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

Proposal for a Series of amendments to UN Regulation No. 13-H (Braking of passenger cars)

Submitted by the 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. It also contains proposals to amend the requirements for the safety of electronic systems in line with those proposed by document ECE/TRANS/WP.29/GRVA/2023/10, for UN Regulation No. 13 (Heavy Vehicle Braking). The modifications to the existing text of the Regulation are marked in bold for new characters and in bold strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2024 as outlined in proposed programme budget for 2024 (A/77/6 (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

Table of Contents, title of Annex 8, amend to read:

"18. Special requirements to be applied to the safety aspects of ~~**complex**~~ electronic ~~**vehicle**~~ control systems"

Table of Contents, after Annex 8, insert a reference to the new appendix:

"**Appendix - Model Annex 8 assessment report**"

Paragraph 2.17.4., amend to read:

2.17.4. *"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**.

Insert new paragraphs 2.25. to 2.32., to read:

(Note: revise paras numbers depending on the adoption of ECE/TRANS/WP.29/GRVA/2024/9)

[2.25. The "*performance of an electrical storage device*" means both its energy storage capacity [J] and its ability to provide electrical power [W].

2.26. "P_w" [W] means the low electrical supply power warning as required by paragraph 5.2.21.6.12. in the case of an electrical [transmission] braking system.

2.27. "*Energy source*" means a device that both generates and provides energy required for the braking system.

2.28. "*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.

2.29. 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.

2.30. "*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).

2.31. "*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.

2.32. "*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.]

Note:

5.1.4. Provisions for the periodic technical inspection of braking systems

[To be reviewed]

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 5.2.4.1., amend to read:

5.2.4.1. 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 secondary braking. This condition shall be met by ~~**means of devices which can easily be actuated when the vehicle is stationary, or by**~~ automatic means.

Insert a new paragraphs 5.2.4.4. and 5.2.4.5., to read:

5.2.4.4. 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.

5.2.4.5. 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 5.2.14.1., amend to read:

5.2.14.1. 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 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 5.2.21.1.1. 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.

Insert new paragraph 5.2.14.4., to read:

[5.2.14.4. 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 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 [AEUPW] warning described in paragraph 5.2.14.1. above.]

Paragraph 5.2.19.3., amend to read:

5.2.19.3. 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 5.2.20.6.**, or in the case of [electrical [transmission] braking systems] paragraph 5.2.21.6.16. respectively shall apply.**

Paragraph 5.2.20., amend to read:

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

Insert new paragraph 5.2.1.31.3.4., to read:

[5.2.1.21.3.4. 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 5.2.21.6.9. and 5.2.21.6.10. 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 5.2.21.6. and subparagraphs, to read:

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

5.2.21.6.1. For electrical [transmission] braking systems, the requirements of this paragraph 5.21.6. apply instead of those of paragraph 5.2.20. above.

5.2.21.6.2. The performance of the electrical storage device(s) shall be sufficient to ensure the residual performance as laid down in paragraph X.X. of Annex

3 to this Regulation *(Residual Braking)* by the actuation of the service brake control when the vehicle is capable of driving.

5.2.21.6.3. **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 8 of this Regulation to the Technical Service.**

5.2.21.6.4. **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.**

5.2.21.6.5. **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 4, Part B, 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.

5.2.21.6.6. **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 B of Annex 4 shall apply.**

5.2.21.6.7. **As an alternative to the requirements of Annex 4, Part B, 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 5.2.21.1.1.

5.2.21.6.8. **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.**

5.2.21.6.9. **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 4, Part B, paragraph 1.2.1. The yellow warning signal described in paragraph 5.2.21.1.2. shall be used.**

5.2.21.6.10. 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 4, Part B, paragraph 1.2.1. The yellow warning signal described in paragraph 5.2.21.1.2. shall be used.

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

5.2.21.6.11.1. 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 4, the energy management system shall be assessed under Annex 8. 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 8.

5.2.21.6.11.2. 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.

5.2.21.6.12. 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 5.0 s after the appearance/detection. The yellow warning signal specified in paragraph 5.2.21.1.2. may be used.

5.2.21.6.13. 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 1 paragraph [17.x].

5.2.21.6.14. 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.

5.2.21.6.15. The red warning signal specified in paragraph 5.2.21.1.1. 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.

5.2.21.6.16. 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 5.2.14.1. (b) of this Regulation such that further discharge of these reserves is prevented. Compliance may be demonstrated by calculation or by a practical test.

5.2.21.6.17. 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 5.2.21.1.1. and 5.2.21.1.2., 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 3 *(Residual Braking)* 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.

5.2.21.6.18. 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.

5.2.21.6.19. If the auxiliary equipment is supplied with energy from the electric transmission, the following requirements shall be fulfilled.

5.2.21.6.19.1. 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.

[5.2.21.6.19.2. In the event of a failure in the energy source or electrical supply device, whilst he 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.]

Insert new transitional provisions (paragraph 12) to read:

12. Transitional Provisions

12.1. …

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 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 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 2028.**

12.1.4. **As from 1 September 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.**

Annex 4

Introduction, amend to read:

"Provisions relating to energy sources and energy storage devices (energy accumulators)

A. Hydraulic braking systems with stored energy.

Insert new section B to read:

B. **Electrical [transmission] braking systems with stored energy**.

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 B).**

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 5.2.21.6.7. to this Regulation.**

1.1.3. **It shall be possible to easily identify the electrical storage devices of the different braking circuits.**

1.2. Vehicles equipped with a electrical [transmission] braking system with stored energy shall meet the following requirements:

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.

1.2.3.5. 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 3, 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 3, paragraph 2.2.3. 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 3, 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 3 (Type-I test) and paragraph 1.5.2.1. (Hot performance). Contrary to the requirements of the Type-I test, in all cases the number of brake actuations shall be 20; brake actuations 16 to 20 shall be of the same duration and with and equivalent energy demand to that of actuation number 15.

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 3.

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 3.

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.

2.2.5. 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 5.2.14.1. (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 5.2.21.6.12. is activated.]

Annex 6

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 […]**

Annex 8, amend to read:

Annex 8

Special requirements to be applied to the safety aspects of complex electronic vehicle control systems

1. General

This annex defines the special requirements for documentation, fault strategy and verification with respect to the safety aspects of **Electronic System(s) (paragraph 2.3.) and** complex electronic ~~**vehicle**~~ control systems (paragraph ~~2.3.~~ **2.4.** below) as far as this Regulation is concerned.

~~**This annex may also be called, by special paragraphs in this Regulation, for safety related functions which are controlled by electronic system(s).**~~

This annex does not specify the performance criteria for "the system" but covers the methodology applied to the design process and the information which shall be disclosed to the Technical Service, for type approval purposes.

This information shall show that "the system" respects, under ~~**normal**~~ **non-fault** and fault conditions, all the appropriate performance requirements specified elsewhere in this Regulation.

2. Definitions

For the purposes of this annex,

2.1. **"The System" means an electronic control system or complex electronic control system that provides or forms part of the control transmission of a function to which this Regulation applies. This also includes any other system covered in the scope of this Regulation, as well as transmission links to or from other systems that are outside the scope of this Regulation, that acts on a function to which this Regulation applies.**

2.2. "*Safety concept*" is a description of the measures designed into the system, for example within the electronic units, so as to address system integrity and thereby ensure safe operation **under fault and non-fault conditions, including** ~~**even**~~ in the event of an electrical failure.

The possibility of a fall-back to partial operation or even to a back-up system for vital vehicle functions may be a part of the safety concept.

2.3. "*Electronic control system*" means a combination of units, designed to co-operate in the production of the stated vehicle control function by electronic data processing.

Such systems, ~~**often**~~ **commonly** controlled by software, are built from discrete functional components such as sensors, electronic control units and actuators and connected by transmission links. They may include mechanical, **electro-mechanical,** electro-pneumatic or electro-hydraulic elements.

"*The system*", referred to herein**,** is the one for which type approval is being sought.

2.4. "*Complex electronic* ~~***vehicle***~~ *control systems*" are those electronic control systems **in** which ~~**are subject to a hierarchy of control in which a controlled**~~ **a** function may be over-ridden by a higher-level electronic control system/function.

A function which is over-ridden becomes part of the complex **electronic control** system**, as well as any overriding system/function within the scope of this Regulation. The transmission links to and from overriding systems/function outside of the scope of this Regulation shall also be included.**

2.5. "*Higher-level control*" systems/functions are those which employ additional processing and/or sensing provisions to modify vehicle behaviour by commanding variations in the normal function(s) of the vehicle control system.

This allows complex systems to automatically change their objectives with a priority which depends on the sensed circumstances.

2.6. "*Units*" are the smallest divisions of system components which will be considered in this annex, since these combinations of components will be treated as single entities for purposes of identification, analysis or replacement.

2.7. "*Transmission links*" are the means used for inter-connecting distributed units for the purpose of conveying signals, operating data or an energy supply.

This equipment is generally electrical but may, in some part, be optical, pneumatic, hydraulic or mechanical.

2.8. "*Range of control*" refers to an output variable and defines the range over which the system is likely to exercise control.

2.9. "*Boundary of functional operation*" defines the boundaries of the external physical limits within which the system is able to maintain control.

2.10. **"*Control strategy*" means a strategy to ensure robust and safe operation of the function(s) of "The System" in response to the input from the vehicle or the driver.**

This may include the automatic deactivation of a function or temporary performance restrictions.

3. Documentation

3.1. Requirements

The manufacturer shall provide a documentation package which gives access to the basic design of "the system" and the means by which it is linked to other vehicle systems or by which it directly controls output variables.

The function(s) of "the system"**, including the control strategies,** and the safety concept, as laid down by the manufacturer, shall be explained.

Documentation shall be brief yet provide evidence that the design and development has had the benefit of expertise from all the system fields which are involved.

For periodic technical inspections, the documentation shall describe how the current operational status of "the system" can be checked.

The Technical Service shall assess the documentation package, as specified in paragraph 3.4., to show that "The System":

(a) Is designed to operate, under fault conditions, in such a way that it does not induce safety critical risks,

(b) Implements strategies which do not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation; and,

(c) Respects, under non-fault and fault conditions, all the appropriate performance requirements specified elsewhere in this Regulation; and,

(d) Was developed according to the development process/method ~~declared~~ chosen by the manufacturer according to paragraph 3.4.4.

3.1.1. Documentation shall be made available in two parts:

(a) The formal documentation package for the approval, containing the material listed in paragraph 3. (with the exception of that of paragraph 3.4.4. below) which shall be supplied to the Technical Service at the time of submission of the type-approval application. ~~**This will be taken**~~ **This documentation package shall be used by the Technical Service** as the basic reference for the verification process set out in paragraph 4. of this annex. The Technical Service shall ensure that this documentation package remains available for a period determined in agreement with the Approval Authority. This period shall be at least 10 years counted from the time when production of the vehicle is definitely discontinued.

(b) Additional **confidential** material and analysis data (**intellectual property**) of paragraph 3.4.4., which shall be retained by the manufacturer, but made open for inspection **(e.g., on-site in the engineering facilities of the manufacturer)** at the time of type approval. **The manufacturer shall ensure that this material and analysis data remains available for a period of 10 years counted from the time when production of the vehicle is definitely discontinued.**

3.2. Description of the functions of "the system"**, including control strategies.**

A description shall be provided which gives a simple explanation of all the ~~**control**~~ functions**, including control strategies,** of "the system" and the methods employed to achieve the objectives, including a statement of the mechanism(s) by which control is exercised.

Any described function that can be over-ridden shall be identified and a further description of the changed rationale of the function's operation provided.

3.2.1. A list of all input and sensed variables shall be provided and the working range of these defined**, along with a description of how each variable affects system behaviour.**

3.2.2. A list of all output variables which are controlled by "the system" shall be provided and an ~~**indication**~~ **explanation** given, in each case, of whether the control is direct or via another vehicle system. The range of control (paragraph **2.8.**~~2.7.~~) exercised on each such variable shall be defined.

3.2.3. Limits defining the boundaries of functional operation (paragraph **2.9.**~~2.8.~~ above) shall be stated where appropriate to system performance.

3.3. System layout and schematics

3.3.1. Inventory of components

A list shall be provided, collating all the units of "the system" and mentioning the other vehicle systems which are needed to achieve the control function in question.

An outline schematic showing these units in combination shall be provided with both the equipment distribution and the interconnections made clear.

3.3.2. Functions of the units

The function of each unit of "the system" shall be outlined and the signals linking it with other units or with other vehicle systems shall be shown. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

3.3.3. Interconnections

Interconnections within "the system" shall be shown by a circuit diagram for the electrical transmission links, by an optical-fibre diagram for optical links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified

diagrammatic layout for mechanical linkages. **The transmission links both to and from other systems shall also be shown.**

3.3.4. Signal flow and priorities

There shall be a clear correspondence between these transmission links and the signals carried between units.

Priorities of signals on multiplexed data paths shall be stated, wherever priority may be an issue affecting performance or safety as far as this Regulation is concerned.

3.3.5. Identification of units

Each unit shall be clearly and unambiguously identifiable (e.g. by marking for hardware and marking or software output for software content) to provide corresponding hardware and documentation association.

Where functions are combined within a single unit or indeed within a single computer, but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single hardware identification marking shall be used.

The manufacturer shall, by the use of this identification, affirm that the equipment supplied conforms to the corresponding document.

3.3.5.1. The identification defines the hardware and software version and, where the latter changes such as to alter the function of the unit as far as this Regulation is concerned, this identification shall also be changed.

3.4. Safety concept of the manufacturer

3.4.1. The manufacturer shall provide a statement which affirms that the strategy chosen to achieve "the system" objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.

The vehicle manufacturer shall supplement this statement by an explanation showing in overall terms how the chosen strategy ensures that "The System" objectives do not prejudice the safe operation of the systems referred above, and by a description of the part of the validation plan supporting the statement.

The Technical Service shall perform an assessment to establish that the vehicle manufacturer's explanation of the chosen strategy is understandable, logical and that the validation plan is suitable and has been completed.

The Technical Service may perform tests, or may require tests to be performed, as specified in paragraph 4. below, to verify that "the system" operates as per the chosen strategy.

3.4.2. In respect of software employed in "the system", the outline architecture shall be explained and the design methods and tools used shall be identified. The manufacturer shall **~~be prepared, if required, to~~** show **~~some~~** evidence of the means by which they determined the realisation of the system logic, during the design and development process.

3.4.3. The manufacturer shall provide the technical authorities with an explanation of the design provisions built into "the system" so as to generate safe operation under fault conditions. Possible design provisions for failure in "the system" are for example:

(a) Fall-back to operation using a partial system;

(b) Change-over to a separate back-up system;

(c) Removal of the high-level function.

In case of a failure, the driver shall be warned for example by warning signal or message display. When the system is not deactivated by the driver, e.g. by turning

the ignition (run) switch to "off", or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.

3.4.3.1. If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.

3.4.3.2. If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built-in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.

3.4.3.3. If the chosen provision selects the removal of the Higher-Level Function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.

3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any ~~**one of those specified faults which will have a bearing on vehicle control performance or safety**~~ **fault identified by the procedure below which will have a bearing on vehicle control, performance, or safety**.

~~**This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.**~~

The ~~**chosen**~~ analytical approach(es)**, chosen by the manufacturer,** shall be established and maintained by the manufacturer and shall be made open for inspection by the Technical Service at the time of the type-approval.

The Technical Service shall perform an assessment of the application of the analytical approach(es). The assessment shall include:

(a) Inspection of the safety approach at the concept (vehicle) level with confirmation that it includes consideration of interactions with other vehicle systems. This approach may be based on a Hazard / Risk analysis appropriate to system safety.

(b) Inspection of the safety approach at the system level. This approach may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety.

(c) Inspection of the validation plans and results. This validation may use, for example, Hardware in the Loop (HIL) testing, vehicle on–road operational testing, or any means appropriate for validation.

The assessment shall consist of checks of hazards and faults chosen by the Technical Service to establish that the manufacturer's explanation of the safety concept is understandable, logical and that the validation plan is suitable and has been completed.

The Technical Service may perform tests, or may require tests to be performed, as specified in paragraph 4. below, to verify the safety concept.

3.4.4.1. This documentation shall itemize the parameters being monitored and shall set out, for each fault condition of the type defined in paragraph 3.4.4. above, the warning signal to be given to the driver and/or to service/technical inspection personnel.

3.4.4.2. Where this Regulation contains particular requirements for the operation of "The System" under different environmental conditions, this documentation shall describe the measures in place to ensure compliance with those requirements.

4. Verification and test

4.1. The functional operation of "the system", as laid out in the documents required in paragraph 3. above, shall be tested as follows:

4.1.1. Verification of the function of "the system"

~~As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the manufacturer's basic benchmark specification unless this is subject to a specified performance test as part of the approval procedure of this or another Regulation.~~

The Technical Service shall verify "The System" under non-fault conditions by testing a number of selected functions from those described by the manufacturer in paragraph 3.2. above.

The verification of the performance of those selected functions shall be conducted following the manufacturer's test procedures unless a test procedure is specified in this Regulation.

For cases where the braking system is subject to input signal(s) from systems outside the scope of this Regulation, the test shall be conducted using the test procedure of the relevant UN regulation, or by another means that generates the relevant input signal(s), (e.g. simulation).

For complex electronic systems, these tests shall include scenarios whereby a declared function is overridden.

4.1.1.1. The verification results shall correspond with the description, including the control strategies, provided by the manufacturer in paragraph 3.2.

4.1.2. Verification of the safety concept of paragraph 3.4. above

The reaction of "the system" shall~~, at the discretion of the type approval authority,~~ be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.

The Technical Service shall conduct this check for at least one individual unit but shall not check the reaction of "The System" to multiple simultaneous failures of individual units.

The Technical Service shall verify that these tests include aspects that may have an impact on vehicle controllability and user information (HMI aspects).

4.1.2.1. The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate.

4.2. Simulation tools and mathematical models for verification of the safety concept may be used in accordance with Schedule 8 of Revision 3 of the 1958 Agreement, in particular for scenarios that are difficult on a test track or in real driving conditions. Manufacturers shall demonstrate the scope of the simulation tool, its validity for the scenario concerned as well as the validation performed for the simulation tool chain (correlation of the outcome with physical tests).

5. Reporting by Technical Service

Reporting of the assessment by the Technical Service shall be performed in such a manner that allows traceability, e.g., versions of documents inspected are coded and listed in the records of the Technical Service.

An example of a possible layout for the assessment form from the Technical Service to the Type Approval Authority is given in Appendix 1 to this Annex."

Insert a new Annex 18 - Appendix, to read:

"Annex 8 – Appendix

Model assessment form for electronic, and/or complex electronic, control systems

Test report No: .....

1. Identification

1.1. Vehicle make: .....

1.2. Type: .....

1.3. Means of identification of type if marked on the vehicle: .....

1.4. Location of that marking: .....

1.5. Manufacturer's name and address: .....

1.6. If applicable, name and address of manufacturer's representative:

1.7. Manufacturer's formal documentation package:

Documentation reference No: .....
Date of original issue: .....
Date of latest update: .....

2. Test vehicle(s)/system(s) description

2.1. General description: .....

2.2. Description of the functions of "The System", including control strategies (Annex 8, paragraph 3.2.): .....

2.2.1. List of input and sensed variables and their working range including a description the effect of the variable on system behaviour (Annex 8, paragraph 3.2.1.): .....

2.2.2. List of output variables and their range of control (Annex 8, paragraph 3.2.2.): .....

2.2.2.1. Directly controlled: .....

2.2.2.2. Controlled via other vehicle systems: .....

2.2.3 Boundaries of functional operation (Annex 8, paragraph 3.2.3.): ..

2.3. Description System layout and schematics (Annex 8, paragraph 3.3.):

2.3.1. Inventory of components (Annex 8, paragraph 3.3.1.): .....

2.3.2. Functions of the units (Annex 8, paragraph 3.3.2.): .....

2.3.3. Interconnections (Annex 8, paragraph 3.3.3.): .....

2.3.4. **Signal flow and priorities (Annex 8, paragraph 3.3.4.): .....**

2.3.5. **Identification of units (hardware & software) (Annex 8, paragraph 3.3.5.): .....**

3. **Manufacturer's safety concept.**

3.1. **Manufacturer's declaration (Annex 8, paragraph 3.4.1.):**

The manufacturer(s) ..... affirm(s) that the strategy chosen to achieve "The System", objectives will not, under non-fault conditions, prejudice the safe operation of the vehicle.

3.2. **Software (outline architecture, software design methods and tools used) (Annex 8, paragraph 3.4.2.): .....**

3.3. **Explanation of design provisions built into "The System" under fault conditions (Annex 8, paragraph 3.4.3.): .....**

3.4. **Documented analyses of the behaviour of "The System" under individual fault conditions (Annex 8, paragraph 3.4.4.1.): .....**

3.4.1. **Parameters monitored: .....**

3.4.2. **Warning signals generated: .....**

3.5. **Description of the measures in place for environmental conditions (Annex 8, paragraph 3.4.4.2.): .....**

3.6. **Provisions for the periodic technical inspection of "The System" (Annex 8, paragraph 3.1.).**

Description of the method by which the operational status of the system can be checked: .....

4. **Verification and test.**

4.1. **Verification of the function of "The System" (Annex 8, paragraph 4.1.1.): .....**

4.1.1. **List of the selected functions and a description of the test procedures used: .....**

4.1.2. **Test results verified according to Annex 8, paragraph 4.1.1.1. Yes/No.**

4.2. **Verification of the system safety concept (Annex 8, paragraph 4.1.2.):**

4.2.1. **Unit(s) tested and their function: .....**

4.2.2. **Simulated fault(s): .....**

4.2.3. **Test results verified according to Annex 8, paragraph 4.1.2. Yes/No.**

4.3. **Date of test: .....**

4.4. **This test has been carried out and the results reported in accordance with Annex 8 to UN Regulation No. 13 as last amended by the …….…… series of amendments.**

Technical Service carrying out the test:

Signed: .....Date: .....

4.5. Comments: .....

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. The proposal mirrors, where appropriate, the changes proposed for Regulation 13 (Heavy Vehicle Braking).

2. It also includes proposals to introduce changes to Annex 8, safety aspects of complex electronic control systems. These changes had been proposed separately for Regulation 13 (ECE/TRANS/WP.29/GRVA/2023/10). The intention is that the changes to the electronic system safety requirements will apply to both Regulations on the introduction of braking systems that rely on the use of stored electrical energy.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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.