctuates due to ABS operation, the nominal brake actuation force shall be the mean value applied for the duration of the stop.

- Brake application rate:
The brake actuation force shall be applied in 0.2 – 0.5 seconds
- Number of stops: Maximum of 3 stops
- For each stop, accelerate the vehicle to the test speed and then activate the brake control under the conditions specified above. ~~The brake control may be released and the test concluded when the vehicle speed has reduced by 20 km/h.~~

4.9.5.2 Performance requirements

When the vehicle **is** tested in accordance with the test procedures **set out in paragraph 4.9.5.1**, there shall be no wheel lock and the vehicle wheels shall stay within the test lane.

4.9.6 Wheel lock check - high to low friction surface transition.

4.9.6.1 Test conditions and procedure

- Test surfaces:
A ~~length of~~ **wet** high friction surface **of > 0.8 PFC** immediately followed by a ~~length of~~ low friction surface.
- Initial brake temperature : $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$
- Test speed:
The speed that will result in 50 km/h or 0.5V max, whichever is the lower, at the point where the vehicle passes from the high friction to the low friction surface.
- Brake application:
 - a. Each brake control separately **and**:
 - b. Where ABS is fitted to both brake systems, both controls **are** ~~shall also be~~ activated at the same moment.
- Brake actuation force:
Hand control = $200\text{N} \pm 20\%$
Foot control = $350\text{N} \pm 20\%$
These forces may be increased in order to ensure that the ABS is **fully** cycling during the stop.

For systems where the brake actuation force fluctuates due to ABS operation, the nominal brake actuation force shall be the mean value applied for the duration of the stop.

- Number of stops: Maximum of 3 stops
- For each stop, accelerate the vehicle to the test speed and then activate the brake control **before the vehicle reaches the transition from one friction surface to the other.** ~~under the conditions specified above.~~
- ~~The brake control may be released and the test concluded when the vehicle speed has reduced by 20 km/hr after crossing the surface transition point.~~

4.9.6.2 Performance requirements

When the vehicle **is** tested in accordance with the test procedures **set out** in 4.9.6.1, there shall be no wheel lock and the vehicle wheels shall stay within the test lane.

4.9.7 Wheel lock check - low to high friction surface transition.

4.9.7.1 Test conditions and procedure

- Test surfaces:
A ~~length of~~ low friction surface immediately followed by a ~~length of~~ **wet** high friction surface **of > 0.8 PFC**
- Initial brake temperature : $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$
- Test speed:
The speed that will result in 50 km/h or 0.5V max, whichever is the lower, at the point where the vehicle passes from the low friction to the high friction surface.
- Brake application:
 - a. Each brake control separately **and:**
 - b. Where ABS is fitted to both brake systems, both controls **are** activated at the same moment.
- Brake actuation force:
Hand control = $200\text{N} \pm 20\%$
Foot control = $350\text{N} \pm 20\%$
These forces may be increased in order to ensure that the ABS is **fully** cycling during the stop.
For systems where the brake actuation force fluctuates due to ABS operation, the nominal brake actuation force shall be the mean value applied for the duration of the stop.

- Number of stops: Maximum of 3 stops
- For each stop, accelerate the vehicle to the test speed and then activate the brake control **before the vehicle reaches the transition from one friction surface to the other**. ~~under the conditions specified above.~~
- Record the vehicle's continuous deceleration.

4.9.7.2 Performance requirements

- When the vehicle **is** tested in accordance with the test procedures **set out in paragraph 4.9.7.1**, there shall be no wheel lock and the vehicle wheels shall stay within the test lane.
- **[After passing over the transition point between the low and high friction surfaces, the vehicle deceleration shall increase.]**

4.9.8 Stops with an ABS electrical failure.

4.9.8.1 Test conditions and procedure

- **With the ABS electrical system disabled**, carry out the test **set out in paragraph 4.3** (Dry stop test – single brake control activated) applying the conditions relevant to the brake system and vehicle being tested.

4.9.8.2 Performance requirements

When the brakes **are** tested in accordance with the test procedure **set out in paragraph 4.9.8.1**:

- **the system shall comply with the failure warning requirements of paragraph 3.1.11 and**
- the minimum requirements for stopping distance or MFDD shall be as specified in **column 2 or 3, respectively, under the heading “single rear brakes only” in the table to paragraph 4.3.3.**

4.10 Partial failure test – for split service brake systems

4.10.1 General information:

- The test is only applicable to vehicles that are equipped with split service brake systems.
- The test is to confirm the performance of the remaining sub system in the event of a hydraulic system leakage failure.

4.10.2 Vehicle condition

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

4.10.3 Test conditions and procedure

- Initial brake temperature: $\geq 55^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$
- Test speeds: 50 km/h and 100 km/h or 0.8 V_{max} , whichever is lower.
- ~~Minimum test speed = 25 km/h~~
- Brake actuation force:
 - Hand control $\leq 250\text{N}$
 - Foot control $\leq 400\text{N}$
- Number of stops: until the vehicle meets the performance requirements, with a maximum of 6 tests **for each test speed.**
- **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 apply the brakes under the conditions specified above.
- Repeat **the test** for each subsystem.

4.10.4 Performance requirements

When the brakes **are** tested in accordance with the test procedure **set out** in **paragraph 4.10.3**:

- the system shall comply with the failure warning requirements **set out in paragraph 3.1.10** and
- the stopping distance (S) shall be $\leq 0.1 V + 0.012V^2$
(where V is the specified test speed in km/h and S is the required stopping distance in metres)
or the MFDD shall be $\geq 3.3\text{m/s}^2$

4.11 **Power-assisted braking system** failure Test

4.11.1 General information:

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

4.11.2 Test conditions and procedure

- Carry out the test **set out in paragraph** 4.3 (Dry Stop Test – single brake control activated) if ~~required~~ for each brake system with the **power assistance** disabled.

4.11.3 Performance requirements

When the **service brake system** has been tested in accordance with the test procedure **set out in paragraph** 4.11.2, the stopping distance shall be as specified in column 2 or the MFDD shall be as specified in column 3 of the following table:

column 2		column 3	
Vehicle Category	STOPPING DISTANCE (S) (Where V is the specified test speed in km/h and S is the required stopping distance in metres)	Θ R	MFDD
Single rear brake system only			
3-1	$S \leq 0.1 V + 0.014V^2$		$\geq 2.7 \text{ m/s}^2$
3-2	$S \leq 0.1 V + 0.014V^2$		$\geq 2.7\text{m/s}^2$
3-3	$S \leq 0.1 V + 0.013V^2$		$\geq 2.9\text{m/s}^2$
3-5	$S \leq 0.1 V + 0.011V^2$		$\geq 3.6\text{m/s}^2$
Vehicles with CBS – secondary brake only			
ALL	$S \leq 0.1 V + 0.015V^2$		$\geq 2.5 \text{ m/s}^2$

~~Stopping distance (S) shall be $\leq 0.1 V + \frac{V^2}{65}$~~

~~(where V is the specified test speed in km/h and S is the corrected stopping distance in metres)~~

~~_____ or the MFDD shall be $\geq 2.5 \text{ m/s}^2$~~

- Note that if the **power assistance may be** activated by more than one control, the above performance shall be achieved ~~for~~ **when** each control is applied separately.