



Economic and Social Council

Distr.: General
16 November 2023

English only

Economic Commission for Europe

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

Working Party on Automated/Autonomous and Connected Vehicles

Eighteenth session

Geneva, 22-26 January 2024

Item 8(b) of the provisional agenda

UN Regulations Nos. 13, 13-H, 139, 140 and UN GTR No. 8:

Electromechanical braking

Proposal for a new series of amendments to UN Regulation No. 13 (Heavy Vehicle Braking)

Submitted by the expert from the United Kingdom of Great Britain and Northern Ireland, Chair of the Special Interest Group on electrical braking systems *

The text reproduced below was prepared by the Chair of the Special Interest Group concerning electrical braking systems and is based on informal document GRVA-15-17. It is aimed at recognising technical advances and the emergence of a new type of braking system that employs stored electrical energy for both the control transmission and the energy transmission. The modifications to the existing text of the Regulation are marked in bold for new characters and in bold strikethrough for deleted characters.

It is expected that this proposal will be considered in combination with document ECE/TRANS/WP.29/GRVA/2023/10, and that the two will form a package for adoption as a series of amendments to UN Regulation No. 13.

* In accordance with the programme of work of the Inland Transport Committee for 2024 as outlined in proposed programme budget for 2024 (A/78/6 (part V sect. 20) para 20.5), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.



I. Proposal

Contents, Annex 8 title, amend to read:

8. Provisions relating to specific conditions for **compressed-air braking systems fitted with** spring braking systems.

Paragraph 2.21.4., amend to read:

- 2.21.4. "*Electric state of charge (SOC)*" means the instantaneous ratio of electric quantity of energy stored in **a traction battery an electrical storage device (e.g., battery, capacitor, etc.)** relative to the maximum quantity of electric energy which could be stored in this **battery device**.

Paragraph 2.3.1., amend to read:

- 2.3.1. "*Reference braking forces*" means the braking forces of one axle generated at the circumference of the tyre on a roller brake tester, relative to brake actuator pressure **or brake demand value respectively** and declared at the time of type approval.

Insert new paragraphs 2.44. to 2.52., to read:

- [2.44. "*Wheel brake demand value*" means the demand value for the braking force of a single wheel brake being electrically actuated. This shall be demonstrated to the satisfaction of the Technical Service, **including through the test specified in Annex 4, paragraph 1.8.2.5. (a) and submission of detailed documentation explaining the strategies implemented in the system and how this ensures endurance braking requirements can always be met.**
- 2.45. The "*performance of an electrical storage device*" means both its energy storage capacity [J] and its ability to provide electrical power [W].
- 2.46. "*P_w*" [W] means the low electrical supply power warning as required by paragraph 5.2.1.35.12. in the case of an electrical [transmission] braking system.
- 2.47. "*Energy source*" means a device that both generates and provides energy required for the braking system.
- 2.48. "*Electrical storage device*" means a device, or combination of individual devices, each capable of storing an electrical charge and of providing electrical power to the braking system transmission. Electrical storage devices which are connected in series and/or parallel for the purpose of supplying a single braking circuit, shall be considered as one electrical storage device within this Regulation.
- 2.49. The "*effect of ageing*" is quantifying the degradation of an electrical storage device, with regard to its ability to provide energy and power to an electrical transmission braking system, due to e.g., the effects of time, use, and environmental exposure.
- 2.50. "*Electrical supply device*" means a device (e.g. battery, REESS, DC/DC converter, generator, fuel-cell or a combination of these components) that supplies electrical power to the braking system's electrical storage device(s).
- 2.51. "*Electrical transmission braking system*" means a braking system of a power-driven vehicle where the service braking force, and transmission, depend exclusively on the use, controlled by the driver, of energy provided from electrical storage devices.

- 2.52. **“Energy Management System”** means, an electrical device, being part of, or used by, an electrical [transmission] braking system, that monitors critical variables that impact on the electrical intrinsic capability of an electrical storage device (e.g., voltage, temperature, internal resistance, effect of ageing, state of charge, power consumption, charging cycles, etc.) and deduces the actual capability of that device to fulfil the performance requirements of this Regulation.]

Paragraph 5.1.4.5.1., amend to read:

- 5.1.4.5.1. The data of the compressed-air or electrical [transmission] braking system for the functional and efficiency test shall be specified at the vehicle in a visible position in indelible form, or made freely available in another way (e.g. handbook, electronic data record).

Insert new paragraph 5.1.4.5.3., to read:

- 5.1.4.5.3. For power-driven vehicle equipped with electrical [transmission] braking system the vehicle manufacturer shall describe, at the time of type approval, the procedure by which it can be checked that the warning signal [AEUPW] and Pw are operational and fulfil the requirements of this Regulation. The procedure may be initiated e.g. by triggering an internal self-check routine that may include external actions by the operator.

Renumber current paragraphs 5.1.4.6.2. and 5.1.4.6.3. as 5.1.4.6.1.1. and 5.1.4.6.1.2.

Insert new paragraph 5.1.4.6.2. to read:

- [5.1.4.6.2. Reference braking forces for electrical [transmission] braking system using a roller brake tester shall be defined according to the following requirements.
- 5.1.4.6.2.1. It shall be possible on the vehicle to evaluate the relationship between the brake demand value(s) (e.g. as a percent value, voltage, etc.) and the measured braking force on a roller brake tester. The vehicle manufacturer shall describe the method by which this can be realized, and make this information available freely by e.g. handbook, electronic data record etc.
- 5.1.4.6.2.2. Reference braking forces are to be determined for each axle for a brake demand value from zero to a value corresponding to a braking force generated under Type-0 conditions. The applicant for type approval shall nominate these reference braking forces. These data shall be made available by the vehicle manufacturer, according to paragraph 5.1.4.5.1. above.
- 5.1.4.6.2.3. The reference braking forces shall be declared such that the vehicle is capable of generating a braking rate equivalent to that defined in Annex 4 of this Regulation for the relevant vehicle (50 per cent in the case of vehicles of category M₂, M₃, N₂, and N₃) whenever the measured roller braking force, for each axle irrespective of load, is not less than the reference braking force for a given brake demand value within the declared operating brake demand value range¹.]

Paragraph 5.2.1.2.7.2., amend to read:

- 5.2.1.2.7.2. If the service braking force and transmission depend ... below. **In case of compressed-air braking systems, in** each service braking circuit in at least one of the air reservoirs a device for draining and exhausting is required in an adequate and easily accessible position;

Renumber existing paragraph 5.2.1.2.7.3. as 5.2.1.2.7.4.

Paragraph 5.2.1.5., amend to read:

- 5.2.1.5. Where use is made of energy other than the muscular energy of the driver, there need not be more than one supply of such energy (hydraulic pump, air compressor, **electrical supply device**, etc.). The means by which the device constituting that ~~source~~ **supply, if it is driven**, shall be as safe as practicable."

Paragraph 5.2.1.5.1., amend to read:

- 5.2.1.5.1. In the event of failure in any part of the transmission of a braking system, the feed to the part not affected by the failure shall continue to be ensured if required for the purpose of halting the vehicle with the degree of effectiveness prescribed for residual and/or secondary braking. This condition shall be met by ~~means of devices which can be easily actuated when the vehicle is stationary, or by~~ automatic means.

Insert a new paragraph 5.2.1.5.4., to read:

- 5.2.1.5.4. However, as an alternative to the provisions of paragraphs 5.2.1.5.1. and 5.2.1.5.2., for an [electrical [transmission] braking system] these requirements are considered to be met if the requirements of paragraph 5.2.1.5.4.1. are satisfied.**

- 5.2.1.5.4.1. After any single transmission failure it shall still be possible after eight full-stroke actuations of the service braking system control, to achieve, at the ninth application, at least the performance prescribed for the secondary braking system or, where secondary performance requiring the use of stored energy is achieved by a separate control, it shall still be possible after eight full-stroke actuations to achieve, at the ninth application, the residual performance prescribed in paragraph 5.2.1.4. of this Regulation. Each full-stroke application shall be for a duration of at least [8.0] seconds with there being an interval of no more than [5.0] seconds between the release of the brake control and its subsequent actuation.**

Paragraph 5.2.1.8.1.1., amend to read:

- 5.2.1.8.1.1. A difference in transverse braking pressures **[or wheel brake demand value on any]** axle of:
- (a) 25 per cent of the higher value for vehicle decelerations $\geq 2 \text{ m/s}^2$;
 - (b) A value corresponding to 25 per cent at 2 m/s^2 for decelerations below this rate.

Paragraph 5.2.1.13.1., amend to read:

- 5.2.1.13.1. Any vehicle fitted with a service brake actuated from an energy **reserve** shall, where the prescribed secondary braking performance cannot be obtained by means of this braking system without the use of the stored energy, be provided with a warning device, in addition to a pressure gauge **(in the case of a pneumatic transmission)** where fitted, giving an optical or acoustic signal **at the latest** when the stored energy **([or the actual capability, as relevant])**, in any part of the system, falls to a ~~value~~ **a condition ([e.g., a pressure value, in case of a pneumatic transmission])** at which without re-charging of the **reserve** and irrespective of the load conditions of the vehicle:

- (a) For braking systems other than an electrical [transmission] braking system**, it is possible to apply the service brake control a fifth time after four full-stroke actuations and obtain the prescribed secondary braking performance;

(b) For electrical [transmission] braking systems, the prescribed service brake performance cannot be achieved, or it is still possible to apply the service brake control a fifth time after four full-stroke actuations and obtain at least the secondary braking performance, whichever occurs first.

Without faults in the service brake transmission and with the brakes adjusted as closely as possible.

This warning device shall be directly and permanently connected to the circuit. The red warning signal specified in paragraph 5.2.1.29.1.1. shall be used as the optical warning signal. When the engine is running, **or during a run cycle (e.g., in case of a vehicle propelled by an electric motor)**, under normal operating conditions and there are no faults in the braking system, as is the case in approval tests for this type, the warning device shall give no signal except during the time required for charging the energy **reserve(s) after each new engine start/run cycle.**

5.2.1.13.1.1. However, in the case of vehicles which are only considered to comply with the requirements of paragraph 5.2.1.5.1. of this Regulation by virtue of meeting the requirements of paragraph 1.2.2. of Part C of Annex 7 to this Regulation, the warning device shall consist of an acoustic signal in addition to an optical signal. These devices need not operate simultaneously, provided that each of them meet the above requirements and the acoustic signal is not actuated before the optical signal. The red warning signal specified in paragraph 5.2.1.29.1.1. shall be used as the optical warning signal.

5.2.1.13.1.2. This acoustic device may be rendered inoperative while the handbrake is applied and/or, at the choice of the manufacturer, in the case of automatic transmission the selector is in the 'Park' position.

Insert new paragraph 5.2.1.13.2., to read:

[5.2.1.13.2. In addition, any vehicle equipped with an electrical [transmission] braking system shall be equipped to determine and display the ["actual electrical usable performance (AEUP)"] of each of the electrical storage devices. [This shall be expressed as a percentage of the [certified usable performance] of the electric storage device.

The indicators for each [AEUP] value may share a common space in accordance with UN Regulation No. 121. They need not be permanently visible, however they must be visible immediately to the driver in response to a manual demand at any time that the ignition/start switch is in the "on" (run) position.

Furthermore, the [actual usable electrical performance] [percentage value of stored energy] in each of the electrical storage devices shall be displayed automatically on activation of the [AEUP_w] warning described in paragraph 5.2.1.13.1. above.]

Paragraph 5.2.1.18., amend to read:

5.2.1.18. In the case of a vehicle authorized to tow a trailer of category O₃ or O₄ **[which is equipped with a compressed-air braking system]**, its braking system shall satisfy the following conditions:

Paragraph 5.2.1.26.3., amend to read:

5.2.1.26.3. Auxiliary equipment may be supplied with energy from 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 5.2.1.27.7. **or in the case of [electrical [transmission] braking systems] paragraph 5.2.1.35.16. respectively shall apply.**

Paragraph 5.2.1.27., amend to read:

[5.2.1.27. Special additional requirements for service braking systems with electric control transmission **except [electrical [transmission] braking systems]**

Insert new paragraph 5.2.1.29.4.4., to read:

[5.2.1.29.4.4. In the case of an electrical [transmission] braking system employing an electrical storage device (or devices) it shall be ensured that the value of electrical performance at which the warning signal required by paragraph 5.2.1.35.9. and 5.2.1.35.10. is activated, is respected despite the effect of environmental conditions (e.g., temperature) and ageing. The manufacture shall show to the satisfaction of the type-approval authority, how this is achieved.]

Insert new paragraph 5.2.1.35., to read:

[5.2.1.35. Special additional requirements for electrical [transmission] braking systems.

5.2.1.35.1. For electrical [transmission] braking systems, the requirements of this paragraph 5.2.1.35. apply instead of those of paragraph 5.2.1.27. above.

5.2.1.35.2. The performance of the electrical storage device(s) shall be sufficient to ensure the residual performance as laid down in paragraph 2.4. of Annex 4 to this Regulation by the actuation of the service brake control when the vehicle is capable of driving.

5.2.1.35.3. The functionality of the system triggering the warning levels [AEUP_w] and P_w shall be described by the vehicle manufacturer together with the documentation package required in Annex 18 of this Regulation to the Technical Service.

5.2.1.35.4. With the parking brake released, the service braking system shall be able to generate a static total braking force at least equivalent to that required by the prescribed Type-0 test, even when the ignition/start switch has been switched off and/or the key has been removed. In the case of power-driven vehicles equipped with an interface according to paragraph 5.1.3 and authorized to tow trailers of category O₃ or O₄, such vehicles shall provide a full control signal for the service braking system of the trailer. It should be understood that sufficient energy is available in the energy transmission of the service braking system.

5.2.1.35.5. For an electrical storage device feeding only the electric control transmission, the full control range of the service braking system shall be guaranteed after the following test procedure.

This test shall be carried out starting from the nominal value of the energy level and the [electrical storage device] not being fed. With the control transmission in operation, the braking control shall be kept released for at least 20 minutes before performing 20 full stroke application of the brakes, with an application time of [8.0] seconds and a released time of [5.0] seconds between each actuation.

This requirement shall not be construed as a departure from the requirements of Annex 7, Part D, paragraph 1.

In order to avoid the activation of the red warning signal due to the excessive consumption of electrical energy of the electrical energy transmission, the electrical energy transmission may be switched off.

5.2.1.35.6. In the case that the electrical storage devices are providing electrical energy for the electrical control and electrical energy transmission, the requirements of paragraph 1.2.1. of Part D of Annex 7 shall apply.

5.2.1.35.7. As an alternative to the requirements of Annex 7, Part D, paragraph 1.2., electrical storage devices that provide power only to the control transmission of the braking system may satisfy the following requirement.

If the energy in an electrical storage device falls to a value at which the function or performance of a control transmission will be affected, the control transmission shall be provided with the power necessary for its correct operation directly from the electrical supply device. It should be understood that there is no fault or failure of the electrical supply device.

This alternative power supply shall be provided automatically no later than on the actuation of the control. The energy value at which this alternative supply is required shall be declared by the vehicle manufacturer to the type-approval authority / technical service and the transition verified at the time of type-approval.

In addition, this condition shall be signalled to the driver by use of the red warning signal specified in paragraphs 5.2.1.29.1.1.

5.2.1.35.8. The electrical storage devices may be used also by other vehicle systems as long as the energy consumption of these systems cannot cause the reserves of energy to fall under a level which ensures the prescribed service braking performance.

5.2.1.35.9. A warning signal shall be displayed when the energy storage capacity of the electrical storage device(s) is not sufficient to fulfil the requirements of Annex 7, Part D, paragraph 1.2.1. The yellow warning signal described in paragraph 5.2.1.29.1.2. shall be used.

5.2.1.35.10. A warning signal shall be displayed when the electrical energy level in the electrical storage device(s) is insufficient for more than 60 seconds to fulfil the prescribed braking performance in Annex 7, Part D, paragraph 1.2.1. The yellow warning signal described in paragraph 5.2.1.29.1.2. shall be used.

5.2.1.35.11. There shall be an energy management system for each electrical storage device of the transmission.

5.2.1.35.11.1. The energy management system shall be capable of continuously assessing the electrical storage devices, to deliver to the brake transmission the needed power over time to fulfil the performance requirements of this Regulation and, where appropriate, of activating the warning signals required by this Regulation.

In addition to fulfilling the performance requirements of Annex 7, the energy management system shall be assessed under Annex 18. The manufacturer shall provide details of the operation of the energy management system, and the input variables (including the sensitivity of the performance of the energy storage device to those variables). This information shall be part of the documentation required by Annex 18.

5.2.1.35.11.2. It shall be demonstrated that the energy management system accurately identifies the condition at which the warning signals required by this Regulation are activated.

The Technical Service shall take account of the influence of the individual variables used by the energy management system on the capability of the electrical storage device(s), to assess if the accuracy of the energy management system is ensured under all operating conditions that can reasonably be foreseen (e.g., changes in temperature). Details of the assessment shall be included in the test report. ^{*/}

Footnote ^{/} For practical reasons, e.g, climate chamber tests, and at the request of the manufacturer, the technical service may assess the performance of the energy management system during the development cycle of the vehicle.*

- 5.2.1.35.12. In the case that the supply of power requested by the electrical storage device(s) cannot be met by the electrical supply device and delivered power falls below 90 % of currently requested, a power warning (P_w) to the driver shall be activated no later than 5 s after the appearance/detection. The yellow warning signal specified in paragraph 5.2.1.29.1.2. may be used.
- 5.2.1.35.13. The functions to monitor the ageing and charging of the electrical storage devices shall be checked at the time of type approval. The method by which this check is carried out shall be agreed between the vehicle manufacturer and technical service. The values of [CUP, MRUP, AEUP_w etc], specified by the manufacturer and verified in the assessment, shall be declared in Annex 2 paragraph [17.x].
- 5.2.1.35.14. In the case where the braking system of the vehicle shares the same electrical supply as other vehicle systems and there is low power available from that supply, the braking system shall have priority.
- However, if that electrical supply device also supplies the steering equipment, the steering shall have priority over the braking system in accordance with UN Regulation No. 79.
- 5.2.1.35.15. The red warning signal specified in paragraph 5.2.1.29.1.1. shall be activated when the service braking performance is not anymore ensured by at least two independent service braking circuits from each achieving the prescribed secondary or residual braking performance.
- 5.2.1.35.16. If auxiliary equipment is supplied with energy from the same electrical storage device(s) as the electric transmission, it shall be ensured that the supply of energy (in the case of a driven energy source with the engine running at a speed not greater than 80 per cent of the maximum power speed) is sufficient to fulfil the prescribed deceleration values by either provision of an energy supply which is able to prevent discharge of these reserves when all auxiliary equipment is functioning or by automatically switching off pre-selected parts of the auxiliary equipment at a level above the critical level referred to in paragraph 5.2.1.13.1. (b) of this Regulation such that further discharge of these reserves is prevented. Compliance may be demonstrated by calculation or by a practical test. In the case of power-driven vehicles equipped with an interface according to paragraph 5.1.3. and authorized to tow a trailer of Category O₃ or O₄ the energy consumption of the trailer shall be taken into account by a load of 400 W if this consumption is provided by the electrical storage device(s).
- 5.2.1.35.17. A failure within the electric transmission, [^{*/}] that affects the function and performance of systems addressed in this Regulation shall be indicated to the driver by the red or yellow warning signal specified in paragraphs 5.2.1.29.1.1. and 5.2.1.29.1.2., 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 (e.g.

breakage, disconnection) shall be signalled to the driver as soon as they occur, and the prescribed residual braking performance shall be fulfilled by operating the service braking control in accordance with paragraph 2.4. of Annex 4 to this Regulation. These requirements shall not be construed as a departure from the requirements concerning secondary braking.

*Footnote */ Until uniform test procedures have been agreed, the manufacturer shall provide the Technical Service with an analysis of potential failures within the electrical transmission and their effects. This information shall be subject to discussion and agreement between the Technical Service and the vehicle manufacturer.*

- 5.2.1.35.18. In the case of a single temporary failure (< 40 ms) within the electric control transmission, excluding its energy supply, (e.g. non-transmitted signal or data error) there shall be no distinguishable effect on the service braking performance.
- 5.2.1.35.19. In the case of a power-driven vehicle, electrically connected to a trailer via an electric control line, a clear warning shall be provided to the driver whenever the trailer provides the failure information that the stored energy in any part of the service braking system on the trailer falls below the warning level, as specified in paragraph 5.2.2.16. below. A similar warning shall also be provided when a continuous failure (> 40 ms) within the electric control transmission of the trailer, excluding its energy reserve, precludes achievement of the prescribed service braking performance of the trailer, as specified in paragraph 5.2.2.15.2.1. below. The red warning signal specified in paragraph 5.2.1.29.2.1. shall be used for this purpose.
- 5.2.1.35.20. In the case of a failure in the electric control transmission of the service braking system of a towing vehicle equipped with an electric control line according to paragraph 5.1.3.1.2. or 5.1.3.1.3., the full actuation of the brakes of the trailer shall remain ensured.
- 5.2.1.35.21. If the auxiliary equipment is supplied with energy from the electric transmission, the following requirements shall be fulfilled.
- 5.2.1.35.21.1. In the event of a failure in the energy source or electrical supply device, whilst the vehicle is in motion, the energy in the electrical storage device(s) shall be sufficient to actuate the brakes when the control is applied.
- [5.2.1.35.21.2. In the event of a failure in the energy source or electrical supply device, whilst the vehicle is stationary and the parking braking system applied, the energy in the electrical storage device(s) shall be sufficient to actuate the lights even when the brakes are applied.]

Annex 2

Renumber existing paragraph 17. to 26. as 18. to 27.

Insert a new paragraph 17., to read:

- 17.** Additional information in the case of power-driven vehicle equipped with an electrical [transmission] braking system.
- 17.1.** Vehicle is/is not² equipped with an electrical [transmission] braking system
- 17.2.** In the case where a towing vehicle is equipped with an electrical [transmission] braking system the vehicle is/is not² authorized to tow a trailer with a compressed-air braking system
- 17.3.** Low electrical performance levels [AEUP_{wf} in[J and W] respectively for the electrical storage device(s) of each service braking circuit.

- 17.4. **Certified Usable Performance [(CUP)] in [J and W] respectively for the electrical storage device(s) of each service braking circuit.**
- 17.5. **[Minimum Required Usable Performances (MRUP)] in [J and W] respectively for the electrical storage device(s) of each service braking circuit.**
- 17.6. **Low electrical performance levels [AEUPW] in [J and W] respectively for the electrical storage device(s) of each service braking circuit.**
- 17.7. **The maximum charging power in W for the electrical storage device(s) of each service braking circuit.]**

Annex 4

Paragraph 1.2.11., amend to read:

1.2.11. Status of the energy reserve during the Annex 4 tests:

(a) 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 per cent 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.

(b) **For a vehicle with an electrical [transmission] braking system, and without a simulated failure, the energy in the electrical storage devices shall be kept above [AEUP_w] limit.**

Paragraph 1.5.1.7.2., amend to read:

- 1.5.1.7.2. In the case of vehicles equipped with hydraulically operated disc brakes [**or electrically controlled adjustment mechanisms**] no setting requirements are deemed necessary."

Insert a new paragraph 4.1.4., to read:

- 4.1.4. In the case of vehicles fitted with an electrical [transmission] braking system, 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 [clamp force] at the least favourable brake, reaches a level corresponding to the prescribed performance within 0.6 second.**

Annex 7

Insert a new section to read:

- D. Electrical [transmission] braking system.**
 - 1. Capacity of electrical storage devices**
 - 1.1. General**
 - 1.1.1. Vehicles equipped with an electrical [transmission] braking system shall be equipped with electrical storage devices of a capacity meeting the requirements of paragraph 1.2. of this annex (Part D).**
 - 1.1.2. Electrical storage devices that provide power only to the control transmission of the braking system may, as an alternative, satisfy the requirements of paragraph 5.2.1.35.7. to this Regulation.**
 - 1.1.3. It shall be possible to easily identify the electrical storage devices of the different braking circuits.**

- 1.2. Power-driven vehicles**
- 1.2.1.** The energy storage capacity [J] of the electrical storage device(s) shall be such that, when it is fully charged, as a minimum, after eight full-stroke actuations of the service braking system control the performance (at the ninth braking) at least fulfils the specified secondary braking performance. Additionally, it shall be such that, on at least the first actuation, the prescribed performance of the service braking system can be achieved.
- 1.2.2.** The value(s) of the energy level in the electrical storage device(s) of each braking circuit, available to satisfy the condition of paragraph 1.2.1. above, shall be specified by the manufacturer as [the minimum energy storage capacity (i.e. the energy value of MRUP)].^[3]
- Footnote [3] The value of the [minimum required usable performance] shall be stated in the approval document.
- 1.2.3.** Testing shall be performed in conformity with the following requirements:
- 1.2.3.1.** The initial value of electrical energy in each of the electrical storage device(s) of each braking circuit shall be no greater than the specified values of energy specified in 1.2.2. [(i.e. the energy value of MRUP)]. The electrical storage devices shall not be supplied with further energy during the test.
- The procedure by which the electrical storage devices are prepared for this test shall be agreed between the manufacturer and the type-approval authority. This procedure shall be recorded in the test report and included in the type-approval documentation.
- 1.2.3.2.** Each full-stroke actuation shall be for a duration of at least [~~7.0~~ 8.0] seconds with an interval of no more than [~~9.0~~ 5.0] seconds between the release of the brake control and its subsequent actuation.
- 1.2.3.3.** Each full stroke actuation shall cause a power demand on the electrical storage devices [equivalent to that required to provide maximum performance] from the service braking system. It shall be ensured that the energy provided to the brake system transmission during this test is provided only by the electrical storage devices.
- 1.2.3.4.** In the case of power-driven vehicles to which the coupling of a trailer is authorized and with a pneumatic control line, the supply line shall be stopped and a compressed-air reservoir of 0.5 litre capacity shall be connected directly to the coupling head of the pneumatic control line. Before each braking actuation, the pressure in this compressed-air reservoir shall be completely eliminated. After 8 full stroke actuations, at the additional (ninth) actuation of the service braking system control, the energy level supplied to the pneumatic control line shall not fall below a level equivalent to one-half the figure obtained at the first brake actuation.
- 1.2.3.5.** It shall be ensured that the energy consumed by the service braking is not reduced by energy saving functions when carrying out the test during standstill compared to a driving situation.
- 1.2.3.6.** The capability to achieve the prescribed secondary braking performance shall be confirmed by dynamic testing in accordance with Annex 4, using only the electrical energy available from the electrical storage devices at the completion of the relevant tests of paragraph 1.2.3. above. However, the requirement of Annex 4, paragraph 2.2.5. to simulate a failure into the braking system shall not apply.

- 1.2.3.7. The capability to achieve the prescribed service braking performance at the first actuation shall be confirmed by the type 0 dynamic testing in accordance with Annex 4, with an initial level of energy in the electrical storage devices not greater than the specified values of energy specified in 1.2.2. (i.e. the energy value of [MRUP]).
- [2. Capacity of the electrical supply device
- 2.1. General
- The energy supply device (including the energy source, if fitted) shall meet the requirements set forth in the following paragraphs.
- Testing shall be performed in conformity with the following requirements:
- 2.2. Conditions of measurement
- 2.2.1. The capacity of the energy supply device shall be assessed using the procedures of paragraph 1.5.1. of Annex 4 (Type-I test) and paragraph 1.5.3.1. (Hot performance). Contrary to the requirements of the Type-I test, in all cases the number of brake actuations shall be 20.
- 2.2.2. This test may be conducted under static conditions. In this case the duration of the braking event, the energy consumed by the braking system and the interval between braking events, shall be determined during the dynamic Type-I and hot performance tests of Annex 4.
- (a) In the case of vehicles of categories M₃ N₂ and N₃, the energy provided to the electrical storage device(s) during the static test shall be equivalent to the value of the energy provided by the electrical supply device to the electrical storage device(s) during 20 actuations of the dynamic Type-I followed by one actuation of the hot performance test of Annex 4.
- (b) In the case of vehicles of categories M₂ and N₁, the brake actuations 16 to 20 shall be of the same duration and with an equivalent energy demand to that of actuation number 15. The interval between brake actuations shall be the same. The energy provided to the electrical storage device(s) during the static test shall be equivalent to the mean value of the energy provided by the electrical supply device to the electrical storage device(s) during 15 actuations of the dynamic Type-I followed by one actuation of the hot performance test of Annex 4.
- 2.2.3. At the commencement of the test:
- (a) (The maximum performance of the electrical supply device shall be ensured ...)
- (b) The energy level in the electrical storage devices shall not exceed the value of the minimum required usable performance as confirmed by paragraph 1.2. above.
- 2.2.4. For vehicles authorized to tow a trailer of category O₃ or O₄, the electrical requirement of the trailer shall be represented by an electrical demand of 400 W. This demand shall be applied either directly to the electrical supply device or to the reserve of energy used for the trailer supply (indirect supply), whichever is appropriate. This requirement shall not apply if the electrical demand of the trailer is provided from a source that is neither directly nor indirectly maintained by the electrical supply device.
- Where the energy supply device provides power for other vehicle systems, including auxiliary systems, and where they will not impose a power demand during the Type-I test procedure, the manufacturer shall declare

the total power demand of those systems and this shall be represented during the test by an equivalent electrical demand on the electrical supply device.

The total power demand shall be continuously present throughout the test procedure.

2.2.5. The energy level in the electrical storage device(s) during, and on completion of, the test defined in paragraph 2.2. above, shall not fall to the [AEUP_w] value as described in paragraph 5.2.1.13.1. (b) of this Regulation.

2.2.6. The value of the power supplied by the electrical supply device shall not fall to a level at which the warning signal [P_w] required by paragraph 5.2.1.35.12. is activated.]

3. Capacity of pneumatic energy sources

In the case of vehicles to which the coupling of a trailer with a compressed-air braking system is authorized, also the following provisions apply:

3.1. Definitions

3.1.1. "p" = is the pressure in the pneumatic energy storage device(s) of an attached trailer with the capacity of at least the volume defined by paragraph 3.2.4.

3.1.2. "p₃" = 450 kPa

3.1.3. "p₄" = 700 kPa

3.1.4. "t₄" is the time required for the relative pressure (of the attached trailer energy storage device with a volume as defined in paragraph 3.2.4.) to rise from 0 to p₃, and "t₅" is the time required for the relative pressure to rise from 0 to p₄.

3.2. Conditions of measurement

This shall be demonstrated to the satisfaction of the Technical Service, including through the test specified in Annex 4, paragraph 1.8.2.5. (a) and submission of detailed documentation explaining the strategies implemented in the system and how this ensures endurance braking requirements can always be met."

3.2.1. In all cases, the speed of the compressor shall be that obtained when the engine is running at the speed corresponding to its maximum power or at the speed allowed by the governor.

3.2.2. During the tests to determine the time t₄ and the time t₅, the pneumatic energy storage device(s) for auxiliary equipment shall be isolated.

3.2.3. In case that the supply line is not only fed directly by the energy source but also from an energy storage device of the motor vehicle, also the pressure in this compressed-air reservoir shall be completely eliminated.

3.2.4. The trailer shall be represented by a pneumatic energy storage device whose maximum relative pressure p (expressed in kPa / 100) is that which can be supplied through the towing vehicle's supply circuit and whose volume V, expressed in litres, is given by the formula $p \times V = 20 R$ (R being the permissible maximum mass, in tonnes, on the axles of the trailer).

3.3. Interpretation of results (Conditions of measurement as per paragraph 3.2.)

3.3.1. The time t₄ recorded for the least-favoured energy storage device shall not exceed 6 minutes.

- 3.3.2. The time t_5 recorded for the least-favoured energy storage device shall not exceed 9 minutes.
- 3.4. Additional test
- 3.4.1. If the power-driven vehicle is equipped with one or more pneumatic energy storage devices for auxiliary equipment, an additional test shall be performed during which no irregularity shall occur in the operation of the valves controlling the filling of the pneumatic energy storage device(s) for auxiliary equipment.
- 3.4.2. In the event of a failure in the pneumatic auxiliary equipment it shall be prevented that this failure cannot cause a pressure drop in the supply line (if present) below the pressure of 650 kPa.
- 3.4.3. It shall be verified during the aforesaid test that the time t_5 necessary to raise the pressure from 0 to p_4 in the attached trailer energy storage device is less than:
- 3.4.3.1. 11 minutes.
- 3.4.3.2. The test shall be performed with all air reservoirs installed in the towing vehicle and with an attached trailer energy storage device of a volume as defined in paragraph 3.2.4.

Annex 8

Amend title to read:

Provisions relating to specific conditions for **compressed-air braking systems fitted with** spring braking systems

Annex 13

Paragraph 5.1.1.3., amend to read:

- 5.1.1.3 **The supply to the energy transmission storage device(s) shall then be cut off.**

Paragraph 5.1.1.4., amend to read:

- 5.1.1.4. The service braking control device shall then be fully actuated four times in succession with the vehicle stationary. **In the case of an electrical [transmission] braking system, each full-stroke actuation shall be for a duration of at least [8.0] seconds with there being an interval of no more than [5.0] seconds between the release of the brake control and its subsequent actuation.**

Appendix 2

Paragraph 1.1.3., amend to read:

- 1.1.3. A number of tests at increments of line pressure / **wheel brake demand value** shall be carried out to determine the maximum ...

II. Justification

1. This proposal seeks to permit the use of braking systems that rely purely on the use of stored electrical energy, controlled by the driver, to provide the service braking performance prescribed in this Regulation
2. The use of electrical energy to fulfil certain functions of the braking has been acknowledged for many years. Higher level functions such as anti-lock braking and stability control employ electrical controls and electronically controlled braking systems, where the

control transmission of the braking system primarily electric have been accepted for many years. Advances in technology present the opportunity for both the control and the energy transmissions of the service brake system to be delivered with electrical energy.

3. The security of the electrical energy is recognised as being the most significant concern for this new generation of braking systems. This proposal sets out the requirements for an energy management system to be an integral part of the monitoring requirements for electrical braking systems. The energy management system will ensure that, should the stored energy fall to a value at which prescribed performance criteria cannot be met, timely warnings are provided to the driver. This monitoring and warning requirement is in alignment with that which is expected of compressed-air braking systems today.

4. At the 17th session of GRVA, the Special Interest Group on electrical braking presented the philosophy of the “State of Function” that would be used to deduce the status of the reserves of energy available to the braking system (GRVA-17-19). This proposal does not refer directly to state of function, this will vary between technologies, but the principles that were described will be integral to the functioning of an energy management system.

5. In addition, the proposal includes provisions to ensure that the effect of ageing, duty cycles, charging cycles, temperature cycles, temperature extremes, etc., are thoroughly considered and warnings provided at any point that the ageing effect could compromise the fulfilment of the requirements of this Regulation.

6. The proposal has been prepared to ensure that electrical braking systems will provide at least the same level of safety and security that is provided by the systems that we know today.
