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DRAFT SUPPLEMENT 2 TO REGULATION No. 13-H

(Harmonized braking)

Note: The text reproduced below was adopted by the Administrative Committee (AC.1) of the amended 1958 Agreement at its eighteenth session, following the recommendation by WP.29 at its one-hundred-and-twenty-fourth session. It is based on documents TRANS/WP.29/2001/35 and Add.1, as amended (TRANS/WP.29/792, para. 134). Minor editorial corrections were made by the secretariat (footnote numbers in paras. 5.2.18.6. and 5.2.20.3.).

Paragraph 2.5., delete the words "but controlled by him".

Paragraph 2.17., amend to read:

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

Paragraph 2.17.1., should be deleted.

Paragraphs 2.17.2. to 2.17.6. (former), renumber as paragraphs 2.17.1. to 2.17.5.

Insert a new paragraph 2.18., to read:

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

Paragraphs 2.18. and 2.18.1., renumber as paragraphs 2.19. and 2.19.1.

Insert new paragraphs 2.19. and 2.20., to read:

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

2.20. "Selective braking" means a function within a complex electronic control system where actuation of individual brakes is made by automatic means in which vehicle retardation is secondary to vehicle behaviour modification."

Insert a new paragraph 5.1.3., to read:

"5.1.3. The requirements of annex 8 shall be applied to the safety aspects of all complex electronic vehicle control systems which provide or form part of the control transmission of the braking function included those which utilize the braking system(s) for automatically commanded braking or selective braking.

However, systems or functions, which use the braking system as the means of achieving a higher level objective, are subject to annex 8 only insofar as they have a direct effect on the braking system. If such systems are provided, they must not be deactivated during type Approval Testing of the braking system."

Paragraph 5.2.2.4., amend to read:

"... the vehicle is in motion. This requirement may be met by the actuation of the vehicle's service braking system, even partially, by means of an auxiliary control."

Paragraphs 5.2.6. and 5.2.7., amend to read (including a new footnote 3/):

- "5.2.6. The service braking system shall act on all wheels of the vehicle and shall distribute its action appropriately among the axles.
- 5.2.7. In the case of vehicles equipped with electric regenerative braking systems of category B, the braking input from other sources of braking, may be suitably phased to allow the electric regenerative braking system alone to be applied, provided that both the following conditions are met:
- 5.2.7.1. Intrinsic variations in the torque output of the electrical regenerative braking system (e.g. as a result of changes in the electric state of charge in the traction batteries) are automatically compensated by appropriate variation in the phasing relationship as long as the requirements 3/ of one of the following annexes to this Regulation are satisfied:
- Annex 3 paragraph 1.3.2., or
Annex 6 section 5.3. (including the case with the electric motor engaged), and
- 5.2.7.2. Wherever necessary, to ensure that braking rate 3/ remains related to the driver's braking demand, having regard to the available tyre/road adhesion, braking shall automatically be caused to act on all wheels of the vehicle.

3/ The Authority, which is to grant approval, shall have the right to check the service braking system by additional vehicle test procedures."

Paragraph 5.2.8., amend to read (footnote 3/ should be deleted):

- "5.2.8. The action of the service braking system shall be distributed between the wheels of one and the same axle symmetrically in relation to the longitudinal median plane of the vehicle.
- Compensation and functions, such as anti-lock, which may cause deviations from this symmetrical distribution shall be declared."

Paragraph 5.2.10., amend to read:

- "5.2.10. The service, secondary and parking braking systems must act on braking surfaces connected to the wheels through components of adequate strength.
- Where braking torque for a particular axle or axles is provided by both a friction braking system and an electrical regenerative braking system of category B, disconnection of the latter source is permitted, providing that the friction braking source remains permanently connected and able to provide the compensation referred to in paragraph 5.2.7.1.

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

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

Disconnection of the braking surfaces of the parking braking system shall be permitted only on condition that the disconnection is controlled exclusively by the driver from his driving seat, by a system incapable of being brought into action by a leak."

Paragraph 5.2.18., amend to read:

"5.2.18. Additional requirements for vehicles equipped with electric regenerative braking systems."

Paragraphs 5.2.18.1. to 5.2.18.2.1., amend to read:

"5.2.18.1. Vehicles fitted with an electric regenerative braking system of category A.

"5.2.18.2. Vehicles fitted with an electric regenerative braking system of category B."

5.2.18.2.1. It must not be possible to disconnect, partially or totally, one part of the service braking system other than by automatic means. This should not be construed as a departure from the requirements of paragraph 5.2.10."

Paragraph 5.2.18.3., amend to read:

"5.2.18.3. For vehicles fitted with an electric regenerative braking system of either category, all the relevant prescriptions shall apply "

Insert a new paragraph 5.2.18.6., including its corresponding footnote 4/, to read:

"5.2.18.6. The state of charge of the traction batteries is determined by the method set out in appendix 1 to annex 3 to this Regulation. 4/

4/ By agreement with the technical service, state of charge assessment will not be required for vehicles, which have an on-board energy source for charging the traction batteries and the means for regulating their state of charge."

Paragraph 5.2.20.3., the reference to footnote 4/ and footnote 4/ (former), renumber as footnote 5/.

Annex 1,

Insert a new item 20., to read:

"20. . Adequate documentation according to annex 8 was supplied in respect of the following system(s): Yes / No / Not applicable"

Items 20. to 29. (former), renumber as items 21. to 30.

Annex 3,

Paragraphs 1.2.8. and 1.2.9., amend to read:

"1.2.8. For vehicles powered completely or partially by an electric motor (or motors), permanently connected to the wheels, all tests must be carried out with these motor(s) connected.

1.2.9. For vehicles as described in paragraph 1.2.8. above, fitted
..... "

Insert a new paragraph 1.2.11., to read:

"1.2.11. For a vehicle with electrically actuated service brakes powered from traction batteries (or an auxiliary battery) which receive(s) energy only from an independent external charging system, these batteries shall, during braking performance testing, be at an average of not more than 5 per cent above that state of charge at which the brake failure warning prescribed in paragraph 5.2.20.5. 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."

Paragraph 1.3.2., amend to read:

"1.3.2. Behaviour of the vehicle during braking on a road on which adhesion is reduced must meet the relevant requirements of annex 5 and/or annex 6 to this Regulation."

Insert a new paragraph 1.3.2.1. (including a new footnote 1/), to read:

"1.3.2.1. In the case of a braking system according to paragraph 5.2.7. where the braking for a particular axle (or axles) is comprised of more than one source of braking torque, and any individual source can be varied with respect to the other(s), the vehicle shall satisfy the requirements of annex 5, or alternatively, annex 6 under all relationships permitted by its control strategy 1/.

1/ The manufacturer shall provide the technical service with the family of braking curves permitted by the automatic control strategy. These curves may be verified by the technical service."

Insert a new paragraph 1.4.1.2.3., to read:

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

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

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

This condition is deemed to be satisfied if the state of charge of the batteries is in one of the following conditions:

- (a) at the maximum charge level recommended by the manufacturer, as listed in the vehicle specification,
- (b) at a level not less than 95 per cent of the full charge level, where the manufacturer has made no specific recommendation,
- (c) at a maximum level resulting from automatic charge control on the vehicle."

Paragraphs 1.4.1.2.3. and 1.4.1.2.4. (former), renumber as paragraphs 1.4.1.2.4. and 1.4.1.2.5.

Paragraph 1.5.1.6., amend to read:

"1.5.1.6. For vehicles not having sufficient autonomy to carry out the cycles of heating of the brakes, the tests shall be carried out by achieving the prescribed speed before the first braking application and thereafter by using the maximum acceleration available to regain speed and then braking successively at the speed reached at the end of each 45 second cycle duration."

Insert a new paragraph 1.5.1.7., to read:

"1.5.1.7. For vehicles equipped with an electric regenerative braking system of category B, the condition of the vehicle batteries at the start of the test, shall be such that the braking force contribution provided by the electric regenerative braking system does not exceed the minimum guaranteed by the system design. This requirement is deemed to be satisfied if the batteries are at one of the state of charge conditions as listed in paragraph 1.4.1.2.3. above."

Paragraph 1.5.2.2., the reference to footnote 1/ (former) and the footnote 1/, renumber as footnote 2/

Paragraph 1.5.2.3., amend to read:

"1.5.2.3. For vehicles fitted with an electric" "

Insert a new paragraph 1.5.2.4., to read:

"1.5.2.4. In the case of vehicles equipped with an electric regenerative braking system of category B, having carried out the heating cycles according to paragraph 1.5.1.6. of this annex, the hot performance test shall be carried out at the maximum speed which can be reached by the vehicle at the end of the brake heating cycles, unless the speed specified in paragraph 2.1.1. (A) of this annex can be reached.

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

Following the recovery process and test, further reconditioning of the linings shall be permitted before the test is made to compare this second cold performance with that achieved in the hot test, against the criteria of paragraphs 1.5.2.2. or 1.5.2.5. of this annex."

Paragraph 1.5.2.4. (former), renumber as paragraph 1.5.2.5.

Paragraph 1.5.2.5. (former), should be deleted.

Insert a new paragraph 1.5.3.1., to read:

"1.5.3.1. Vehicles equipped with an electrical regenerative braking system of category B may have their batteries re-charged or replaced by a charged set, in order to complete the recovery procedure."

Insert a new paragraph 1.5.4.1., to read:

"1.5.4.1. For vehicles equipped with an electrical regenerative braking system of category B, the recovery test shall be made with no regenerative braking component, i.e. under the conditions of paragraph 1.5.4. above.

After the further reconditioning of the linings, a second repeat Type-0 test shall be made from the same speed and with no electric regenerative braking contribution as in the recovery test with the engine/motors disconnected, and comparison shall be made between these test results.

The recovery performance must not be less than 70 per cent, nor more than 150 per cent of the figure recorded in this final repeat Type-0 test."

Paragraphs 2.2.4. to 2.2.4.2., amend to read:

"2.2.4. For vehicles employing electric regenerative braking systems, the braking performance shall additionally be checked under the two following failure conditions:

2.2.4.1. For a total failure of the electric component of the service braking output.

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

Insert a new appendix 1 to annex 3, to read:

"Annex 3 - Appendix 1

PROCEDURE FOR MONITORING THE STATE OF BATTERY CHARGE.

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

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

1. Procedure.

- 1.1. If the batteries are new or have been subject to extended storage, they shall be cycled as recommended by the manufacturer. A minimum 8 hour soak period at ambient temperature shall be allowed after completion of cycling.

A full charge shall be established using the manufacturer's recommended charging procedure.

- 1.3. When the braking tests of paragraphs 1.2.11., 1.4.1.2.3., 1.5.1.6., 1.5.1.7. and 1.5.2.4. of annex 3 are conducted the watt-hours consumed by the traction motors and supplied by the regenerative braking system shall be recorded as a running total which shall then be used to determine the state of charge existing at the beginning or end of a particular test.

- 1.4. To replicate a level of state of charge in the batteries for comparative tests, such as those of paragraph 1.5.2.4., the batteries shall be either recharged to that level or charged to above that level and discharged into a fixed load at approximately constant power until the required state of charge is reached. Alternatively, for vehicles with battery powered electric traction only, the state of charge may be adjusted by running the vehicle. Tests conducted with a battery partially charged at their start shall be commenced as soon as possible after the desired state of charge has been reached.

_____ "

Annex 5,

Paragraph 3.2.3., amend to read:

- "3.2.3. For vehicles fitted with an electric regenerative braking system "

Annex 6,

Paragraph 4.1., footnote 2/, amend to read:

"2/ The manufacturer shall provide the Technical Service with documentation relating to the controller(s) which follows the format set out in annex 8."

Paragraph 4.1.1., including its corresponding footnote 3/, amend to read:

"4.1.1. Sensor anomalies, which cannot be detected under static conditions, shall be detected not later than when the vehicle speed exceed 10 km/h 3/. However, to prevent erroneous fault indication when a sensor is not generating a vehicle speed output, due to non-rotation of a wheel, verification may be delayed but detected not later than when the vehicle speed exceeds 15 km/h.

3/ The warning signal may light up again while the vehicle is stationary, provided that it is extinguished before the vehicle speed reaches 10 km/h or 15 km/h, as appropriate, when no defect is present."

Paragraph 4.1.2., amend to read:

"4.1.2. When the anti-lock braking system is energized with the vehicle stationary, electrically controlled pneumatic modulator valve(s) shall cycle at least once."

Paragraph 4.1.3., should be deleted.

Paragraph 5.2.5., amend by the addition of footnote 7/ to read:

".....
shall be checked with the vehicle both laden and unladen 7/.

The laden test

7/ Until a uniform test procedure is established, the tests required by this paragraph may have to be repeated for vehicles equipped with electrical regenerative braking systems, in order to determine the effect of different braking distribution values provided by automatic functions on the vehicle."

Footnotes 7/ to 9/ (former), along with the corresponding references, renumber as footnotes 8/ to 10/.

Paragraph 5.3.7., amend by the addition of a reference to the new footnote 7/, to read:

"..... and during these tests no part of the (outer) tyres must cross this boundary 7/."

Insert a new annex 8, 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 Complex Electronic Vehicle Control Systems (definition 2.3. 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 must be disclosed to the Technical Service, for Type Approval purposes.

This information shall show that "The System" respects, under normal and fault conditions, all the appropriate performance requirements specified elsewhere in this Regulation.

2. DEFINITIONS

For the purposes of this annex,

- 2.1. "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 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.

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

Such systems, often 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-pneumatic or electro-hydraulic elements.

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

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

A function which is over-ridden becomes part of the complex system.

- 2.4. "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.

- 2.5. "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.

- 2.6. "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 mechanical, pneumatic or hydraulic.

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

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

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" 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.

3.1.1. Documentation shall be made available in 2 parts:

- (a) The formal documentation package for the approval, containing the material listed in Section 3 (with the exception of that of paragraph 3.4.4.) which shall be supplied to the technical service at the time of submission of the type approval application. This will be taken as the

basic reference for the verification process set out in paragraph 4. of this annex.

- (b) Additional material and analysis data of paragraph 3.4.4., which shall be retained by the manufacturer, but made open for inspection at the time of type approval.

3.2. Description of the functions of "The System"

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

- 3.2.1. A list of all input and sensed variables shall be provided and the working range of these defined.
- 3.2.2. A list of all output variables which are controlled by "The System" shall be provided and an indication given, in each case, of whether the control is direct or via another vehicle system. The range of control (paragraph 2.7.) exercised on each such variable shall be defined.
- 3.2.3. Limits defining the boundaries of functional operation (paragraph 2.8.) 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 electric transmission links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages.

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.

- 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, eg. 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.

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) 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.

- 3.4.4.1. This documentation shall itemise 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.

4. VERIFICATION AND TEST

- 4.1. The functional operation of "The System", as laid out in the documents required in paragraph 3., 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.

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

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.

- 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."
-