

ECONOMIC COMMISSION FOR EUROPE

INLAND TRANSPORT COMMITTEE

World Forum for Harmonization of Vehicle Regulations (WP.29)

Working Party on Brakes and Running Gear (GRRE)
Fifty-sixth session, 20-22 September 2004,

PROPOSAL FOR DRAFT AMENDMENTS TO REGULATION No. 13

(Braking)

Transmitted by the expert from the United Kingdom

Note: The text reproduced below has been prepared by the expert from the United Kingdom and proposes amendments to the paragraphs in Annex 4 of Regulation 13 that need to be amended in order to delete category M₁ vehicles.

Note: This document is distributed to the Experts on Brakes and Running Gear only.

Annex 4

BRAKING TESTS AND PERFORMANCE OF BRAKING SYSTEMS

1. BRAKING TESTS.

1.1. General

- 1.1.1. The performance prescribed for braking systems is based on the stopping distance and/or the mean fully developed deceleration. The performance of a braking system shall be determined by measuring the stopping distance in relation to the initial speed of the vehicle and/or by measuring the mean fully developed deceleration during the test.
- 1.1.2. The stopping distance shall be the distance covered by the vehicle from the moment when the driver begins to actuate the control of the braking system until the moment when the vehicle stops; the initial speed shall be the speed at the moment when the driver begins to actuate the control of the braking system; the initial speed shall not be less than **98%** of the prescribed speed for the test in question.

The mean fully developed deceleration (**MFDD**) shall be calculated as the deceleration averaged with respect to distance over the interval v_b to v_e according to the following formula:

$$\text{MFDD } d_m = \frac{v_b^2 - v_e^2}{25.92(S_c - S_b)} \text{ m/s}^2$$

where: v_o = initial vehicle speed in km/h,
 v_b = vehicle speed at 0.8 v_o in km/h, and v_e = vehicle speed at 0.1 v_o in km/h,
 S_b = distance travelled between v_o and v_b in metres,
 S_e = distance travelled between v_o and v_e in metres.

The speed and distance shall be determined using instrumentation having an accuracy of $\pm 1\%$ at the prescribed speed for the test. The MFDD may be determined by other methods than the measurement of speed and distance; in this case, the accuracy of the MFDD shall be within $\pm 3\%$

- 1.2. For the approval of any vehicle, the braking performance shall be measured during road tests conducted in the following conditions:
- 1.2.1. the vehicle's condition as regards mass must be as prescribed for each type of test and be specified in the test report;
- 1.2.2. the test must be carried out at the speeds prescribed for each type of test; if the maximum design speed of a vehicle is lower than the speed prescribed for a test, the test shall be performed at the vehicle's maximum speed;
- 1.2.3. during the tests, the force applied to the control of the braking system in order to obtain the prescribed performance must not exceed the maximum force laid down for the test vehicle's category;
- 1.2.4. the road must have a surface affording good adhesion, unless specified otherwise in the relevant Annexes;
- 1.2.5. the tests must be performed when there is no wind liable to affect the results;
- 1.2.6. at the start of the tests, the tyres must be cold and at the pressure prescribed for the load actually borne by the wheels when the vehicle is stationary;
- 1.2.7. the prescribed performance must be obtained without locking of the wheels, without deviation of the vehicle from its course, and without abnormal vibration. ^{1/}

^{1/} Wheel-locking is permitted where specifically mentioned.

- 1.2.8.** For vehicles powered completely or partially by an electric motor (or motors) permanently connected to the wheels, all tests must be carried out with the motor(s) connected.
- 1.2.9.** For vehicles as described in paragraph **1.2.8.** above, fitted with an electric regenerative braking system of **category A**, behaviour tests defined in paragraph **1.4.3.1.** of this Annex shall be carried out on a track with a low adhesion coefficient (as defined in paragraph **5.2.2.** of **Annex 13**).
- 1.2.9.1.** Moreover, for vehicles fitted with an electric regenerative braking system of **category A**, transient conditions such as gear changes or accelerator control release shall not affect the behaviour of the vehicle in test conditions as described in paragraph **1.2.9.** above.
- 1.2.10.** During the tests specified in paragraphs **1.2.9.** and **1.2.9.1.** above, wheel locking is not allowed. However, **steering correction** is permitted if the angular rotation of the steering control is within **120°** during the **initial 2 seconds** and not more than **240° in total**.
- 1.2.11.** For a vehicle with **electrically actuated service brakes** powered from traction batteries (or an auxiliary battery) which receive(s) energy only from an **independent external** charging system, these batteries shall, during braking performance testing, be at an average of **not more than 5%** above that state of charge at which the brake failure warning prescribed in **paragraph 5.2.1.27.6.** is required to be given.

If this warning is given, the batteries may receive some recharge during the tests, to keep them in the required state of charge range.

1.3. Behaviour of the vehicle during braking

- 1.3.1.** In braking tests, and in particular in those at high speed, the general behaviour of the vehicle during braking must be checked.
- 1.3.2.** Behaviour of the vehicle during braking on a road on which adhesion is reduced. The behaviour of vehicles of categories **M₂, M₃, N₁, N₂, N₃, O₃ and O₄** on a road on which adhesion is reduced must meet the relevant requirements of **Annex 10** and/or **Annex 13** to this Regulation.
- 1.3.2.1.** In the case of a braking system according to **paragraph 5.2.1.7.2.**, where the braking for a particular axle (or axles) is comprised of **more than one source** of braking torque, and any individual source can be varied with respect to the other(s), the vehicle shall satisfy the requirements of **Annex 10**, or alternatively **Annex 13**, under all relationships permitted by its control strategy.^{2/}

1.4. Type-0 test (ordinary performance test with brakes cold)

1.4.1. General

- 1.4.1.1.** The brakes must be cold; a brake is deemed to be cold when the temperature measured on the disc or on the outside of the drum is below **100°C**.
- 1.4.1.2.** The test must be conducted in the following conditions:

^{2/} The manufacturer shall provide the Technical Service with the family of braking curves permitted by the automatic control strategy employed. These curves may be verified by the Technical Service.

- 1.4.1.2.1.** the vehicle must be laden, the distribution of its mass among the axles being that stated by the manufacturer; where provision is made for several arrangements of the load on

the axles the distribution of the maximum mass among the axles must be such that the load on each axle is proportional to the maximum permissible load for each axle. In the case of tractors for semi-trailers, the load may be re-positioned approximately half-way between the king-pin position resulting from the above loading conditions and the centre-line of the rear axle(s),

1.4.1.2.2. every test must be **repeated** on the **unladen** vehicle. In the case of a power-driven vehicle there may be, in addition to the driver, a second person on the front seat who is responsible for noting the results of the test;

in the case of a tractor for a semi-trailer, the unladen tests will be conducted with the vehicle in its solo condition, including a mass representing the fifth wheel. It will also include a mass representing a spare wheel, if this is included in the standard specification of the vehicle;

in the case of a vehicle presented as a bare chassis-cab, a supplementary load may be added to simulate the mass of the body, not exceeding the minimum mass declared by the manufacturer in **Annex 2** to this Regulation,

In the case of a vehicle equipped with an electric regenerative braking system, the requirements depend on the category of this system:

Category A. Any separate electric regenerative braking control which is provided, shall not be used during the Type-0 tests.

Category B. The contribution of the electric regenerative braking system to the braking force generated shall not exceed that minimum level guaranteed by the system design.

This requirement is deemed to be satisfied if the batteries are at one of the following **state of charge** conditions where state of charge ^{3/} is determined by the method set out in **Appendix 1** to this Annex:

at the maximum charge level as **recommended by the manufacturer** in the vehicle specification, or

at a level **not less than 95%** of the full charge level, where the manufacturer has made no specific recommendation, or

at the **maximum** level which results from **automatic charge control on the vehicle**.

^{3/} By agreement with the Technical Service, 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.

1.4.1.2.3. the limits prescribed for minimum performance, both for tests with the vehicle unladen and for tests with the vehicle laden, shall be those laid down hereunder for each category of vehicles; the vehicle must satisfy **both** the prescribed stopping distance and the prescribed mean fully developed deceleration for the relevant vehicle category,

but it may not be necessary to actually measure both parameters.

1.4.1.2.4. The road must be level.

1.4.2. Type-0 test with engine disconnected

The test must be carried out at the speed prescribed for the category to which the vehicle belongs, the figures prescribed in this connection being subject to a certain margin of tolerance. The minimum performance prescribed for each category must be attained.

1.4.3. Type-0 test with engine connected

1.4.3.1. Tests must also be carried out at various speeds, the lowest being equal to **30%** of the maximum speed of the vehicle and the highest being equal to **80%** of that speed. In the case of vehicles equipped with a speed limiter, this limiter speed shall be taken as the maximum speed of the vehicle. The maximum practical performance figures shall be measured and the behaviour of the vehicle shall be recorded in the test report. Tractors for semi-trailers, artificially loaded to simulate the effects of a laden semi-trailer shall not be tested beyond **80 km/h**.

1.4.3.2. Further tests shall be carried out with the engine connected, from the speed prescribed for the category to which the vehicle belongs. The minimum performance prescribed for each category must be attained. Tractive units for semi-trailers, artificially loaded to simulate the effects of a laden semi-trailer shall not be tested beyond **80 km/h**.

1.4.4. Type-0 test for vehicles of category O, equipped with compressed-air brakes.

1.4.4.1. The braking performance of the trailer can be calculated either from the braking rate of the towing vehicle plus the trailer and the measured thrust on the coupling or, in certain cases, from the braking rate of the towing vehicle plus the trailer with only the trailer being braked. The engine of the towing vehicle must be disconnected during the braking test.

In the case where only the trailer is braked, to take account of the extra mass being retarded, the performance will be taken to be the mean fully developed deceleration.

1.4.4.2. With the exception of cases according to paragraphs **1.4.4.3.** and **1.4.4.4.** of this Annex, it is necessary for the determination of the braking rate of the trailer to measure the braking rate of the towing vehicle plus the trailer and the thrust on the coupling. The towing vehicle has to meet the requirements laid down in Annex 10 to this Regulation with regard to the relationship between the ratio **T_M/P_M** and the pressure **p_m** . The braking rate of the trailer is calculated according to the following formula:

$$z_R = z_{R+M} + \frac{D}{P_R}$$

where:

z_R = braking rate of the trailer
 z_{R+M} = braking rate of the towing vehicle plus the trailer
 D = thrust on the coupling
(tractive force: +D)
(compressive force: - D)
 P_R = total normal static reaction between road surface and wheels of trailer (**Annex 10**)

- 1.4.4.3.** If a trailer has a continuous or semi-continuous braking system where the pressure in the brake actuators does not change during braking despite the dynamic axle load shifting, and in the case of semi-trailers, the trailer alone may be braked. The braking rate of the trailer is calculated according to the following formula:

$$z_R = (z_{R+M} - R) \cdot \frac{P_M + P_R}{P_R} + R$$

where:

- R = rolling resistance value = **0.01**
 P_M = total normal static reaction between road surface and wheels of towing vehicles for trailers (**Annex 10**)

- 1.4.4.4.** Alternatively, the evaluation of the braking rate of the trailer may be done by braking the trailer alone. In this case the pressure used shall be the same as that measured in the brake actuators during the braking of the combination.

1.5. Type-I test (fade test)

1.5.1. With repeated braking

- 1.5.1.1.** The service braking systems of all power-driven vehicles must be tested by successively applying and releasing the brakes a number of times, the vehicle being laden, in the conditions shown in the table below:

Category of vehicle	Conditions			
	v ₁ (km/h)	v ₂ (km/h)	Δt (sec)	n
M ₂	80% v _{max} ≤ 100	v _{1/2}	55	15
N ₁	80% v _{max} ≤ 120	v _{1/2}	55	15
M ₃ , N ₂ , N ₃	80% v _{max} ≤ 60	v _{1/2}	60	20

where:

- v₁ = initial speed, at beginning of braking
 v₂ = speed at end of braking
 v_{max} = maximum speed of vehicle
 n = number of brake applications
 Δt = duration of a braking cycle: time elapsing between the initiation of one brake application and the initiation of the next.

- 1.5.1.2.** If the characteristics of the vehicle make it impossible to abide by the duration prescribed for Δt, the duration may be increased; in any event, in addition to the time necessary for braking and accelerating the vehicle, a period of **10 seconds** must be allowed in each cycle for **stabilizing** the speed v₁.
- 1.5.1.3.** In these tests, the force applied to the control must be so adjusted as to attain the mean fully developed deceleration of **3 m/s²** at the first brake application; this force must remain **constant throughout the succeeding brake applications**.
- 1.5.1.4.** During brake applications, the highest gear ratio (excluding overdrive, etc.) must be continuously engaged.
- 1.5.1.5.** For regaining speed after braking, the gearbox must be used in such a way as to attain the speed v₁ in the shortest possible time (maximum acceleration allowed by the engine and gearbox).

- 1.5.1.6.** For vehicles not having sufficient autonomy to carry out the cycles of heating of the brakes, the

tests shall be carried out by achieving the prescribed speed before the first braking application and thereafter by using the maximum acceleration available to regain speed and then braking successively at the speed reached at the end of each time cycle duration as specified, for the appropriate vehicle category, in paragraph 1.5.1.1. above.

- 1.5.1.7. For vehicles equipped with an **electric regenerative braking system** of **category B**, the condition of the vehicle batteries at the start of the test, shall be such that the braking force contribution provided by the electric regenerative braking system does not exceed the minimum guaranteed by the system design.

This requirement is deemed to be satisfied if the batteries are at one of the state of charge conditions listed in the **fourth** clause of **paragraph 1.4.1.2.2.** above.

- 1.5.1.8. In the case of vehicles equipped with **automatic brake adjustment devices** the adjustment of the brakes shall, prior to the Type-I test above, be set according to the following procedures as appropriate:

- 1.5.1.8.1. In the case of vehicles equipped with air operated brakes the adjustment of the brakes shall be such as to enable the automatic brake adjustment device to function. For this purpose the actuator stroke shall be adjusted to:

$$S_0 \geq 1.1 S_{re-adjust}$$

with an upper limit not exceeding a value recommended by the manufacturer.) where:

$S_{re-adjust}$ is the re-adjustment stroke according to the specification of the manufacturer of the automatic brake adjustment device, ie. the stroke where it starts to re-adjust the running clearance of the brake with an actuator pressure of **15%** of the brake system operating pressure but not less than **1.0 bar**.

By agreement with the Technical Service, where it is impractical to measure the actuator stroke, the initial setting shall be agreed with that Technical Service.

From the above condition, the brake shall be operated with an actuator pressure of 30% of the brake system operating pressure but not less than 2.0 bar, 50 times in succession. This shall be followed by a single brake application with an actuator pressure of ≥ 6.5 bar.

- 1.5.1.8.2. In the case of vehicles equipped with hydraulically operated disc brakes, no settings requirements are deemed to be necessary.

- 1.5.1.8.3. In the case of vehicles equipped with hydraulically operated drum brakes, the adjustment of the brakes shall be as specified by the manufacturer.

1.5.2. With continuous braking

- 1.5.2.1. The service brakes of trailers of categories **O₂** and **O₃** must be tested in such a manner that, the vehicle being laden, the energy input to the brakes is equivalent to that recorded in the same period of time with a laden vehicle driven at a steady speed of **40 km/h** on a **7% down-gradient** for a distance of **1.7 km**.

- 1.5.2.2. The test may be carried out on a level road, the trailer being drawn by a towing vehicle; during the test, the force applied to the control must be adjusted so as to keep the resistance of the trailer constant (**7%** of the maximum total stationary axle load of the trailer). If the power

available for hauling is insufficient, the test can be conducted at a lower speed but over a greater distance as shown in the table below:

Speed (km/h)	Distance (metres)
40	1700
30	1950
20	2500
15	3100

1.5.2.3. In the case of trailers equipped with automatic brake adjustment devices, the adjustment of the brakes shall, prior to the **Type-I** test prescribed above, be set according to the procedure laid down in paragraph **1.7.1.1.** of this Annex.

1.5.3. Hot performance

1.5.3.1. At the end of the Type-I test (test described in paragraph **1.5.1.** or the test described in paragraph **1.5.2.** of this Annex) the hot performance of the service braking system must be measured in the same conditions (and in particular at a **constant control force** no greater than the mean force actually used) as for the Type-0 test with the engine disconnected (the temperature conditions may be different).

1.5.3.1.1. For power-driven vehicles this hot performance must not be less than **80%** of that prescribed for the category in question, nor less than **60%** of the figure recorded in the Type-0 test with the engine disconnected.

1.5.3.1.2. For vehicles fitted with an **electric regenerative braking** system of **category A**, during brake applications, the highest gear shall be continuously engaged and the separate electric regenerative braking control, if any, shall not be used.

1.5.3.1.3. In the case of vehicles equipped with an electric regenerative braking system of **category B**, having carried out the heating cycles according to **paragraph 1.5.1.6.** of this annex, the hot performance test shall be carried out at the maximum speed which can be reached by the vehicle at the end of the brake heating cycles, unless the speed specified in **paragraph 1.4.2.** of this Annex can be reached.

For comparison, the Type-0 test with cold brakes shall be repeated from this same speed and with a similar electric regenerative braking contribution, as set by an appropriate state of battery charge, as was available during the **hot performance test**.

Reconditioning of the linings shall be permitted before the test is made to compare this second Type-0 cold performance with that achieved in the hot test, against the criteria of **paragraphs 1.5.3.1.1. and 1.5.3.2.** of this Annex.

1.5.3.1.4. However, **in the case of trailers**, the hot brake force at the periphery of the wheels when tested at 40 km/h must not be less than **36%** of the maximum stationary wheel load, nor less than **60%** of the figure recorded in the Type-0 test at the same speed.

1.5.3.2. In the case of a power-driven vehicle which satisfies the **60%** requirement specified in

paragraph 1.5.3.1.1. above, but which cannot comply with the **80%** requirement of paragraph 1.5.3.1.1. above, a further hot performance test may be carried out using a control force not exceeding that specified in **paragraph 2** of this Annex for the relevant vehicle category. The results of both tests shall be entered in the report.

1.5.4. Free Running Test

In the case of motor vehicles equipped with automatic brake adjustment devices, the brakes, after completing the tests defined in **paragraph 1.5.3.** above, will be allowed to cool to a temperature representative of a cold brake (ie. $\leq 100^{\circ}\text{C}$) and it should be verified that the vehicle is capable of free running by fulfilling one of the following conditions:

- a) Wheels are running freely and may be rotated by hand
- b) It is ascertained that, when the vehicle is driven at a constant speed of $v = 60 \text{ km/h}$ with the brakes released, the asymptotic temperatures shall not exceed a drum/disc temperature increase of 80°C , then the residual brake moments are regarded as acceptable.

1.6. Type-II test (downhill behaviour test)

1.6.1. Laden power-driven vehicles must be tested in such a manner that the energy input is equivalent to that recorded in the same period of time with a laden vehicle driven at an average speed of **30 km/h** on a **6%** down-gradient for a distance of **6 km**, with the appropriate gear engaged and the retarder, if the vehicle is equipped with one, being used. The gear engaged must be such that the speed of the engine (revs/min) does not exceed the maximum value prescribed by the manufacturer.

1.6.2. For vehicles in which the energy is absorbed by the braking action of the **engine alone**, a tolerance of $\pm 5 \text{ km/h}$ on the average speed shall be permitted, and the gear enabling the speed to be stabilized at the value closest to **30 km/h** on the **6%** down-gradient shall be engaged. If the performance of the braking action of the engine alone is determined by a measurement of deceleration, it shall be sufficient if the mean deceleration measured is at least **0.5 m/s²**.

1.6.3. At the end of the test, the hot performance of the service braking system must be measured in the same conditions as for the Type-0 test with the engine disconnected (the temperature conditions may be different). This hot performance must give a stopping distance not exceeding the following values and a mean fully developed deceleration not less than the following values, using a control force not exceeding **70 daN**,

category **M₃** $0.15v + (1.33 v^2/130)$ (the second term corresponds to a mean fully developed deceleration (d_m) of **3.75 m/s²**)

category **N₃** $0.15v + (1.33 v^2/115)$ (the second term corresponds to a mean fully developed deceleration (d_m) of **3.3 m/s²**)

1.6.4. Vehicles cited in paragraphs **1.8.1.1.**, **1.8.1.2.** and **1.8.1.3.** below must satisfy the Type-IIA test described in section **1.8.2.** below instead of the Type-II test.

1.7. Type-III test (fade test for vehicles of Category O₄)

1.7.1. Track test

1.7.1.1. The adjustment of the brakes shall, prior to the Type-III test below, be set according to the following procedures as appropriate:

1.7.1.1.1. In the case of trailers with air operated brakes, the adjustment of the brakes shall be such as to enable the automatic brake adjustment device to function. For this purpose the actuator stroke shall be adjusted to:

$$S_o \geq 1.1 S_{re-adjust}$$

(with an upper limit not exceeding a value recommended by the manufacturer.)

where:

$S_{re-adjust}$ is the re-adjustment stroke according to the specification of the manufacturer of the automatic adjustment device, ie. the stroke where, with an actuator pressure of **1.0 bar**, it starts to re-adjust the running clearance of the brake.

By agreement with the Technical Service, where it is impractical to measure the actuator stroke, the initial setting shall be agreed with that Technical Service.

From the above condition the brake shall be operated with an actuator pressure of **2.0 bar, 50 times** in succession. This shall be followed by a single brake application with an actuator pressure of ≥ 6.5 bar.

1.7.1.1.2. In the case of trailers equipped with hydraulically operated disc brakes, no setting requirements are deemed to be necessary.

1.7.1.1.3. In the case of trailers equipped with hydraulically operated drum brakes, the adjustment of the brakes shall be as specified by the manufacturer.

1.7.1.2. For the road test the conditions shall be as follows:

number of brake applications:	20
duration of a braking cycle:	60 s
initial speed at the beginning of braking:	60 km/h
Braking applications:	In these tests, the force applied to the control must be so adjusted as to attain the mean fully developed deceleration of 3m/s² in relation to the trailer mass P_R at the first brake application; this force must remain constant throughout the succeeding brake applications.

The braking rate of a trailer is calculated according to the formula given in paragraph 1.4.4.3. of Regulation No. 13, **Annex 4**:

$$Z_R = (Z_{R+M} - R) \cdot \frac{P_M + P_R}{P_R} + R$$

The speed at the end of braking (**Annex 11, Appendix 2, paragraph 3.1.5.**):

$$v_2 = v_1 \sqrt{\frac{P_M + P_1 + P_2/4}{P_M + P_1 + P_2}}$$

where:

Z_R	=	braking rate of the trailer
Z_{R+M}	=	braking rate of the vehicle combination (motor vehicle and trailer)

R	=	rolling resistance value = 0.01	
P _M	=	total normal static reaction between the road surface and the wheels of towing vehicle for trailer (kg)	
P _R	=	total normal static reaction between the road surface and the wheels of trailer (kg)	
P ₁	=	part of the mass of the trailer borne by the unbraked axle(s) (kg)	
P ₂	=	part of the mass of the trailer borne by the braked axle(s) (kg)	
v ₁	=	initial speed (km/h)	v ₂ = final speed (km/h)

1.7.2. Hot performance

At the end of the test according to paragraph 1.7.1., the hot performance of the service braking system must be measured under the same conditions as for the Type-0 test with, however, different temperature conditions and starting from an initial speed of **60 km/h**. The hot brake-force at the periphery of the wheels must then not be less than **40%** of the maximum stationary wheel load, and not less than **60%** of the figure recorded in the Type-0 test at the same speed.

1.7.3. Free Running Test

After completing the tests defined in paragraph 1.7.2. above, the brakes shall be allowed to cool to a temperature representative of a cold brake (ie. $\leq 100^{\circ}\text{C}$) and it shall be verified that the trailer is capable of free running by fulfilling one of the following conditions:

- a) Wheels are running freely and may be rotated by hand.
- b) It is ascertained that, when the trailer is driven at a constant speed of **V = 60 km/h** with the brakes released, the asymptotic temperatures shall not exceed a drum/disc temperature increase of **80°C**, then the residual brake moments are regarded as acceptable.

1.8. Type IIA test (endurance braking performance)

1.8.1. Vehicles of the following categories shall be subject to the Type IIA test:

1.8.1.1. **Interurban motor coaches** and long distance touring motor coaches of category **M₃**.

1.8.1.2. Vehicles of category **N₃** which are authorized to **tow a trailer** of category **O₄**. If the maximum mass exceeds **26 tonnes**, the test mass is limited to **26 tonnes** or, in the case where the unladen mass exceeds **26 tonnes**, this mass is to be taken into account by calculation.

1.8.1.3. Certain vehicles subject to the **ADR** (see **Annex 5**).

1.8.2. Test conditions and performance requirements:

- 1.8.2.1.** The performance of the endurance braking system shall be tested at the maximum mass of the vehicle or vehicle combination.
- 1.8.2.2. Laden vehicles** must be tested in such a manner that the energy input is equivalent to that recorded in the same period of time with a laden vehicle driven at an average speed of **30 km/h** on a **7%** down-gradient for a distance of **6 km**. During the test, the service, secondary and parking braking systems must not be engaged. The gear engaged must be such that the speed of the engine does not exceed the maximum value prescribed by the manufacturer. An integrated endurance braking system may be used, provided that it is **suitably phased** such that the **service braking** system is **not applied**; this may be verified by checking that its brakes remain cold, as defined in paragraph **1.4.1.1.** of **Annex 4** to this Regulation.
- 1.8.2.3.** For vehicles in which the energy is absorbed by the braking action of the **engine alone**, a tolerance of **± 5 km/h** on the average speed shall be permitted, and the gear enabling the speed to be stabilized at a value closest to **30 km/h** on a **7%** down-gradient shall be engaged. If the performance of the braking action of the engine alone is determined by measuring the deceleration, it shall be sufficient if the mean deceleration measured is at least **0.6 m/s²**.

2. PERFORMANCE OF BRAKING SYSTEMS OF VEHICLES OF CATEGORIES M AND N.

2.1. Service Braking System.

- 2.1.1.** The service braking systems of vehicles of categories M and N shall be tested under the conditions shown in the following table:

	Vehicle category	M ₂	M ₃	N ₁	N ₂	N ₃
	Type of test ->	0-I	0-I-II or IIA	0-I	0-I	0-I-II
Type-0 test with engine Disconnected	V S ≤ d _m ≥	60 km/h	60 km/h	80 km/h	60 km/h	60 km/h
		0.15v + (v ² /130)				
		5.0 m/s²				
Type-0 test with engine Connected	v = 80% v _{max} but not exceeding: S ≤ d _m ≥	100 km/h	90 km/h	120 km/h	100 km/h	90 km/h
		0.15v + (v ² /103.5)				
		4.0 m/s²				
	F ≤	70 daN				

where: v = prescribed test speed
 S = stopping distance in metres
 d_m = mean fully developed deceleration (MFDD)
 F = force applied to foot control
 v_{max} = maximum speed of the vehicle

- 2.1.2. In the case of a **power-driven vehicle** authorized to tow an **unbraked trailer**, the minimum performance **prescribed** for the corresponding power-driven vehicle category (for the Type-0 test with engine disconnected) must be attained with the unbraked trailer coupled to the power-driven vehicle and with the unbraked trailer laden to the maximum mass declared by the power-driven vehicle manufacturer.

The combination performance shall be verified by calculations referring to the maximum braking performance actually achieved by the power-driven vehicle alone (laden) during the Type-0 test with the engine disconnected, using the following formula (no practical tests with a coupled unbraked trailer are required):

where:

$$d_{M+R} = d_M \cdot \frac{P_M}{P_M + P_R}$$

d_{M+R} = calculated MFDD of the power-driven vehicle when coupled to an unbraked trailer, in m/s^2

d_M = maximum MFDD of the power-driven vehicle alone achieved during the Type-0 test with engine disconnected, in m/s^2

P_M = mass of the power-driven vehicle (laden)

P_R = maximum mass of an unbraked trailer which may be coupled, as declared by the power-driven vehicle manufacturer

2.2. Secondary Braking System.

- 2.2.1. The secondary braking system, even if the control which actuates it is also used for other braking functions, must give a stopping distance not exceeding the following values and a mean fully developed deceleration not less than the following values:

category **M₂, M₃** $0.15 v + (2v^2/130)$
(the second term corresponds to a d_m of **2.5 m/s^2**)

category **N** $0.15 v + (2v^2/115)$
(the second term corresponds to a d_m of **2.2 m/s^2**)

- 2.2.2. If the control is manual, the prescribed performance must be obtained by applying to the control a force not exceeding **60 daN** and the control must be so placed that it can be easily and quickly grasped by the driver.
- 2.2.3. If it is a foot control, the prescribed performance must be obtained by applying to the control a force not exceeding **70 daN** and the control must be so placed that it can be easily and quickly actuated by the driver.
- 2.2.4. The performance of the secondary braking system must be checked by the Type-0 test with engine disconnected from the following initial speeds:
- | | |
|-----------------|---------------------------------|
| M_2 : 60 km/h | M_3 : 60 km/h |
| N_1 : 70 km/h | N_2 : 50 km/h N_3 : 40 km/h |
- 2.2.5. The secondary braking effectiveness test shall be conducted by simulating the actual failure conditions in the service braking system.
- 2.2.6. For vehicles employing **electric regenerative braking** systems, the braking performance shall additionally be checked under the **two** following failure conditions:

- 2.2.6.1. For a total failure of the electric component of the service braking output;

- 2.2.6.2.** In the case where the failure condition causes the electric component to deliver its maximum braking force.

2.3. Parking Braking System.

- 2.3.1.** The parking braking system must, even if it is combined with one of the other braking systems, be capable of holding the laden vehicle stationary on an **18%** up or down-gradient.
- 2.3.2.** On vehicles to which the coupling of a trailer is authorized, the parking braking system of the towing vehicle must be capable of holding the combination of vehicles stationary on a **12%** up or down-gradient.
- 2.3.3.** If the control is manual, the force applied to it must not exceed **60 daN**.
- 2.3.4.** If it is a foot control, the force exerted on the control must not exceed **70 daN**.
- 2.3.5.** A parking braking system which has to be actuated several times before it attains the prescribed performance is admissible.
- 2.3.6.** To check compliance with the requirement specified in paragraph **5.2.1.2.4.** of this Regulation, a **Type-0 test** must be carried out with the engine disconnected at an initial test speed of **30 km/h**. The mean fully developed deceleration on application of the control of the parking brake system and the deceleration immediately before the vehicle stops shall not be less than **1.5 m/s²**. The test shall be carried out with the **laden** vehicle. The force exerted on the braking control device shall not exceed the specified values.
- 2.4. Residual Service Braking after transmission failure.**

- 2.4.1.** The residual performance of the service braking system, in the event of failure in a part of its transmission, must give a stopping distance not exceeding the following values and a mean fully developed deceleration not less than the following values, using a control force not exceeding **70 daN**, when checked by the Type-0 test with the engine disconnected from the following initial speeds for the relevant vehicle category:

Stopping distance (m) and mean fully developed deceleration d_m (m/s²).

	(km/h)	S. Dist. LADEN (m)	d_m (m/s ²)	S. Dist UNLADEN (m)	d_m (m/s ²)
M ₂	60	$0.15v + (100/30) \cdot (v^2/130)$	1.5	$0.15v + (100/25) \cdot (v^2/130)$	1.3
M ₃	60	$0.15v + (100/30) \cdot (v^2/130)$	1.5	$0.15v + (100/30) \cdot (v^2/130)$	1.5
N₁	70	$0.15v + (100/30) \cdot (v^2/115)$	1.3	$0.15v + (100/25) \cdot (v^2/115)$	1.1
N ₂	50	$0.15v + (100/30) \cdot (v^2/115)$	1.3	$0.15v + (100/25) \cdot (v^2/115)$	1.1
N ₃	40	$0.15v + (100/30) \cdot (v^2/115)$	1.3	$0.15v + (100/30) \cdot (v^2/115)$	1.3

- 2.4.2.** The residual braking effectiveness test shall be conducted by simulating the actual failure conditions in the service braking system.

3. PERFORMANCE OF BRAKING SYSTEMS OF VEHICLES OF CATEGORY O.

3.1. Service Braking System.

3.1.1. Provision relating to tests of vehicles of category O₁ :

Where the provision of a service braking system is mandatory, the performance of the system must meet the requirements laid down for vehicles of categories O₂ and O₃ .

3.1.2. Provisions relating to tests of vehicles of categories O₂ and O₃ :

3.1.2.1. If the service braking system is of the continuous or semi-continuous type, the sum of the forces exerted on the periphery of the braked wheels shall be at least x per cent of the maximum stationary wheel load, x having the following values:

full trailer, laden and unladen----- 50%
semi-trailer, laden and unladen-----45%
centre-axle trailer, laden and unladen----50%

3.1.2.2. If the trailer is fitted with a compressed-air braking system, the pressure in the supply line shall not exceed **7 bar** during the brake test and the signal value in the control line shall not exceed the following values, depending on the installation:

- (a) **6.5 bar** in the pneumatic control line;
- (b) a digital demand value corresponding to **6.5 bar** (as defined in **ISO 11992:(1998)**) in the electric control line.

The test speed is **60 km/h**. A supplementary test at **40 km/h** shall be carried out with the laden trailer for comparison with the Type-I test result.

3.1.2.3. If the braking system is of the inertia type, it must comply with the requirements of **Annex 12** to this Regulation.

3.1.2.4. In addition, the vehicles must undergo the Type-I test.

3.1.2.5. In Type-I tests of a semi-trailer, the mass braked by the latter's axle(s) must correspond to the maximum axle load(s) (not including the king pin load).

3.1.3. Provisions relating to tests of vehicles of category O₄ :

3.1.3.1. If the service braking system is of the continuous or semi-continuous type, the sum of the forces exerted on the periphery of the braked wheels shall be at least x per cent of the maximum stationary wheel load, x having the following values:

full trailer, laden and unladen----- 50%
semi-trailer, laden and unladen-----45%
centre-axle trailer, laden and unladen----50%

3.1.3.2. If the trailer is fitted with a compressed-air braking system, the pressure in the control line must not exceed **6.5 bar**, and the pressure in the supply line must not exceed **7.0 bar** during the brake test. The test speed is **60 km/h**.

3.1.3.3. In addition, the vehicles must undergo the **Type-III** test.

3.1.3.4. In the **Type-III test of a semi-trailer**, the mass braked by the latter's axle(s) must correspond to the maximum axle load(s).

3.2. Parking Braking System.

- 3.2.1.** The parking braking system with which the trailer is equipped must be capable of holding the laden trailer stationary, when separated from the towing vehicle, on an **18%** up or down gradient. The force applied to the control device must not exceed **60 daN**.
- 3.3. Automatic Braking System.**
- 3.3.1.** The automatic braking performance in the event of a failure, as described in paragraph **5.2.1.18.3.** of this Regulation, when testing the laden vehicle from a speed of **40 km/h**, shall not be less than **13.5%** of the maximum stationary wheel load. Wheel-locking at performance levels above **13.5%** is permitted.
- 4. RESPONSE TIME.**
- 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:
- 4.1.1.** in an emergency manoeuvre, the time elapsing between the moment when the control device begins to be actuated and the moment when the braking force on the least favourably placed axle reaches the level corresponding to the prescribed performance must not exceed **0.6 seconds**.
- 4.1.2.** in the case of vehicles fitted with **compressed-air** braking systems, the requirements of paragraph **4.1.1.** above are considered to be satisfied if the vehicle complies with the provisions of **Annex 6** to this Regulation.
- 4.1.3.** In the case of vehicles fitted with **hydraulic** braking systems, the requirements of paragraph **4.1.1.** 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**.

Annex 4 - Appendix 1

PROCEDURE FOR MONITORING THE STATE OF BATTERY CHARGE.

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

The procedure requires the use of a **bi-directional DC Watt-hour meter**.

1. Procedure.

- 1.1. If the batteries are new or have been subject to extended storage, they shall be cycled as recommended by the manufacturer. A minimum 8 hour soak period at ambient temperature shall be allowed after completion of cycling.
- 1.2. A full charge shall be established using the manufacturer's recommended charging procedure.
- 1.3. When the braking tests of paragraphs 1.2.11., 1.4.1.2.2., 1.5.1.6., and 1.5.3.1.3. of **Annex 4** are conducted, the watt-hours consumed by the traction motors and supplied by the regenerative braking system shall be recorded as a running total which shall then be used to determine the state of charge existing at the beginning or end of a particular test.
- 1.4. To replicate a level of **state of charge** in the batteries for comparative tests, such as those of **paragraph 1.5.3.1.3.**, the batteries shall be either recharged to that level or charged to above that level and discharged into a fixed load at approximately constant power until the required state of charge is reached.
Alternatively, for vehicles with battery powered electric traction only, the state of charge may be adjusted by running the vehicle. Tests conducted with a battery partially charged at their start shall be commenced as soon as possible after the desired state of charge has been reached.

Annex 5

ADDITIONAL PROVISIONS APPLICABLE TO CERTAIN VEHICLES AS SPECIFIED IN THE ADR

1. SCOPE

This Annex applies to certain vehicles for which the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) contains specific requirements as concerns anti-lock and endurance braking performance.

2. REQUIREMENTS

2.1. General provisions

Power-driven vehicles and trailers intended for use as transport units for dangerous goods shall fulfil all relevant technical requirements of this Regulation. In addition, the following technical provisions shall apply as appropriate.

2.2. Anti-lock braking system of trailers

2.2.1. Trailers of **category O₄** shall be equipped with **category A** anti-lock systems as defined in **Annex 13** of this Regulation.

2.3. Endurance braking system

2.3.1. Power-driven vehicles having a maximum mass **exceeding 16 tonnes**, or authorized to **tow a trailer of category O₄** shall be fitted with an endurance braking system according to **paragraph 2.14.** of this Regulation which complies with the following requirements:

2.3.1.1. The endurance braking control configurations shall be from a type described in **paragraphs 2.14.2.1. to 2.14.2.3.** of this Regulation.

2.3.1.2. In the case of an electrical failure of the anti-lock system, integrated or combined **endurance braking systems** shall be **switched off automatically.**

2.3.1.3. The effectiveness of the endurance braking system shall be controlled by the anti-lock braking system such that the axle(s) braked by the endurance braking system cannot be locked by that system at speeds **above 15 km/h.** However, this requirement shall not apply to that part of the braking system constituted by the natural engine braking.

2.3.1.4. The **endurance** braking system shall comprise several **stages** of effectiveness, including a low stage appropriate for the unladen condition. Where the endurance braking system of a power-driven vehicle is constituted by its engine, the different gear ratios shall be considered to provide the different stages of effectiveness.

2.3.1.5. The performance of the endurance braking system must be such that it fulfils the requirements of **paragraph 1.8. of Annex 4** to this Regulation (Type-II A test), with a laden vehicle mass comprising the laden mass of the motor vehicle and its authorized maximum towed mass but not exceeding a **total of 44 tonnes.**

If a trailer is equipped with an endurance braking system it shall fulfil the requirements of **paragraphs 2.3.1.1. to 2.3.1.4.** above as appropriate.