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Economic Commission for Europe**Inland Transport Committee****World Forum for Harmonization of Vehicle Regulations****Working Party on Automated/Autonomous and Connected Vehicles****Nineteenth session**

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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 special interest group on electrical braking systems***

The text reproduced below was prepared by the special interest group concerning electrical braking systems and is based on informal document GRVA-15-17. It supersedes document ECE/TRANS/WP.29/GRVA/2024/13.

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 (Sect. 20), table 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 2.31., amend to read:

- 2.31. "*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 2.55., to read:

- 2.44. "*Wheel brake demand value*" means the demand value for the braking force of a single wheel brake being electrically actuated.
- 2.45. The "*performance of an electrical storage device*" means its ability to provide power (W) and quantity of energy (Wh) when fully charged.
- 2.46. "*P_w*" (W) means the low electrical supply power warning as required by paragraph 5.2.1.35.9. 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 irreversible degradation of the performance of an electrical storage device, due to e.g., the effects of time, use, and environmental exposure.
- 2.50. "*Electrical supply*" means a device (e.g. battery, REESS, generator, fuel-cell or a combination of these components) that supplies electrical power to the braking system's electrical storage device(s).
- 2.51. "*Energy Management System*" means, an electrical device(s), being part of, or used by, an electrical transmission braking system, that monitors critical variables that impact on the performance and state of the electrical storage devices (e.g., voltage, temperature, internal resistance, effect of ageing, state of charge, power consumption, charging cycles, etc.) and deduces the actual capability of the devices to fulfil the performance requirements of this Regulation.
- 2.52. "*Electronically controlled Braking System*" (EBS) means a service braking system where the control is generating an electrical signal in the control transmission and electrical output signals to devices which generate actuating forces produced from stored or generated pneumatic energy.
- 2.53. "*Electrical Transmission Braking System*" (ETBS) 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.

- 2.5.4. “*Auxiliary equipment*” means, for the purposes of this Regulation, the collective of systems, functions, or components, including those that are essential to the operation of the vehicle, that are supplied with energy from the same energy reserves as the braking system.
- 2.5.5. The “*state of an electrical storage device*” means its ability to provide power (W) and quantity of energy (Wh) at the time.

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 an 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 detection means triggering the warning signals specified in paragraphs 5.2.1.35.6., 5.2.1.35.7. and 5.2.1.35.9. are operational.

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 an 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, brake pedal force or stroke) 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 range*.

Footnote reads: * For the purpose of periodic technical inspection, the minimum limit braking rate values defined for the whole vehicle may need adjustment to reflect national or international in-service requirements.

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;

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 (energy source or electrical supply, as relevant)** of such energy (hydraulic pump, air compressor, etc.), but the means by which the device constituting that ~~source~~ **supply** is driven shall be as safe as practicable.

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 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 actuations to achieve, at the ninth application, the residual performance prescribed in paragraph 5.2.1.4. of this Regulation. Each full actuation shall be as specified in Annex 7 Part D paragraph 1.2.3.3.**

Insert a new paragraph 5.2.1.7.3. to read:

- 5.2.1.7.3. Compensation provided, at any time, to ensure that the braking rate* of the vehicle remains related to the driver's braking demand, shall be declared. The manufacturer shall provide the Technical Service with a description of the compensation function(s), including the limits of operation, and the strategy that ensures this compensation does not compromise the safety of the vehicle, its occupants, or other road users.**

Footnote reads: * The Type Approval Authority, which is to grant approval, shall have the right to check the service braking system by additional vehicle test procedures. The assessment of the function shall be recorded in the test report.

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 ~~reservoir~~ **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 **an indication of the available energy** (e.g. a pressure gauge) where fitted, giving an optical or acoustic signal **at the latest** when the stored energy **(or the state of an electrical storage device, as relevant)** in any part of the system, falls to a **level value** at which without re-charging of the ~~reservoir~~ **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***

actuators 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, as relevant.

Footnote reads: * A full actuation means the actuation of the control in accordance with Annex 7, Part D, paragraph 1.2.3.3 for a duration of 8.0 seconds or for a time T as described in that paragraph.

Renumber 5.2.1.13.1.2. as 5.2.1.13.1.3.

Insert a new paragraph 5.2.1.13.1.2.

5.2.1.13.1.2. In addition, for vehicles equipped with an electrical transmission braking system, there shall be an acoustic signal that is activated no later than 60 seconds after the activation of the red warning signal required by paragraph 5.2.1.13.1. (b) or following the first application of the service brake control after activation of that red warning signal, whichever occurs first.

Vehicles which rely for their propulsion on energy from an electrical storage device or devices, shall be deemed to comply with this requirement if the energy to the traction motor(s) is stopped before the energy in the electrical storage device(s) has fallen to a level at which the red warning signal is activated.

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 have an indicator reflecting the effect of ageing on each of the electrical storage devices. This requirement shall not apply to the traction battery that also has the function of an energy storage device (within the meaning of Annex 7, part D).

The indicators for electrical storage devices may share a common space in accordance with UN Regulation No. 121. They need not be permanently visible; however, they shall 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.

The indicator shall provide at least 4 different levels of ageing above the level at which a maintenance of the electrical storage device(s) is recommended. This 5th level shall be given before the warning signal required by 5.2.1.35.6. is activated. The different levels above this indication shall be evenly distributed with respect to the performance of the electrical storage devices.

Paragraph 5.2.1.1.6., amend to read:

5.2.1.16. The pneumatic/hydraulic/electrical auxiliary equipment shall 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 (i.e. reserve within reservoir, accumulator, or electrical storage

devices *) feeding the braking systems to fall below the level indicated in paragraph 5.2.1.13. above.

Footnote reads: * It is understood that an Electronically controlled Braking System according to paragraph 5.2.1.27., is not equipped with an electrical storage device within the meaning of this regulation.

Paragraph 5.2.1.18., amend to read:

5.2.1.18. In the case of a vehicle authorized to tow a trailer of **Categories 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 5.2.1.35.12. respectively** shall apply.

Paragraph 5.2.1.27., amend to read:

5.2.1.27. Special additional requirements for **Electronically controlled Braking Systems**

Insert new paragraph to read:

5.2.1.29.1.3. The warning signals required by this paragraph shall employ the brake system malfunction symbol listed in UN Regulation No. 121.

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 5.2.1.35.6. and 5.2.1.35.7. is activated, is respected despite the effect of environmental conditions (e.g., temperature) and ageing. The manufacture shall show to the satisfaction of the Technical Service, 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. When the state of the electrical storage device(s) is insufficient 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 the release of the parking braking system shall be prevented.

5.2.1.35.2. With the parking brake released, the service braking system shall:

In the case of vehicles of Category M₂, M₃, N₂, and N₃, 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.

In the case of vehicles of Category N₁,

(a) **With the propulsion system on/off control in the "On" ("Run") position, generate a static total braking force at least equivalent to**

that required by the Type-0 test for service braking performance as prescribed in paragraph 2.1. of Annex 4 to this Regulation,

- (b) During the first 60 seconds after the propulsion system on/off control has been deactivated to the "Off" or "Lock" position and/or the ignition key has been removed, three brake applications shall generate a static total braking force at least equivalent to that required by the Type-0 test for service braking performance as prescribed in paragraph 2.1. of Annex 4 to this Regulation, and
- (c) After the period mentioned above, or as from the fourth brake application within the 60 second period, whichever occurs first, generate a static total braking force at least equivalent to that required by the Type-0 test for secondary braking performance as prescribed in paragraph 2.2. of Annex 4 to this Regulation.

It should be understood that sufficient energy is available in the energy transmission of the service braking system.

- 5.2.1.35.3. 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* application of the service brake control, with 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.

Footnote reads: * A full actuation means the actuation of the control in accordance with Annex 7, Part D, paragraph 1.2.3.3. for a duration of 8.0 seconds or for a time T as described in that paragraph.

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

- 5.2.1.35.5. 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. It should be understood that there is no fault or failure of the electrical supply.

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 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.

- 5.2.1.35.6. A warning signal shall be displayed no later than when the effect of ageing on the electrical storage device(s) is such that its performance 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.

- 5.2.1.35.7. A warning signal shall be displayed no later than when the state of 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.
- 5.2.1.35.8. There shall be an energy management system for the electrical storage devices of the transmission.
- 5.2.1.35.8.1. The energy management system shall be capable of continuously assessing the electrical storage devices, to determine their ability 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.

If the assessment is not complete at the time that the start/run switch is moved to the on (run) position, a red warning signal shall be activated and shall remain active until the safe status of the electrical transmission braking system has been confirmed. The red warning signal prescribed in paragraph 5.2.1.29.1.1. may be used. This requirement shall apply even after a maintenance operation on the electrical storage device and/or the energy management system (e.g. the replacement/temporary disconnection of an electrical storage device, or the replacement of the energy management system itself).

The method by which the energy management system determines the safe status, including after maintenance, shall be described by the manufacturer at the time of type approval. Compliance with these requirements shall be demonstrated to the satisfaction of the Technical Service, including an assessment according to Annex 18.

- 5.2.1.35.8.2. 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 both the performance and the state of the electrical storage device(s).

The Technical Service shall verify that the accuracy of the energy management system is ensured under all operating conditions (for example different environmental conditions) that can reasonably be foreseen by reviewing the documentation provided by the manufacturer and performing tests of the energy management system in different conditions (e.g., changes in temperature).

- 5.2.1.35.8.3. In the context of the assessment described in paragraph 5.2.1.35.8.2., the manufacturer shall provide the following information as part of the documentation required by Annex 18, paragraph 3:

- (a) Regarding the Energy Management System;
- i. A detailed overview of the energy management system, explaining its architecture, components, and functionality,
 - ii. A description of how the system monitors electrical storage devices.
 - iii. Sufficient information about the energy management system strategy to illustrate the algorithms and logic used to assess the state and the performance of electrical storage devices.

- iv. A list of all the input variables considered by the energy management system in assessing the state and the performance of the electrical storage devices.
 - v. A sensitivity analysis showing how each of the listed variables affects the ability of the energy management system to accurately identify when a warning signal shall be activated.
- (b) Regarding the relevant verification testing the documentation shall include:
- i. The thresholds, or criteria, that trigger the warning signals described in paragraph 5.2.1.29.1.1. and paragraph 5.2.1.29.1.2.
 - ii. Results of verification testing to assess the accuracy of the energy management system.
 - iii. Data on different operating conditions, such as temperature or battery ageing.
 - iv. An outline of the boundary conditions that could impact the accuracy of the energy management system (e.g., temperature, aging characteristics)
 - v. In response to paragraph 3.4.4. of Annex 18, a description of the strategy in the event of a failure of the energy management system, or of an input channel to the energy management system, when relevant to the braking functionality.
 - vi. When applicable, the procedures for updating the energy management system and ensuring its ongoing maintenance.
 - vii. The appropriate testing procedures to be taken into account when performing the relevant verification testing to assess compliance with paragraph 5.2.1.35.6. and paragraph 5.2.1.35.7.

5.2.1.35.8.4. In the event of a failure of the energy management system or an input channel of the energy management system that prevents the assessment of the state of the energy storage device(s), a red visual warning signal, accompanied by an audible signal, shall be activated at the moment of the detection of the failure (i.e. a first time in operation then at each start-up thereafter). The operation of the acoustic signal may be temporary, but the visual warning must remain active as long as the failure persists. The red warning signal prescribed in paragraph 5.2.1.29.1.1 may be used for visual alert. If the manufacturer's failure strategy affects braking functionality, details shall be given in the documentation required in paragraph 5.2.1.35.8.3.

Even in the event of the failure described above, if the energy management system is still able to assess the status of the energy storage device(s), it is sufficient to use only the yellow warning signal specified in paragraph 5.2.1.29.1.2.

5.2.1.35.9. In the case that the supply of power requested by the electrical transmission cannot be met by the electrical supply, a power warning (Pw) to the driver shall be activated no later than 5.0 s after the appearance/detection. The yellow warning signal specified in paragraph 5.2.1.29.1.2. may be used.

The functionality of the system triggering the warning level Pw shall be described by the vehicle manufacturer as part of the documentation package required in Annex 18 of this Regulation to the Technical Service.

5.2.1.35.10. In case auxiliary equipment is supplied from the same electrical storage device(s) as the braking system, and in the event of a failure of the electrical supply (including the energy source, if fitted) that is providing energy to this electrical storage device(s) the

- Auxiliary equipment shall be switched off, and/or
- The vehicle shall be automatically brought to standstill,

before the critical level referred to in paragraph 5.2.1.13.1. (b) of this Regulation is reached.

In either case, the operation of auxiliary equipment required to satisfy subject to the performance requirements of another safety related UN regulation shall not be affected.

In the case of a vehicle that is not equipped with an onboard electrical supply (e.g. an electric vehicle with a traction battery having the function of an energy storage device) the mitigation required by this paragraph shall also be applied before the critical level referred to in paragraph 5.2.1.13.1. (b) of this Regulation is reached, or following a failure that would prevent the traction battery from providing power to the braking system.

- 5.2.1.35.11. 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.
- 5.2.1.35.12. The electrical supply shall be able to ensure that the state of the electrical storage device(s) remains sufficient to fulfil the prescribed service braking performance.

Additionally, in case the auxiliary equipment is supplied from the same electrical supply (including the energy source, if fitted) as the braking system, the requirement above shall be fulfilled even when all the auxiliary equipment is functioning. Where two or more auxiliary equipment cannot operate simultaneously (e.g. the climate control system cannot provide both heating and cooling at the same time), only the highest power consuming system, function, or component, shall be considered during the assessment. The manufacturer shall declare the total power demand of the auxiliary equipment and provide evidence to justify the exclusion of any auxiliary equipment.

This shall be assessed in accordance with the requirements set out in Annex 7, part D, section 2 of this regulation.

In the case of a vehicle that is powered by an internal combustion engine, and which has a driven electrical energy source (e.g. an alternator), to maintain the electrical supply, compliance with this paragraph may be assessed with the engine running at a speed not greater than 80 per cent of the maximum power speed.

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 400W if this consumption is provided by the electrical storage device(s).

- 5.2.1.35.13. 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 reads: * 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.

- 5.2.1.35.14. 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.
- 5.2.1.35.15. 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.
- 5.2.1.35.16. 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.
- 5.2.1.35.17. If the auxiliary equipment is supplied with energy from the electric transmission, the following requirements shall be fulfilled.
- 5.2.1.35.17.1. In the event of a failure in the energy source or electrical supply, whilst the vehicle is in motion, the energy in the electrical storage device(s) shall be sufficient to satisfy the brake performance requirements defined in paragraph 5.2.1.13.1. (b).
- Where that electrical supply also has a role as an electrical storage device for one circuit of the transmission, a failure of that supply shall not affect ability of the electrical storage device of another circuit to provide the power necessary to achieve the prescribed secondary brake performance.
- 5.2.1.35.17.2. In the event of a failure in the energy source or electrical supply, 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.
- 5.2.1.35.18. Low Energy Emergency Function
- 5.2.1.35.18.1. Within 60 seconds of the activation of the acoustic warning signal required by paragraph 5.2.1.13.1.2., there shall be an automatic function to progressively reduce the vehicle's speed such that it cannot exceed 20 km/h. Once the vehicle has come to a standstill, it shall be prevented from rolling away and there shall be sufficient electrical power available for it to be possible to apply the parking brake. Furthermore, for vehicles of categories of N₂, N₃, M₂, M₃, it shall be possible to release the parking braking system, if necessary, by the use of tools and/or an auxiliary device carried/fitted on the vehicle.

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.**

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 state of the electrical storage devices shall be kept above the level specified in paragraph 5.2.1.13.1.b.**

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.
- 1.5.3. Hot performance**
- 15.3.1.** **At the end of the Type-I test (test described in paragraph 1.5.1.) or test described in paragraph 1.5.2. of this annex) the hot performance of the service braking system shall be measured in the same conditions (and, in particular, at a constant control force no greater than the mean force, or brake demand value, actually used) as for the Type-0 test with the engine disconnected (the temperature conditions may be different).**
- Any system or function that provides compensation for a loss of brake performance due to heat fade shall be inoperative during this test.**

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 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. Performance 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 performance 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 5.2.1.35.5. 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 performance of the electrical storage device(s) shall be such that, as a minimum, after eight full actuations of the service braking system control (as described in paragraph 1.2.3.3. below) the performance (at the ninth braking) at least fulfils the requirements specified for secondary braking. 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.** Testing shall be performed in conformity with the following requirements:
- 1.2.2.1.** At the commencement of the test, the state of the electrical storage device(s) of each braking circuit shall be such that the necessary condition to display the yellow warning signal specified in paragraph 5.2.1.35.7. is fulfilled. Additionally, the state shall not be higher than the value which can be delivered by an electrical storage device whose performance has degraded to a point where the warning specified in 5.2.1.35.6. is displayed.
- In the case that a traction battery also has the function of an energy storage device (within the meaning of this Annex), the state of the traction battery at the commencement of the test may be such that the battery can no longer provide power to the traction motors. This condition may be a result of the actual capability of the traction battery being insufficient, or when of the control strategy of the vehicle suspends the supply of energy to the traction motor(s).
- 1.2.2.2.** For vehicles authorized to tow a trailer of Category O3 or O4, testing shall be performed in conformity with the following requirements:
- The initial energy level in the energy storage device(s) shall be that specified by the manufacturer. It shall be such as to enable at least the prescribed minimum pressures at the coupling heads of the supply line and the pneumatic control line as specified in Annex 10 paragraphs 3.1.3.1. and 3.1.3.4.;
 - The energy storage device(s) shall not be fed; in addition, any energy storage device(s) for auxiliary equipment shall be isolated.
- The initial energy level shall be stated in the approval document.
- 1.2.3.** The electrical storage devices shall not be supplied with further energy during the test.
- 1.2.3.1.** The procedure by which the electrical storage devices are prepared for this test shall be agreed between the manufacturer and the Technical Service. This procedure shall be recorded in the test report and included in the type-approval documentation.
- 1.2.3.2.** Each full actuation shall be for a duration of at least 8.0 seconds with an interval, specified by the vehicle manufacturer, of at least 5.0 seconds between the release of the brake control and its subsequent actuation.
- The vehicle manufacturer may provide cooling to the electromechanical actuators during the static phase of the test.
- 1.2.3.3.** Each actuation shall cause a demand (a_{ref}) on the brake actuators necessary to deliver the maximum possible deceleration designed to be delivered by the system in the Type-0 condition (e.g. cold brakes, Type-0 speed, laden, fully charged electrical storage devices), limited to $8.0m/s^2$.
- The demand value to the brake actuators may be reduced to a lower value $a_{reduced}$, while not being lower than the prescribed service braking deceleration. In this case, the duration-T of each full stroke actuation shall be increased as per according to the following formula below:

$$T = a_{\text{ref}} / a_{\text{reduced}} * 8 \text{ seconds}$$

The method by which the demand is calibrated to deliver a_{ref} or a_{reduced} , as relevant, shall be agreed between the manufacturer and the Technical Service. This procedure shall be recorded in the test report and included in the type-approval documentation.

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 * 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.

Footnote reads: * A full actuation means the actuation of the control in accordance with Annex 7, Part D, paragraph 1.2.3.3. for a duration of 8.0 seconds or for a time T as described in that paragraph.

- 1.2.3.5. It shall be ensured that, when carrying out the test during standstill compared to a driving situation, the energy consumed by the service braking system is not reduced below the demand specified in 1.2.3.3. by energy saving functions.

- 1.2.3.6. The capability to achieve the prescribed secondary braking performance (at the 9th actuation of the brake control) 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 8 full */ actuations performed in static condition (i.e. with the vehicle at standstill), in the test conditions specified in 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.

As an alternative to the dynamic testing above, the ninth actuation of the brake control may be done in static condition. The vehicle manufacturer shall provide evidence that the power provided over the time of the actuation is sufficient to at least achieve the prescribed secondary braking performance in the test condition of Annex 4. The method used to construct this evidence (e.g. based on the comparison of the power consumed by the brake actuators with the value measured during a dynamic test) shall be agreed between the manufacturer and the Technical Service and verified by the Technical Service, recorded in the test report, and included in the type-approval documentation.

Footnote reads: * A full actuation means the actuation of the control in accordance with Annex 7, Part D, paragraph 1.2.3.3 for a duration of 8.0 seconds or for a time T as described in that paragraph.

- 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 paragraph 1.2.2.1.

As an alternative to the dynamic testing above, the actuation of the brake control may be done in static condition. The power necessary to deliver this performance shall be determined using the same procedures as those described in paragraph 1.2.3.6.

2. Capacity of the electrical supply

- 2.1. General

The electrical supply (including the energy source, if fitted) shall meet the requirements set forth in the following paragraphs.

In the case that a traction battery also has the function of an electrical storage device (within the meaning of this Annex), without a source to replenish the traction battery (i.e. beside regenerative braking), the requirements below shall not apply, for the relevant circuit(s).

Testing shall be performed in conformity with the following requirements:

- 2.2. Conditions of measurement**
- 2.2.1.** The capacity of the electrical supply 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 transmission during the static test shall be equivalent to the value of the energy provided by the electrical supply to the electrical transmission 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 transmission during the static test shall be equivalent to the mean value of the energy provided by the electrical supply to the electrical transmission 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 electrical supply operates without any failure.
- (b) The state of the electrical storage devices shall not exceed the value specified in paragraph 1.2.2.1.
- 2.2.4.** Where the electrical supply provides power to auxiliary equipment, the total power demand of the auxiliary systems declared in paragraph 5.2.1.35.12. shall be represented during the test by an equivalent power demand on the electrical supply.
- The total power demand shall be continuously present throughout the test procedure.
- 2.2.5.** 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 or to the reserve of energy used for the trailer supply (indirect supply), whichever is appropriate.
- The total power demand shall be continuously present throughout the test procedure.
- 2.2.6.** The state of the electrical storage device(s) on completion of, the test defined in paragraph 2.2. above, shall not fall to a value at which the red warning signal specified in paragraph 5.2.1.13.1. (b) of this Regulation is activated.
- 2.2.7.** The value of the power supplied by the electrical supply shall not fall to a level at which the warning signal (P_w) required by paragraph 5.2.1.35.9. 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 attached trailer(s) with the capacity of at least the volume defined by paragraph 3.2.4.
- 3.1.2. "p₃" = is the pressure corresponding to 65 per cent of the pressure p₄ defined in paragraph 3.1.3. below.
- 3.1.3. "p₄" = kPa is the value specified by the manufacturer and referred to in paragraph 1.2.2.2. above.
- 3.1.4. "t₄" is the time required for the relative pressure (of the attached trailer(s) energy storage device(s) 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**
- 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 reduced to zero.
- 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**
- 3.3.1. The time t₄ recorded for the least-favoured energy storage device shall not exceed six minutes.
- 3.3.2. The time t₅ recorded for the least-favoured energy storage device shall not exceed nine 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 can 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 t₅ necessary to raise the pressure from 0 to p₄ in the attached trailer energy storage device is less than 11 minutes.
- 3.4.3.1. The test shall be performed with all pneumatic energy storage devices installed in the towing vehicle and with the pneumatic energy storage device(s) of the attached trailer(s) having 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 actuation shall be as defined in Annex 7 Part D paragraph 1.2.3.3.**

Annex 13 - Appendix 2, (Utilization of adhesion)

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. Proposal for amendments to ECE/TRANS/WP.29/GRVA/2023/10

Amend paragraphs 12.1.2., 12.1.3., and 12.1.4. to read:

- “12.1.1. As from the official date of entry into force of the XX series of amendments, no Contracting Party applying this Regulation shall refuse to grant or refuse to accept type approvals under this Regulation as amended by the XX series of amendments.
- 12.1.2. As from the official date of entry into force of the XX series of amendments, Contracting Parties applying this Regulation shall grant type approvals for a vehicle equipped with an ~~electro-mechanical~~ **electrical transmission** braking system only if the vehicle type to be approved meets the requirements of this Regulation as amended by the XX series of amendments.
- 12.1.3. As from 1 September ~~2027~~ **2028**, Contracting Parties applying this Regulation shall not be obliged to accept type approvals to the preceding series of amendments, for a vehicle type having a braking system equipped with an electronic control system, first issued after 1 September ~~2027~~ **2028**.
- 12.1.4. As from 1 September ~~2029~~ **2030**, Contracting Parties applying this Regulation shall not be obliged to accept type approvals issued to the preceding series of amendments to this Regulation.
- 12.1.5. Notwithstanding paragraph 12.1.4., Contracting Parties applying this Regulation shall continue to accept type approvals issued according to the preceding series of amendments to this Regulation, for the vehicles which are not affected by the changes introduced by the XX series of amendments.
- 12.1.6. Notwithstanding the transitional provisions above, Contracting Parties whose application of this Regulation comes into force after the date of entry into force of the most recent series of amendments are not obliged to accept type approvals which were granted in accordance with any of the preceding series of amendments to this Regulation/ are only obliged to accept type approval granted in accordance with the XX series of amendments.
- 12.2. General transitional provisions:
- 12.2.1. Contracting Parties applying this Regulation may grant type approvals according to any preceding series of amendments to this Regulation.

- 12.2.2. Contracting Parties applying this Regulation shall continue to grant extensions of existing approvals to any preceding series of amendments to this Regulation.”

III. Justification

1. This proposal supersedes that of ECE/TRANS/WP.29/GRVA/2024/13.
2. The 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. The proposal mirrors, where appropriate, the changes proposed for Regulation 13-H (Passenger Car Braking).
3. Provisional paragraphs or text in the former document (denoted by []) have been refined and/or agreed and the term “electrical transmission braking system” has been agreed as the descriptor for this new technology.
4. New terms have been introduced that relate to the changed energy medium. The term “electrical storage device” is analogous to the term “reservoir/accumulator” in pneumatic/hydraulic braking systems. The term “performance”, when related to an electrical storage device, is analogous to the “capacity” of an energy reserve or accumulator, and the term “state”, can be viewed as analogous to “pressure” in a “reservoir” or “accumulator”.
5. 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.
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.
7. 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.
8. At the seventeenth 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.
9. 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.
10. This document builds on the requirements set out in ECE/TRANS/WP.29/GRVA/2024/13 and includes additional provisions that require the energy management system to display a warning at the start of a use cycle, unless it has established that sufficient energy exists within the braking transmission to fulfil the performance requirements of this regulation. This requirement applies even after a maintenance event, for example after an electrical disconnection or a change of component. There are also more detailed requirements associated with the information that the manufacturer has to provide about the energy management system at the time of type-approval and also about the expectation of the assessment of the system by the Technical Service during type-approval.

11. It is recognised that other vehicle systems, both essential and optional, will rely on electrical power from the same energy reserves as the braking system. This proposal includes specific measures that ensure that, in the event of there being low electrical energy, the braking system, and other essential safety systems, can continue to function, or that the vehicle is brought to a safe halt.

12. Document ECE/TRANS/WP.29/GRVA/2023/10 provides a revision of the requirements of Annex 18, aimed to accompany this document.

(a) The proposal in part II delays the introduction of changes to Annex 18, proposed in ECE/TRANS/WP.29/GRVA/2023/10, by 12-months. This reflects the period over which the special interest group on electromechanical braking has been working to bring forward its proposals. It also reflects a change in terminology adopted by the Special Interest Group where the term “electro-mechanical braking system” has been replaced with “electrical transmission braking system”.

(b) Document ECE/TRANS/WP.29/GRVA/2023/10 proposes changes to Annex 18 of Regulation 13. It was introduced in parallel with proposals for amendments to Regulation 13 to introduce “electro-mechanical braking systems” (GRVA/15/17). The ambition of the electromechanical braking system proposals was for their adoption in 2023. The original transitional provisions dates of GRVA/2023/10 were agreed to align with that ambition.

(c) GRVA, subsequently, established at its sixteenth session a Special Interest Group to develop the requirements for electromechanical braking systems. Their work is anticipated as being adopted in 2024. It is appropriate therefore to introduce a 12-month extension to the dates proposed in ECE/TRANS/WP.29/GRVA/203/10
