PASSENGER VEHICLE GLOBAL BRAKING REGULATION PVGTR 2005-1a.

(PVGTRbraking-wipe)

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER VEHICLES WITH REGARD TO BRAKING

CONTENTS

REGULATION

1. SCOPE and PURPOSE.

2. APPLICATION.

2.1. This Regulation applies primarily to the braking of vehicles of **category 1-1** , as defined in TRANS/WP29/GRSG/2004/25.

The Application may be extended in National Regulations but the requirements shall not be amended Nationally.

2.2. This Regulation does **not** cover:

2.2.1. vehicles with a design speed **not** exceeding **25 km/h**;

2.2.2. vehicles fitted for invalid drivers.

3. DEFINITIONS.

For the purposes of this Regulation,

3.1. "**Approval of a vehicle**" means the recognised and authorised approval of a vehicle type with regard to braking;

3.2. "**Vehicle type**" means a category of vehicles which do not differ in such essential respects as:

3.2.1. the maximum mass, as defined in paragraph **3.11.** below;

3.2.2. the distribution of mass among the axles;

3.2.3. the maximum design speed;

3.2.4. a different type of braking equipment, with more particular reference to the presence or otherwise of equipment for braking a trailer or presence of an electric braking system;

3.2.5. the engine type;

3.2.6. the number and ratios of gears;

3.2.7. the final drive ratios;

3.2.8. the tyre dimensions;

3.3. "**Braking equipment**" means the combination of parts whose function is progressively to reduce the speed of a moving vehicle or bring it to a halt, or to keep it stationary if it is already halted; these functions are specified in paragraph **4.1.2.** below. The equipment consists of the control, the transmission, and the brake proper;

3.4. "**Control**" means the part such as a pedal, actuated directly by the driver to furnish to the transmission, the energy required for braking or controlling it. This energy may be the muscular energy of the driver, or energy from another source controlled by the driver, or a combination of these various kinds of energy;

3.5. "**Transmission**" means the combination of components comprised between the control and the brake and linking them functionally. The transmission may be mechanical, hydraulic, pneumatic, electric or mixed. Where the braking power is derived from or assisted by a **source of energy** independent of the driver, the reserve of energy in the system is likewise part of the transmission.

The transmission is divided into **two** independent functions: the control transmission and the energy transmission. Whenever the term "transmission" is used alone in this Regulation, it means **both** the "control transmission" and the "energy transmission":

3.5.1. "**Control transmission**" means the combination of the components of the transmission which control the operation of the brakes, including the control function and the necessary reserve(s) of energy;

3.5.2. "**Energy transmission**" means the combination of the components which supply to the brakes the necessary energy for their function, including the reserve(s) of energy necessary for the operation of the brakes;

3.7. "**Different types of Braking Equipment**" means equipment which differ in such essential respects as:

3.7.1. components having different characteristics;

3.7.2. a component made of materials having different characteristics, or a component differing in shape or size;

3.7.3. a different assembly of the components.

3.8. **"Braking Rate"** means the deceleration of the vehicle divided by g (the gravitational acceleration constant).

3.8.1. "**Snub**" means the braking deceleration of a vehicle from a higher reference speed to a lower reference speed that is greater than zero.

3.9. "**Progressive and Graduated braking**" means braking during which, within the normal operating range of the device, and during actuation of the brakes (see paragraph **3.13.** below):

3.9.1. the driver can at any moment increase or decrease the braking force by acting on the control;

3.9.2. the braking force varies proportionally as the action on the control (monotonic function);

3.10. Vehicle Mass.

3.10.1. "**Laden vehicle**" means, except where otherwise stated, a vehicle so laden as to attain its "maximum mass";

3.10.2. **"Unladen or lightly loaded vehicle"** means the unloaded vehicle mass plus an allowance of 180 kg to cover the driver and instrumentation

3.10.3. "**Maximum mass**" means the maximum mass stated by the vehicle manufacturer to be technically permissible (this mass may be higher than the "permissible maximum mass" laid down by the national administration);

3.10.4.. "**The distribution of mass among the axles**" means the distribution of the effect of the gravity on the mass of the vehicle and / or its contents among the axles;

3.11. "**Wheel / axle load**" means the vertical static reaction (force) of the road surface in the contact area on the wheel / wheels of the axle;

3.11.1. "**Maximum stationary wheel / axle load**" means the stationary wheel/axle load achieved under the condition of the laden vehicle;

3.12. "**Hydraulic braking system with stored energy**" means a power braking system where energy is supplied by hydraulic fluid under pressure, stored in one or more accumulator(s) fed from one or more pressure pump(s), each fitted with a means of controlling the pressure between minimum and maximum values specified by the manufacturer;

3.13. "**Actuation**" means both application and release of the control;

3.14. "**Brake hold-off pressure or Brake threshold pressure"** means the maximum brake line pressure for which no brake torque is developed. This can be measured or predicted from the pressure axis intercept of the brake transfer function characteristic. (Torque output to pressure input)

3.15. **"Peak friction coefficient**"of a road surface means the ratio of the maximum value of braking longitudinal force to the simultaneous vertical tyre loading force as the braking torque is progressively increased.

3.16. "**Adhesion utilization curves**" of a vehicle means curves showing, for specified load conditions, the adhesion utilized by each axle plotted against the braking rate of the vehicle.

3.17. "**Electric regenerative braking**" means a braking system which, during deceleration, provides for the conversion of vehicle kinetic energy into electrical energy.

3.17.1. "**Electric regenerative braking control**" means a device which modulates the action of the electric regenerative braking equipment;

3.17.2. "**Electric regenerative braking equipment of category A**" means an electric regenerative braking equipment which is **not** part of the service braking system;

3.17.3. "**Electric regenerative braking equipment of category B**" means an electric regenerative braking equipment which **is** part of the service braking system;

3.17.4. "**Electric State of Charge**" means 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;

3.17.5. "**Traction battery**" means an assembly of accumulators constituting the storage of energy used for powering the traction motor(s) of the vehicle;

3.18. "**Phased braking**" is a means which may be used where two or more sources of braking are operated from a common control, whereby one source may be given priority by phasing back the other source(s) so as to make increased control movement necessary before they begin to be brought into operation.

3.19. "**Automatically commanded braking**" means a function within a Complex Electronic Control System where actuation of the braking system(s) or brakes of certain axles is made for the purpose of generating vehicle retardation with or without a direct action of the driver, resulting from the automatic evaluation of on-board initiated information.

3.20. **"Selective braking**" means a function within a Complex Electronic Control System where actuation of individual brakes is made by automatic means in which vehicle retardation is secondary to vehicle behaviour modification.

3.21. "**Nominal value definitions**" for braking reference performance are required to put a value on the transfer function of the braking system, relating output to input for vehicles individually;

3.21.1. "**Nominal value**" is defined as the characteristic which can be demonstrated at Type Approval and which relates the braking rate of the vehicle on its own to the level of the braking input variable.

3.22. **ABS Definitions,**

3.22.1. **An "anti-lock function"** means a function of a service braking system which automatically modulates the pressures producing the braking forces at the wheels to limit the degree of wheel slip during braking**.**

3.22.2. "**Sensor**" means a component designed to identify and transmit to the controller the conditions of rotation of the wheel(s) or the dynamic conditions of the vehicle.

3.22.3. "**Controller**" means a component designed to evaluate the data transmitted by the sensor(s) and to transmit a signal to the modulator.

3.22.4. "**Modulator**" means a component designed to vary the braking force(s) in accordance with the signal received from the controller.

3.22.5. **"Full cycling"** means that the anti-lock system is repeatedly modulating the brake force to prevent the wheels from locking. Brake applications where modulation only occurs once during the stop shall not be considered to meet this definition.

4. GENERAL REQUIREMENTS

4.1. Braking equipment

4.1.1. The braking equipment shall be so designed, constructed and fitted as to enable the vehicle in normal use, to comply with the provisions of this Regulation.

4.1.2. Brake linings shall not contain asbestos.

4.1.3. The effectiveness of the braking equipment shall not be adversely affected by magnetic or electrical fields.

4.1.4. It shall be possible to generate maximum braking forces under static conditions on a rolling road or roller brake tester.

4.2. Functions of the braking equipment

The braking equipment defined in paragraph **3.3.** must fulfil the following functions:

4.2.1. Service braking system

The service braking system must make it possible to control the movement of the vehicle and to halt it safely, speedily and effectively, whatever its speed and load, on any up or down gradient. It must be possible to graduate this braking action, which the driver must be able to achieve from his driving seat without removing his hands from the steering control.

4.2.2. Secondary braking system

The secondary braking system must make it possible by application of the service brake control to halt the vehicle within a reasonable distance in the event of failure of the service braking system. It must be possible to graduate this braking action, which the driver must be able to obtain from his driving seat without removing his hands from the steering control.

For the purposes of these provisions it is assumed that **not more than one failure of the service braking system can occur at one time.**

4.2.3. Parking braking system

The parking braking system must make it possible to hold the vehicle stationary on an up or down gradient even in the absence of the driver, the working parts being then held in the locked position by a purely mechanical device. The driver must be able to achieve this braking action from his driving seat.

4.2.4. [Where the certification process can accommodate the procedure, the requirements of **Annex 1** shall be applied to the safety aspects of complex electronic vehicle control systems which provide or form part of the control transmission of the braking function including those employing automatically commanded braking or selective braking.

However, functions which use the braking system as a means of achieving a higher level objective, are subject to **Annex 1** only insofar as they have a direct effect on the operation of the braking system.]

4.3. Characteristics of braking systems

4.3.1. Each vehicle shall be equipped with a set of braking systems which satisfy the requirements laid down for service, secondary and parking braking systems.

4.3.1.1. There must be at least **two controls** readily accessible to the driver; the control of the parking brake shall be independent of the service braking control, and may be either a hand or foot control.

4.3.1.2. The **service** braking system and the **parking** braking system may have common components including the transmission(s), provided that, in the event of a failure any component or part of those transmission(s), the requirements for secondary braking are still ensured.

4.3.1.4. the **parking braking system** must be so designed that it can be actuated when the vehicle is in motion; This requirement may be met by the actuation of the **vehicle's service braking system**, even partially, by **means of an auxiliary control**.

4.3.1.5. In the event of **breakage** of any component other than the wheel brakes themselves and the components referred to in paragraph **4.3.1.9.** below, or of any other **failure** of the service braking system (malfunction, partial or total exhaustion of an energy reserve), that part of the service braking system which is not affected by the failure, must be able to bring the vehicle to a halt in the conditions prescribed for **secondary** braking;

4.3.1.6. If service braking is ensured by the action of the driver's muscular energy **assisted** by one or more energy reserves, **secondary braking** must, in the event of failure of that assistance, be capable of being ensured by the driver's muscular energy assisted by the energy reserves, if any, which are unaffected by the failure, the force applied to the service brake control not exceeding the prescribed maximum;

4.3.1.7. If the service braking force and transmission depend exclusively on the use, controlled by the driver, of an **energy reserve**, there must be at least two completely independent energy reserves, each provided with its own transmission, likewise independent; each of them may act on the brakes of only two or more wheels so selected as to be capable of ensuring by themselves the prescribed degree of secondary braking without endangering the stability of the vehicle during braking; in addition, each of the aforesaid energy reserves must be equipped with a warning device as defined in paragraph 4**.3.11.** below;

4.3.1.8. If the service braking force and transmission depend exclusively on the use of an energy reserve, one energy reserve for the transmission is deemed to be sufficient, provided that the prescribed secondary braking is ensured by the action of the driver’s muscular energy acting on the service braking control and the requirements of **paragraph 4.3.3.4.** are met.

4.3.1.9. certain parts, such as the pedal and its bearing, the master cylinder and its piston or pistons, the control valve, the linkage between the pedal and the master cylinder or the control valve, the brake cylinders and their pistons, and the lever-and-cam assemblies of brakes, **shall not be regarded as liable to breakage** if they are amply dimensioned, are readily accessible for maintenance, and exhibit safety features at least equal to those prescribed for other essential components (such as the steering linkage) of the vehicle.
Any such part as aforesaid whose failure would make it impossible to brake the vehicle with a degree of effectiveness at least equal to that prescribed for secondary braking, must be made of metal or of a material with equivalent characteristics and must not undergo notable distortion in normal operation of the braking systems.

4.3.2. The **failure** of a part of a **hydraulic transmission** system resulting in a differential pressure of more than 15.5 bar between the intact and failed brake circuits shall be signalled to the driver by a **red warning signal** specified in paragraph **4.3.19.1.1.** below. **Alternatively**, the lighting up of this warning signal when **the fluid in the reservoir is below a certain level** specified by the manufacturer, shall be permitted.

4.3.3. Where use is made of **energy** other than the muscular energy of the driver, there need not be more than **one source** of such energy (hydraulic pump, electrical generator etc.), but the means by which the device constituting that source is driven, must be as safe as practicable.

4.3.3.1. In the event of failure in any part of the transmission of the braking system, the feed to the part not affected by the failure must continue to be ensured if required, for the purpose of halting the vehicle with the degree of effectiveness prescribed for **secondary braking**. This condition must be met by means of devices which are automatic in operation and the failure shall generate a warning signal as prescribed in section **4.3.11.** below.

4.3.3.2. Furthermore, storage reservoirs located down-circuit of the device which ensures the power feed, must be such that in the case of a failure in the energy supply, after **4** full-stroke actuations of the service brake control, with the brakes adjusted as closely as possible, it is still possible to halt the vehicle at the **5th** application, with the degree of effectiveness prescribed for secondary braking.

4.3.3.3. However, if the braking system cannot meet the requirements of paragraph **4.3.3.1.** because a transmission failure can result in the loss of all continuing power feeds, then the system is acceptable provided that the reservoir capacity is such as to ensure on failure of the energy supply, that secondary braking performance is achieved on the **9th** application after **8** full applications of the braking control.

In this case the warning provisions must meet the requirements of paragraphs **4.3.11.1. and 4.3.11.2.**

4.3.3.4. The requirements of paragraphs **4.3.1.5.** , **4.3.1.6.** , **4.3.1.8.**and **4.3.3.1.** above must be met without the use of any automatic device of a kind such that its ineffectiveness might pass unnoticed through the fact that parts normally in a position of rest come into action only in the event of failure in the braking system.

4.3.4. The service braking system shall act on **all** the wheels of the vehicle and shall distribute its action appropriately among the axles.

4.3.5. In the case of vehicles equipped with **electric regenerative braking** systems of **category B**, the braking input from other sources of braking, may be suitably **phased** to allow the electric regenerative braking system alone to be applied, provided that **both** the following conditions are met:

4.3.5.1. **Intrinsic variations** in the torque output of the electrical regenerative braking system (e.g. as a result of changes in the electric state of charge in the traction batteries) are **automatically compensated** by appropriate variation in the phasing relationship as long as the requirements of paragraphs **5.1.4.3.** or **5.2.6.1.3.**are met, (including the case with the electric motor engaged)
and:

4.3.5.2. wherever necessary, to ensure that braking rate remains related to the driver's braking demand, having regard to the available tyre/road adhesion, braking shall automatically be caused to act on all wheels of the vehicle.

4.3.6. The action of the service braking system shall act on all wheels of the vehicle and be **distributed** between the wheels of one and the same axle **symmetrically** in relation to the longitudinal median plane of the vehicle. Compensation and functions, such as anti-lock, which may cause deviations from this symmetrical distribution shall be declared where Annex 1 is required.

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4.3.6.1. **Compensation** by the electric control transmission for deterioration or defect within the braking system shall be indicated to the driver by means of the yellow warning signal specified in paragraph **4.3.19.1.2.** below. This requirement shall apply for all conditions of loading when compensation exceeds the following limits;

4.3.6.1.1. a difference in **transverse** braking pressures on any axle:

(a) of **25%** of the higher value for vehicle decelerations **≥ 2m/sec^2**,

(b) a value corresponding to **25% at 2m/sec^2** for decelerations below this rate.

4.3.6.1.2. an **individual compensating** value on any axle:

(a) **> 50%** of the nominal value for vehicle decelerations **≥ 2m/sec^2,**

(b) a value corresponding to **50%** of the nominal value at **2m/sec^2** for decelerations below this rate.

4.3.6.2. Compensation as defined above, is permitted **only** when the initial brake application is made at vehicle speeds **>10 km/h.]**

4.3.7. Malfunctions of the **electric control transmission** shall **not** apply the brakes contrary to the driver's intentions.

4.3.8. Where braking torque for a particular axle or axles is provided by **both** a **friction** braking system **and** an **electrical** regenerative braking system of **category B**, disconnection of the latter source is permitted, providing that the friction braking source remains permanently connected and able to provide the **compensation** referred to in paragraph **4.3.5.1.**

However, in the case of **short disconnection transients**, incomplete compensation is accepted, but within **1 s**, this compensation shall have attained at least **75%** of its final value.

Nevertheless, in all cases, the permanently connected friction braking source shall ensure that both the service and secondary braking systems continue to operate with the prescribed degree of effectiveness.

4.3.9. **Wear** of the brakes must be capable of being taken up by means of a system of automatic adjustment. In addition, the control and the components of the transmission and of the brakes must possess a reserve of travel and, if necessary, suitable means of compensation such that, when the brakes become heated, or the brake linings have reached a certain degree of wear, effective braking is ensured without manual adjustment being necessary.

4.3.9.1. Automatic wear adjustment devices shall be such that after heating followed by cooling of the brakes, effective braking is still ensured. In particular the vehicle shall remain capable of normal running after the tests conducted in accordance with paragraph **5.2.15.3.** (cooling after the Hot test).

4.3.9.2. It shall be possible to easily **check this wear** on service brake linings from the outside or underside of the vehicle using commonly available inspection equipment, for instance, by the provision of appropriate inspection holes or by some other means. Alternatively, acoustic or optical devices warning the driver at his driving position when lining replacement is necessary are acceptable. The **yellow** warning signal specified in paragraph **4.3.19.1.2.** below, may be used as the optical warning signal.

4.3.10. In **hydraulic-transmission** braking systems, the filling ports of the **fluid reservoirs** must be readily accessible; in addition, the receptacles containing the reserve fluid must be so designed and constructed that the level of the reserve fluid can be easily checked without the receptacles having to be opened, and the minimum total reservoir capacity is equivalent to the fluid displacement resulting when all the wheel cylinders or caliper pistons serviced by the reservoirs, move from a new lining, fully retracted position to a fully worn, fully applied position. If these latter conditions are not fulfilled, the red warning signal specified in paragraph **4.3.19.1.1.** below, shall draw the driver's attention to any fall in the level of reserve fluid liable to cause a failure of the braking system.

[**4.3.10.1.** Linings are deemed to be fully worn when:
a) Drum brake linings are worn down to 1 rivet/bolt head
b) Bonded linings or pads are worn down to below 0.8 mm thickness.]

[4.3.10.2. The **type of fluid** to be used in hydraulic transmission braking systems shall be identified by the symbol in accordance with **Figure 1 or 2 of ISO Standard 9128 - 1987** and the appropriate **DOT** marking (eg. **DOT3**). The symbol and the marking must be affixed in a visible position in indelible form within **100 mm** of the filling ports of the fluid reservoirs. Additional information may be provided by the manufacturer in letters at least 3.2 mm in height.]

4.3.11. Warning system

4.3.11.1. Stored energy loss and park brake applied.

Any vehicle fitted with a service brake actuated from an energy reservoir, where the prescribed **secondary** braking performance **cannot** be obtained by means of this brake without the use of this stored energy, must be provided with a **warning system**, giving an optical and, where specified, an acoustic signal when the **stored energy**, in any part of the system, falls to a value at which without re-charging of the reservoir and with the vehicle fully laden, it is still just possible to apply the service brake control a **5th** time after **4** full-stroke actuations and obtain the prescribed **secondary braking** performance (without faults in the service brake transmission and with the brakes adjusted as closely as possible).

When the engine is running under normal operating conditions and there are **no faults** in the braking system, the warning system must give **no signal** except during the time required for charging the energy reservoirs after start-up of the engine. The **red** warning signal specified in paragraph **4.3.19.1.1.** below, shall be used as the optical warning signal.

Actuation of the **parking brake** must also be indicated to the driver by this **red** warning signal or alternatively, by a separate red warning signal which may be used for this function, if it complies with the requirements of paragraph **4.3.19.2.**

4.3.11.2. However, in the case of vehicles which only meet the requirements of paragraph **4.3.3.3.** of this Regulation, the warning device shall consist of an **acoustic signal** in addition to an optical signal.
These warnings need not be produced simultaneously, provided that they meet the above requirements and the acoustic signal is not actuated before the optical signal. The **red** warning signal shall be that specified in paragraph **4.3.19.1.1.** below.

4.3.11.3. This acoustic device may be rendered inoperative while the parking brake is applied and/or, at the choice of the manufacturer, in the case of automatic transmission, when the transmission selector is in the "**Park**" position.

4.3.12. Where an **auxiliary source of energy** is essential to the functioning of a braking system, the reserve of energy must be such as to ensure that, if the engine stops or in the event of a failure of the means by which the energy source is driven, the braking performance remains adequate to bring the **vehicle to a halt** in the prescribed conditions.

[**4.3.12.1.** A vehicle with electrically actuated service brakes shall activate the red brake failure warning system prescribed in paragraph **4.3.19.1.1,** when the stored electrical energy falls to a level at which the prescribed service braking for the laden vehicle can no longer be guaranteed. Once this warning, which shall comply with paragraph **4.3.11.2.** is given, the vehicle shall be capable of braking, with the performance required for **secondary braking**, for at least 9 further full service braking applications.]

4.3.13. Any **auxiliary equipment** must be supplied with energy in such a way that during its operation, the prescribed deceleration values can be reached [and that even in the event of damage to the source of energy, the operation of the auxiliary equipment cannot cause the reserves of energy feeding the braking systems to fall below the level indicated in paragraph **4.3.11.1.** above.]?

[4.3.14. In the case of a motor vehicle equipped to **tow a trailer** with **electric service brakes**, the following requirements shall be met:

4.3.14.1. the **power supply** (generator and battery) of the motor vehicle shall have a sufficient capacity to provide the current for an electric braking system. With the engine running at the idling speed recommended by the manufacturer and all electrical devices supplied by the manufacturer as standard equipment of the vehicle switched on, the voltage in the electrical lines shall at maximum current consumption of the electrical braking system (**15 A**) not fall below the value of **9.6V** measured at the connection. The electrical lines shall not be capable of short circuiting even when overloaded;

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4.3.14.2. in the event of a failure in the motor vehicle's service braking system, where that system consists of at least two independent units, the unit or units not affected by the failure shall be capable of partially or fully actuating the brakes of the trailer;

4.3.14.3. the use of the stop-lamp switch and circuit for actuating the electrical braking system is permissible only if the actuating line is connected in parallel with the stop-lamp and the existing stop-lamp switch and circuit are capable of taking the extra load.]

4.3.15. Additional requirements for vehicles equipped with **electric regenerative braking systems**:

4.3.15.1. Vehicles fitted with an **electric regenerative braking system** of category **A**;

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

4.3.15.2. Vehicles fitted with an **electric regenerative braking system** of category **B**;

4.3.15.2.1. It must not be possible to disconnect partially or totally one part of the service braking system other than by an automatic means. This should not be construed as a departure from the requirements of paragraph **4.3.8.**

4.3.15.2.2. the service braking system must have only **one control** device;

4.3.15.2.3. If the operation of the electric component of braking is ensured by a relationship established between information coming from the service brake control and the resulting braking force to the wheels, a failure of this relationship leading to non-compliance with the prescriptions covering either the distribution of braking

among the axles or ABS, must be warned to the driver by an optical warning signal at the latest when the control is actuated and having to remain lit as long as this defect exists and the switch "contact" is in the **"on"** position.

4.3.15.3. For vehicles fitted with an electric regenerative braking system of **both** categories, all the relevant prescriptions shall apply except paragraph **4.3.15.1.** above. In this case, the electric regenerative braking may be activated by the accelerator control and/or the gear neutral position. Additionally, any action on the service braking control must not reduce the above braking effect generated by the release of the accelerator control;

4.3.15.4. The operation of the electric braking must not be adversely affected by magnetic or electric fields;

4.3.15.5. For vehicles equipped with ABS, this function must control the electric braking system.

4.3.15.6. The **state of charge** of the traction batteries is to be determined by the method set out in **Appendix 1** to the test section of this Regulation.

4.3.15.7. **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.

4.3.16. Additional requirements for vehicles equipped with an Anti-lock Braking Function (ABS):

4.3.16.1. General Requirements.

4.3.16.1.1. A vehicle is deemed to be equipped with an **anti-lock function**, if this function includes at least the possibility to determine vehicle behaviour from measured values of all wheel speeds and to modulate individually, the pressures producing the braking forces of at least 3 wheels.
It shall meet the requirements of **Section 5.2.6**. of this Regulation when tested in accordance with the conditions and procedures of that paragraph.

4.3.16.1.2. Any electrical **failure** or sensor anomaly that affects the ABS with respect to the function and performance requirements in Section 5.2.6. of this Regulation, including those in the supply of electricity, the wiring external to the controller, the controller itself and the modulators shall be signalled to the driver by a specific optical warning signal. The **yellow** warning signal specified in paragraph **4.3.19.1.2.** shall be used for this purpose..

4.3.16.1.3. The warning signal may light up again when the vehicle is stationary but, provided no defect is present, it must extinguish before the vehicle reaches a speed of 10km/h.

4.3.16.1.4. Sensor anomalies, which cannot be detected under static conditions, shall be detected not later than when the vehicle speed exceeds **10 km/h**. However, to prevent erroneous fault indication when a sensor is not generating a vehicle speed output due to non-rotation of a wheel, verification may be **delayed** but detected not later than when the vehicle speed exceeds **15 km/h**.

4.3.16.1.5. A manual device may not be provided to disconnect or change the control mode of the ABS unless all the ABS requirements of Section **5.2.6.** are fulfilled in the changed mode**.**

4,3.17. Special additional requirements for the Electric transmission of the Parking Braking system:

4.3.17.1. In the case of a failure within the electric transmission, any unintended actuation of the parking braking system shall be prevented;

4.3.17.2. A **break in the wiring** within the electric transmission or a failure in the control of the parking braking system shall be signalled to the driver by the **yellow** warning signal specified in paragraph **4.3.19.1.2.** When caused by a break in the wiring within the electric control transmission of the parking braking system, this yellow warning signal shall be signalled as soon as the break occurs.

In addition, such a failure in the control or break in the wiring external to the electronic control unit(s) and **excluding** the energy supply, shall be signalled to the driver by **flashing** the **red** warning signal specified in paragraph **4.3.19.1.1**. as long as the **ignition** (start) switch is in the **ON** (run) position including a period of not less than **10 seconds thereafter** and the **control** is in the **ON** (activated) position.

Where actuation of the parking brake is normally indicated by a **separate red** warning signal, satisfying all the requirements of paragraph **4.3.19.2.** this signal **shall** be used to satisfy the above requirement for the **red** signal.

4.3.17.3. Other vehicle electrical loads may be supplied with energy from the same battery which powers the electric transmission of the parking braking system, provided that the supply of energy is sufficient to allow the actuation of the parking braking system in addition to the vehicle electrical load under non-fault conditions. In addition, where the energy reserve is also used by the service braking system, the requirements of paragraph **4.3.18.6.** below, shall apply;

4.3.17.4. After the ignition/start switch, which controls the electrical energy for the braking equipment, has been switched off and/or the key removed, it shall remain possible to apply the parking braking system, whereas releasing shall be prevented.

4.3.18. Special additional requirements for service braking systems with electric control transmission:

4.3.18.1. If the parking brake is released, the service braking system shall be able to generate a static total braking force at least equivalent to that required for **secondary braking**, when the **ignition**/start switch has been **switched off** and/or the key has been removed. It should be understood that **sufficient energy** is available in the energy transmission of the service braking system;

4.3.18.2. A **failure within the electric control transmission**, not including its energy reserve, that affects the function and performance of the systems addressed in this Regulation, shall be indicated to the driver by the red or yellow warning signal specified in paragraphs **4.3.19.1.1.** and **4.3.19.1.2.** below, respectively, as appropriate.

When the prescribed service braking performance can no longer be achieved (red warning signal), failures resulting from a loss of electrical continuity (eg. breakage, disconnection) shall be signalled to the driver as soon as they occur, and the prescribed secondary braking performance shall be fulfilled by operating the service braking control in accordance with paragraph **5.2.12.** of this Regulation

4.3.18.3. In the event of a **failure** of the **energy source** of the electric control transmission, starting from the nominal value of the energy level, the full control range of the service braking system shall be guaranteed after **20** consecutive full stroke actuations of the service braking control.

During the test, the braking control shall be fully applied for **20 seconds** and released for **5 seconds** on each actuation. Unless the actuation energy is provided by an electric motor powered from the common vehicle battery, it should be understood that during this test, sufficient energy is available in the energy transmission to ensure full actuation of the service braking system.

4.3.18.4. When the **battery voltage falls** below a value nominated by the manufacturer at which the prescribed service braking performance can no longer be guaranteed and/or which precludes at least **two independent** service braking circuits from **each** achieving the prescribed **secondary** braking performance, the **red** warning signal specified in paragraph **4.3.19.1.1.** below, shall be activated.

After the warning signal has been activated, it shall be possible to apply the service braking control and obtain at least the **secondary** braking performance prescribed in paragraph **5.2.12.1.4.** to this Regulation. It should be understood that, unless the actuation energy is provided by an electric motor powered from the common vehicle battery, sufficient energy is available in the energy transmission of the service braking system.

4.3.18.5. If other vehicle electrical equipment is supplied with energy from the same battery as the electric control transmission, it shall be ensured that, with the engine running at a speed not greater than **80%** of the maximum power speed, the supply of the energy is sufficient to fulfil the prescribed deceleration values by either:

Provision of an energy supply which is able to prevent discharge of this reserve when all the vehicle electrical equipment is functioning or:

Switching off pre-selected parts of the vehicle electrical load at a voltage above the critical level referred to in paragraph **4.3.18.4.** of this Regulation such that further discharge is prevented.

Compliance with this requirement may be demonstrated by calculation or, where this cannot be accepted, by a practical test.
This paragraph does **not** apply to vehicles where the **prescribed deceleration** values can be reached **without** the use of electrical energy.

4.3.18.6. [If vehicle electrical equipment is supplied with energy from the same battery which supplies the electric control transmission, the following requirements shall be fulfilled:

4.3.18.6.1. In the event of a failure in the energy supply, whilst the vehicle is in motion, the energy in the battery shall be sufficient to actuate the brakes when the control is applied;

4.3.18.6.2. In the event of a failure in the energy source, whilst the vehicle is stationary and the parking braking system applied, the energy in the battery shall be sufficient to actuate the lights even when the brakes are applied. Proposed for deletion]

4.3.19. Brake failure and defect warning signals.

4.3.19.1. General requirements for warning signals
The vehicle shall be equipped with a warning system whose function is to indicate to the driver certain specified failures (or defects) within the braking equipment of the motor vehicle, as set out in the following sub-paragraphs.
Other than as described in paragraph **4.3.19.5.** below, these signals shall be used exclusively for the purposes prescribed by this Regulation.

Each warning device shall display selected symbols in conformance with the GTR on “Control & Tell-tales”(document Trans/WP29/GRSG/2000/8Rev.2)

4.3.19.1.1. A **red warning signal**, indicating failures, defined elsewhere in this Regulation, within the vehicle braking equipment which precludes achievement of the **prescribed service** braking performance and/or which precludes the functioning of at least **one of two** independent service braking circuits.

In particular, this **red** signal shall be used as defined in the list below:

PARAGRAPH	FAULT
4.3.2.7.1.	Differential circuit pressure/low fluid level.
4.3.11.1.	Power system failure (+ acoustic warning as in paragraph **4.3.11.2.**) Parking brake applied.*
4.3.12.1.	Low energy level in Electrically Actuated braking systems.

4.3.16.2.2. ABS + EBD failure.
4.3.18.2. EBS failure resulting in only secondary performance.
4.3.18.3. Low voltage resulting in only secondary performance.
4.3.17.2.1. EPB actuated with a fault present.*
* Parking brake may be indicated by a separate optical device.

4.3.19.1.2. Where applicable, a **yellow warning signal** indicating an electrically detected defect within the vehicle braking equipment which is not indicated by the red warning signal described in paragraph **4.3.19.1.1.** above.

In particular, this **yellow** signal shall be used as defined in the list below:

PARAGRAPH	**FAULT**
4.3.9.2.	Lining wear-out.
4.3.15.2.3.	RBS_B failure.
4,3.16.2.2.	ABS electrical or sensor fault.
4.3.17.2.1.	EPB wiring fault.
4.3.18.2.	EBS wiring fault but with performance maintained.
4.3.18.4.	EBS low voltage but with performance maintained.

4.3.19.1. Optical warning signal display
Optical warning signals shall be visible, even in daylight; the satisfactory condition of the signals shall be easily verifiable by the driver from the driver's seat; the failure of a component of the warning devices shall not entail any loss of the braking system's performance.

4.3.19.2. Activation
Except where stated otherwise:

4.3.19.3. a specified failure or defect shall be signaled to the driver by the above mentioned warning signal(s) not later than on actuation of the relevant braking control;

4.3.19.3.1. the warning signal(s) shall remain displayed as long as the failure/defect persists and the ignition (start) switch is in the "on" (run) position.

4.3.19.3.2. **[**Except in **t**he case of the Electrical park brake, the warning signal shall be constant (not flashing).]

4.3.19.4. Function check
The warning signal(s) mentioned above shall light up when the electrical equipment of the vehicle (and the braking system) is energised.
With the vehicle stationary, the braking system shall verify that none of the specified failures or defects are present before extinguishing the signals.

Those specified failures or defects which should activate the warning signals mentioned above, but which are not detected under static conditions, shall **be stored upon detection** and be displayed at start-up and at all times when the ignition (start) switch is in the "on" (run) position, as long as the failure or defect persists.

4.3.19.5. **Non-specified failures** (or defects) or other information concerning the brakes and/or running gear of the vehicle, may be indicated by the **yellow** signal specified in paragraph **4.3.19.1.2.** above, provided that all the following conditions are fulfilled:

4.3.19.5.1. the vehicle is stationary;

4.3.19.5.2. after the braking equipment is first energised and the signal has indicated that, following the procedures detailed in paragraph **4.3.19.4.** above, **no** specified failures (or defects) have been identified;
and

4.3.19.5.3. non-specified faults or other information shall be indicated only by the flashing of the warning signal. However, the warning signal shall be extinguished by the time when the vehicle first exceeds **10 km/h**.

4.3.20. Generation of a signal to illuminate stop lamps.

4.3.20.1. Activation of the service braking system by the driver shall generate a signal that will be used to illuminate the stop lamps.

4.3.20.2. Activation of the service braking system by "**automatically commanded braking**" shall generate the signal mentioned above. However, when the retardation generated is less than **0.7 m/s^2** at a vehicle speed greater than **50 km/h** the signal may be suppressed.

4.3.20.3. Activation of part of the service braking system by "**selective braking**" may not generate the signal mentioned above. However it is accepted that during a "selective braking" event, the brake control function may change to "automatically commanded braking".

4.3.20.4. Electric regenerative braking systems, which produce a retarding force upon release of the throttle pedal, shall not generate a signal mentioned above

4.3.21. Requirements for power hydraulic braking systems with stored energy

4.3.21.1. Capacity of energy storage devices (energy accumulators).

4.3.21.1.1. Vehicles on which the braking equipment requires the use of stored energy provided by hydraulic fluid under pressure shall be equipped with energy accumulators which are charged with fluid from a power source and regulated between 'cut-in (p_0) and cut-out (p_1) pressures declared by the manufacturer.
The capacity of the accumulator(s) shall meet the requirements of paragraphs **4.3.21.1.3.)** or **4.3.21.1.4.** of this section.

4.3.21.1.2. However, the energy storage devices shall not be required to be of a prescribed capacity if the braking system is such that in the absence of any energy reserve it is possible, using the driver's muscular energy on the service brake control, to achieve a braking performance at least equal to that prescribed for the secondary braking system.

4.3.21.1.3. Vehicles equipped with a hydraulic braking systems with stored energy which meet the requirements of paragraph **4.3.3.1.,** shall, under energy source or transmission failure conditions, provide a level of stored energy such that after **4** full-stroke actuations of the service brake control, it shall still be possible to achieve, on the **5th** application, the performance prescribed for the secondary braking system.

4.3.21.1.4. Vehicles equipped with a single hydraulic power braking circuit shall have a back-up sub-system which is automatically brought into operation if there is a transmission or energy source failure in the main system.

4.3.21.1.5. Vehicles equipped with hydraulic braking systems with stored energy which can only meet the requirements of paragraph **4.3.2.10.3.** of this Regulation shall be accepted if, after any single transmission failure, it shall still be possible after **8** full-stroke actuations of the service brake control, to achieve, at the **9th** application, at least the performance prescribed for the secondary braking system.

4.3.21.2. Capacity of hydraulic fluid energy sources.

The energy source capacity is related to the energy consumed on making a full stroke brake actuation. The capacity is required to be such that the energy used in making 4 full stroke actuations of the service braking system is replenished in a time which does not exceed 20 seconds.

4.3.21.2.1. Definitions for power systems

a) "**p_1**" represents the maximum system operational pressure (cut-out pressure) in the energy storage device(s) specified by the manufacturer.

b) "**p_2**" represents the pressure after four full-stroke actuations with the service brake control, starting at p_1, without having fed the energy storage device(s).

c) "**t**" represents the time required for the pressure to rise from p_2 to p_1 in the energy storage device(s) without application of the brake control.

4.3.21.2.2. Conditions of measurement

a) During the tests to determine the time t , the feed rate of the energy source shall be that obtained when the engine is running at the speed corresponding to its maximum power or at the speed allowed by the over-speed governor.

b) During the test to determine the time t, energy storage device(s) for auxiliary equipment shall not be isolated other than automatically.

4.3.21.3. Requirements.

a) In the case of all vehicles, the time t shall not exceed **20 seconds**.

a) With the engine stationary and commencing at a pressure that may be specified by the manufacturer but does not exceed the cut-in pressure, the **warning device** shall not operate following **2 full-stroke actuations** of the service brake control.

4.3.21.4. Response time.

4.3.21.4.1. Where a vehicle is equipped with a service braking system which is totally or partially **dependent on a source of energy** other than the muscular effort of the driver, the following requirements must be satisfied:

a) in an emergency manoeuvre, the time elapsing between the moment when the service brake control begins to be actuated and the moment when the braking pressure on the least favourably placed axle reaches the level corresponding to the prescribed performance must not exceed **0.6 seconds**;

b) in the case of vehicles fitted with hydraulic power braking systems, the requirements of paragraph **a)** above are considered to be satisfied if, in an emergency manoeuvre, the deceleration of the vehicle or the pressure at the least favourable brake cylinder, reaches a level corresponding to the prescribed performance within **0.6 seconds**.