

Transmitted by the expert from France

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-agenda item 14)

Regulation No. 94

**UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES WITH  
REGARD TO THE PROTECTION OF THE OCCUPANTS IN THE EVENT OF A  
FRONTAL COLLISION**

*Proposal for draft amendments to Regulation No. 94- Rev. 1*

Submitted by the expert from France

The text reproduced below was prepared by the expert from France in order to extend the scope of the present Regulation to all kinds of power train systems above a certain working voltage level. The modifications to the existing text of the Regulation R 94 are based on discussions made at the ELSA adhoc group meeting held in Paris at 22-23 October 2009, and on a working document ECE/Trans/WP.29/GRSP/2009/16 distributed as a document without symbol (informal document No. GRSP-45-03) during the forty-fifth session of the Working Party on Passive Safety (GRSP). The modifications to the existing text of Regulation No. 94 are marked in bold or strikethrough characters.

A. PROPOSAL

CONTENTS, insert a new paragraph, to read:

**"Annex 11 - ELECTRIC SAFETY – TEST PROCEDURES"**

*Insert new paragraphs 2.6. and 2.7.1, to read*

**2.6.7. [The place of the RESS].**

**[2.7.1 For vehicles with electric powertrain, passenger compartment means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing and front bulkhead and the plane of the rear compartment bulkhead or the plane of the rear-seat back support, or rear gate, as well as by the barriers and enclosures provided for protecting from direct contact with high voltage live parts.**

*Insert new definitions 2.15 to 2.31, to read:*

- 2.15. "Electric power train" means the electrical circuit which includes the traction motor(s), and may include the RESS, the electric energy conversion system, the electronic converters, the associated wiring harness and connectors, and the coupling system for charging the RESS.**
- 2.16. "RESS" means rechargeable energy storage system that provides the electric energy for propulsion,**
- 2.17. "Electric Energy-conversion system" means a system (e.g. fuel cell) that generates and provides electric energy for electric propulsion,**
- 2.18. "Electronic converter" means a device capable of controlling and/or converting electric power for electric propulsion.**
- 2.19. "Coupling system for charging the rechargeable energy storage system (RESS)" means the electrical circuit used for charging the RESS from an external electric power supply including the vehicle inlet,**
- 2.20. "Direct contact" means the contact of persons with live parts,**
- 2.21. "Live parts" means conductive part(s) intended to be electrically energized in normal use,**
- 2.22. "Indirect contact" means the contact of persons with exposed conductive parts,**
- 2.23. "Protection degree" means the Protection provided by a barrier/enclosure related to the contact with live parts by a test probe, such as a test finger (IPXXB) as defined in annex 11.**

- 2.24. "**Exposed conductive part**" means the conductive part which can be touched under the provisions of the protection degree IPXXB, and which becomes electrically energized under isolation failure conditions,
- 2.25. "**Electrical circuit**" means an assembly of connected live parts which is designed to be electrically energized in normal operation,
- 2.26. "**Working voltage**" means the highest value of an electrical circuit voltage root-mean-square (rms), specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions. If the electrical circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.
- 2.27. "**Electrical chassis**" means a set made of conductive parts electrically linked together, whose potential is taken as reference,
- 2.28. ["**Protection Barrier / Protection Shielding / Shielding / Barrier-el/ High Voltage Protection**]" means the part providing protection against direct contact to the live parts from any direction of access,
- 2.29. "**Enclosure**" means the part enclosing the internal units and providing protection against direct contact from any direction of access,
- 2.30. "**High Voltage**" means the classification of an electric component or circuit, if its working voltage is  $> 60 \text{ V}$  and  $\leq 1500 \text{ V DC}$  or  $> 30 \text{ V}$  and  $\leq 1000 \text{ V AC}$  root mean square (rms).
- 2.31. "**High Voltage Bus**" means the electrical circuit, including the coupling system for charging the RESS that operates on high voltage

Insert a new paragraph, to read:

### **3.2.6 General description of the RESS type and [location] and the electric powertrain (e.g. hybrid, electric)**

Paragraph 5.2, amend to read:

#### **5.2. Specifications**

The test of the vehicle carried out in accordance with the method described in Annex 3 shall be considered satisfactory if all the conditions set out in paragraphs 5.2.1. to 5.2.8. below are all satisfied at the same time.

Insert new paragraphs 5.2.8 to 5.2.8.3, to read:

**5.2.8. The electric power train, the high voltage components and systems which are galvanically connected to the high voltage bus of the electric power train shall meet the following conditions:**

**5.2.8.1. Not more than [5.0] litres of liquid except coolant from RESS shall spill outside the passenger compartment, and no visible trace of liquid except coolant from RESS shall spill into the passenger compartment, within 30 minutes after a barrier impact test. Compliance may be demonstrated by test or analysis.**

**If the spilled liquid cannot clearly be identified as coolant, the entire amount of liquid should be considered.**

**5.2.8.2. RESS located inside the passenger compartment must remain in the installed location and RESS components shall remain inside RESS. No part of any RESS that is located outside the passenger compartment shall enter the passenger compartment during the test procedures, as determined by visual inspection.**

**5.2.8.3. After the test, at least one of the following criteria specified in paragraph 5.2.8.3.1 to paragraph 5.2.8.3.4 shall be met, according to annex 11. If the vehicle has an automatic disconnect function, the criteria shall be applied to each divided portion individually:**

**5.2.8.3.1 Isolation Resistance: If the electrical circuit divided by the disconnect function includes AC circuit, this part of the high voltage bus/portion shall be considered as an AC high voltage bus/portion. If the electrical circuit divided by the disconnect function doesn't include AC circuit, this part of the high voltage bus/portion shall be considered as a DC high voltage bus/portion.**

**If there is any live part of the high voltage system which does not meet the requirements under the provision of IPXXB;**

**for AC high voltage buses/portions, isolation resistance between the high voltage bus/portion and the electrical chassis shall have minimum value of 500 ohms/volt of working voltage;**

**for DC portion of the high voltage buses/portions after crash, isolation resistance between the high voltage bus/portion and the electrical chassis shall have minimum value of 100 ohms/volt of working voltage.**

**5.2.8.3.2. Voltage: For AC high voltage buses/portions, voltage of the bus/portion shall be equal to or less than 30 VAC. For DC high voltage buses/portions, voltage of the bus/portion shall be equal to or less than 60 VDC**

**5.2.8.3.3. Energy: Energy on the high voltage bus/portion shall be less than 0.2 Joules.**

**5.2.8.3.4. Physical Protection:**

**5.2.8.3.4.1 For protection of live parts, the protection degree IPXXB shall be provided.**

**5.2.8.3.4.2 For protection against indirect contact with live parts, all exposed conductive parts shall be securely connected to the electrical chassis such that no dangerous potentials are produced.**

**The requirements shall be considered to be fulfilled if the resistance between the electrical chassis and all exposed conductive parts shall be less than 0.1 ohm, which is measured when there is a current flow of at least 0.2 amps.**

**The said resistance shall be regarded as lower than 0.1 ohm when it is clearly evident that the DC electrical connection has been established adequately and securely by welding.**

Annex 1- Communication Form, insert a new paragraph 5.3, to read:

**5.3 RESS localisation.....**

Annex 3 - Test procedure- , insert new paragraphs 1.4.4, 1.4.4.1 and 1.4.4.2, to read:

**1.4.4. Electric powertrain adjustments**

**[1.4.4.1. The high voltage system shall be energized.]**

**1.4.4.2. The RESS shall be at a state of charge which allows the normal operation of the power train recommended by the manufacturer.**

Insert a new Annex 11, to read:

## **Annex 11**

### **ELECTRIC SAFETY – TEST PROCEDURES**

**This section describes test procedures. Alternative test and analysis methods may also be used. For example, oscilloscope or megohmmeter measurements are an appropriate alternative to the procedure described below for measuring isolation resistance. Well-established calculation methods also exist to determine electrical energy on high voltage buses.**

## 1 Test setup and equipment

If a high voltage disconnect function is used, measurements are taken from both sides of the device performing the disconnect function.

However, if the high voltage disconnect is integral to the RESS or the energy conversion system and the high-voltage bus of the RESS or the energy conversion system is fully enclosed within a physical barrier or enclosure that maintains protection class IPXXB after crash test, measurements may be taken only downstream of the device performing the disconnect function.

The voltmeter used in this test shall measure DC values and have an internal resistance of at least 10 mega ohms.

## 2 Bus voltage

The following instructions may be used if voltage is measured. Prior to the vehicle crash test measure and record the high voltage bus voltage ( $V_b$ ) (see Figure 1). If  $V_b$  is high voltage, conduct the specified vehicle crash test. After the crash test, determine the high voltage bus voltages ( $V_b$ ,  $V_1$ ,  $V_2$ ) (see Figure 1). [The measurement shall be made after 5 seconds of the vehicle coming to rest after each crash test.]

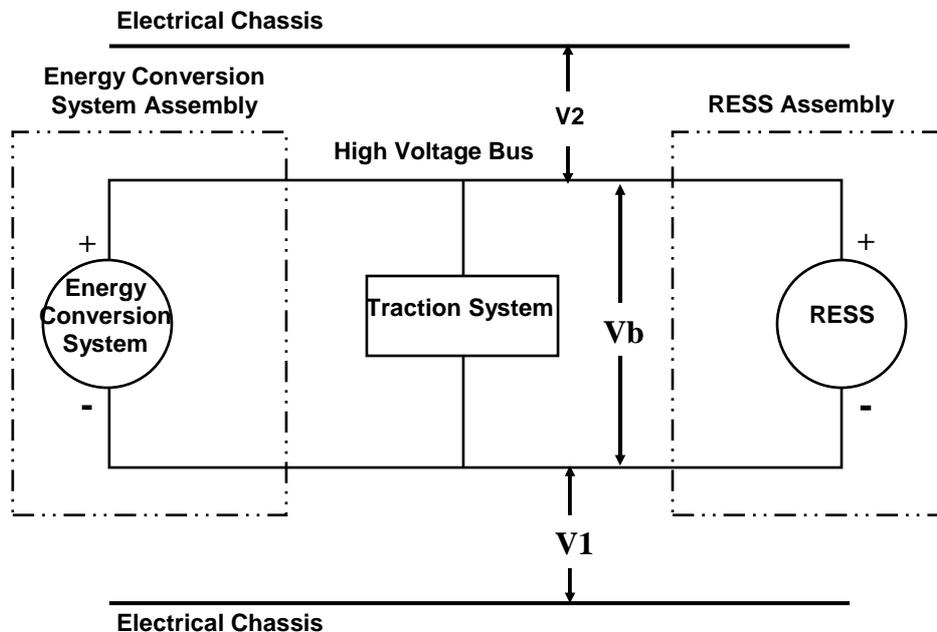


Figure 1: Measurement of  $V_b$ ,  $V_1$ ,  $V_2$

### **3 Isolation resistance measurement method**

#### **3.1 General**

The isolation resistance for each high voltage bus of the vehicle shall be measured or shall be determined by calculation using measurement values from each part or component unit of a high voltage bus (hereinafter referred to as the "divided measurement").

#### **3.2 Measurement Method.**

The isolation resistance measurement shall be conducted by selecting an appropriate measurement method from among those listed in Paragraphs 3.2.1. to 3.2.2., depending on the electrical charge of the live parts or the isolation resistance, etc.

The range of the electrical circuit to be measured shall be clarified in advance, using electrical circuit diagrams, etc.

Moreover, modification necessary for measuring the isolation resistance may be carried out, such as removal of the cover in order to reach the live parts, drawing of measurement lines, change in software, etc.

In cases where the measured values are not stable due to the operation of the on-board isolation resistance monitoring system, etc., necessary modification for conducting the measurement may be carried out, such as stopping of the operation of the device concerned or removing it. Furthermore, when the device is removed, it shall be proven, using drawings, etc., that it will not change the isolation resistance between the live parts and the electrical chassis.

Utmost care shall be exercised as to short circuit, electric shock, etc., for this confirmation might require direct operations of the high-voltage circuit.

##### **3.2.1. Measurement method using DC voltage from off-vehicle sources**

###### **3.2.1.1. Measurement instrument**

An isolation resistance test instrument capable of applying a DC voltage higher than the working voltage of the high voltage bus shall be used.

###### **3.2.1.2. Measurement method**

An insulator resistance test instrument shall be connected between the live parts and the electrical chassis. Then, the isolation resistance shall be measured by applying a DC voltage at least half of the working voltage of the high voltage bus.

If the system has several voltage ranges (e.g. because of boost converter) in galvanically connected circuit and some of the components cannot withstand the working voltage of the entire circuit, the isolation resistance between those components and the electrical chassis can be measured separately by applying at least half of their own working voltage with those component disconnected.

### **3.2.2. Measurement method using the vehicle's own RESS as DC voltage source**

#### **3.2.2.1. Test vehicle conditions**

The high voltage-bus shall be energized by the vehicle's own RESS and/or energy conversion system and the voltage level of the RESS and/or energy conversion system throughout the test shall be at least the nominal operating voltage as specified by the vehicle manufacturer.

#### **3.2.2.2 Measurement instrument**

The voltmeter used in this test shall measure DC values and shall have an internal resistance of at least 10 M $\Omega$ .

#### **3.2.2.3 Measurement method**

##### **3.2.2.3.1 First step**

The voltage is measured as shown in Figure 1 and the high voltage Bus voltage ( $V_b$ ) is recorded.  $V_b$  shall be equal to or greater than the nominal operating voltage of the RESS and/or energy conversion system as specified by the vehicle manufacturer.

##### **3.2.2.3.2. Second step**

Measure and record the voltage ( $V_1$ ) between the negative side of the high voltage bus and the electrical chassis (see Figure 1):

##### **3.2.2.3.3. Third step**

Measure and record the voltage ( $V_2$ ) between the positive side of the high voltage bus and the electrical chassis (see Figure 1):

#### 3.2.2.3.4. Fourth step

If  $V_1$  is greater than or equal to  $V_2$ , insert a standard known resistance ( $R_0$ ) between the negative side of the high voltage bus and the electrical chassis. With  $R_0$  installed, measure the voltage ( $V_{1'}$ ) between the negative side of the high voltage bus and the electrical chassis (see Figure 2). Calculate the electrical isolation ( $R_i$ ) according to the following formula:

$$R_i = R_0 \cdot (V_b / V_{1'} - V_b / V_1) \quad \text{or} \quad R_i = R_0 \cdot V_b \cdot (1 / V_{1'} - 1 / V_1)$$

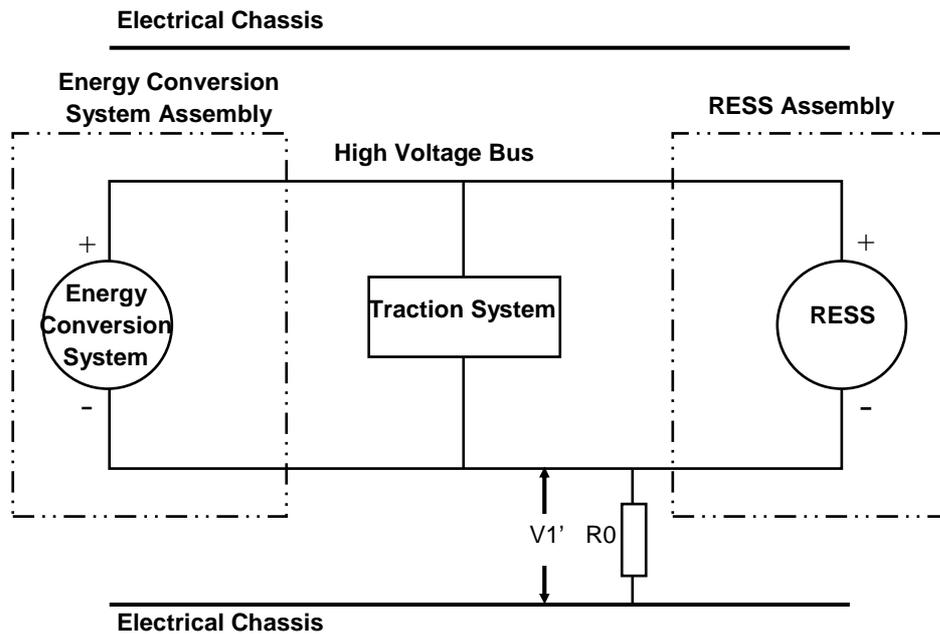


Figure 2: Measurement of  $V_{1'}$

If  $V_2$  is greater than  $V_1$ , insert a standard known resistance ( $R_0$ ) between the positive side of the high voltage bus and the electrical chassis. With  $R_0$  installed, measure the voltage ( $V_2'$ ) between the positive side of the high voltage bus and the electrical chassis. (See Figure 3). Calculate the electrical isolation ( $R_i$ ) according to the formula shown. Divide this electrical isolation value (in ohms) by the nominal operating voltage of the high voltage bus (in volts).

Calculate the electrical isolation ( $R_i$ ) according to the following formula:

$$R_i = R_0 \cdot (V_b / V_2' - V_b / V_2) \quad \text{or} \quad R_i = R_0 \cdot V_b \cdot (1 / V_2' - 1 / V_2)$$

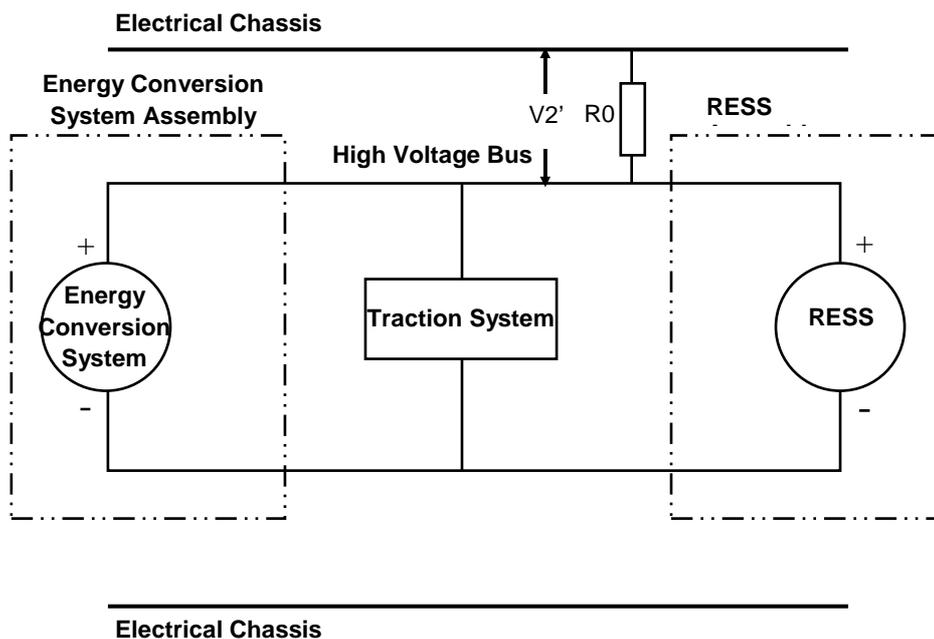


Figure 3: Measurement of  $V_2'$

### 3.2.2.3.5 Fifth step

The electrical isolation value  $R_i$  (in ohms) divided by the working voltage of the high voltage bus (in volts) results in the isolation resistance (in ohms/volt).

#### [NOTE 1:

The standard known resistance  $R_0$  (in ohms) should be the value of the minimum required isolation resistance (in ohms/V) multiplied by the working voltage of the vehicle plus/minus 20% (in volts).  $R_0$  is not required to be precisely this value since the equations are valid for any  $R_0$ ; however, a  $R_0$  value in this range should provide good resolution for the voltage measurements.]

## 4 Electrical Energy

The following procedure may be used if energy is measured.

After the vehicle crash determine the high voltage bus energy (see Figure 4). Install switch S1 and known resistance  $R_e$ . Close switch S1 and measure and record voltage  $V_b$  and current  $I_e$ . Integrate the product of these two measurements with respect to time as shown below to obtain total energy.

$$\int_{t_0}^{t_1} V_b \times I_e dt \quad [t_0 = \text{closing S1 after 5 seconds of the vehicle coming to rest} \\ t_1 = \text{to be defined}]$$

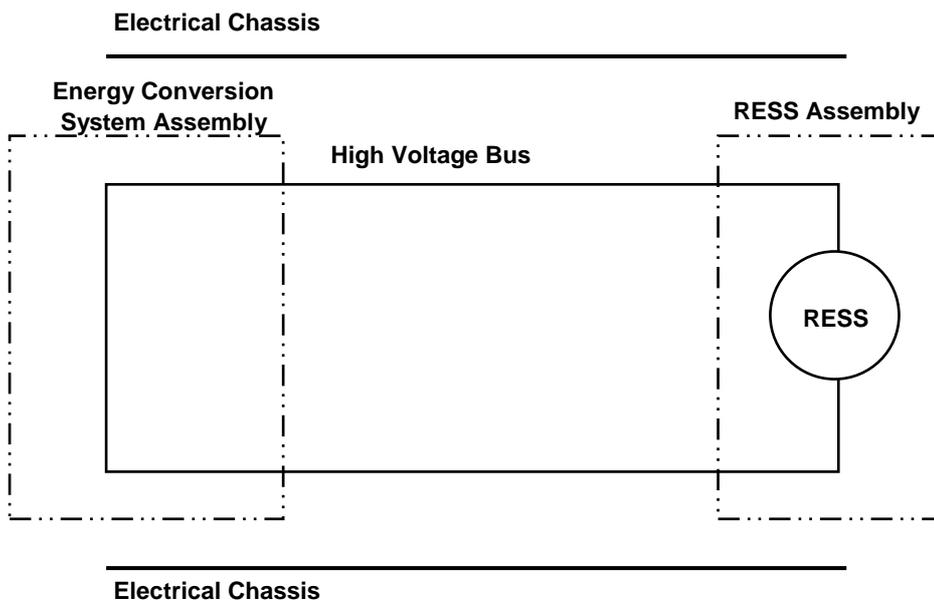


Figure 4: Measurement of high voltage bus energy

## 5 Physical Barrier

The following procedure may be used if physical protection is tested.

### 5-1 Test conditions

The manufacturer shall define the barrier, enclosure and solid insulator that protect the human from the direct contact to the high voltage bus in use (hereinafter referred to as the 'original physical protection').

Any surrounding parts of the high voltage components that can be opened, disassembled or removed without the use of tools after crash test shall be opened, disassembled or removed.

Surrounding parts that cannot be opened, disassembled or removed without the use of tools are considered as a part of the physical barrier.

The access probe is pushed against any openings of the physical barrier with the force  $10\text{ N} \pm 10\%$ . If it partly or fully penetrates into the original physical protection, it is placed in every possible position.

Starting from the straight position, both joints of the test finger shall be successively bent through an angle of up to 90 degree with respect to the axis of the adjoining section of the finger and shall be placed in every possible position.

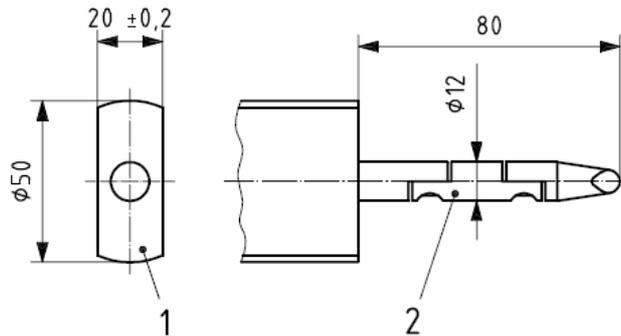
## 5-2 Acceptance conditions

The access probe shall not touch live parts.

A mirror or a fiberscope may be used in order to inspect whether the access probe touches the high voltage buses, if necessary.

### Annex 11 – Appendix 1 - Protection degrees

#### 1 IPXXB Jointed test finger diameter 12; 80 length Dimensions in millimetres



#### Key

- 1 stop face (diameter 50 × 20) (insulating material)
- 2 jointed test finger (metal)

The jointed test finger may penetrate over its full length of 80 mm but shall not contact the hazardous parts, even when its joints are bent at any optional angle (up to 90° from its axis) and are brought into any possible position. The stop face (Ø50 mm x 20 mm) shall not pass through the opening.

## B. JUSTIFICATION

This proposal incorporates provisions in order to ensure that all kinds of M1 vehicles, as defined in the scope of R 94, with power train systems above a certain working voltage level, comply with general requirements on the electrical safety, for the protection of occupants after a crash test. The electrical safety requirements are based on amendments of R 100, document ECE/Trans/WP.29/GRSP/2009/16.

*CONTENTS, insert a new paragraph, to read:*

### **"Annex 11 - ELECTRIC SAFETY – TEST PROCEDURES"**

A new annex is inserted to cover electrical safety requirements based on the R 100 amendments.

*Insert new paragraphs 2.6.7 and 2.7.1, to read*

#### **2.6.7. [The place of the RESS].**

**The place of the electrical source(s) has been introduced in the vehicle type definition as a new parameter to take into account.**

**[2.7.1 For vehicles with electric powertrain, passenger compartment means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing and front bulkhead and the plane of the rear compartment bulkhead or the plane of the rear-seat back support, or rear gate, as well as by the barriers and enclosures provided for protecting from direct contact with high voltage live parts.**

This definition is necessary regarding the new prescriptions introduced for electrical safety purposes.

*Insert new definitions 2.15 to 2.31, to read:*

New definitions used in the proposed amendments, are inserted. They are in line with the current amendment proposal for R 100.

*Insert a new paragraph, to read:*

#### **3.2.7 General description of the RESS type and [location] and the electric powertrain (e.g. hybrid, electric)**

Paragraph 3 "Application for approval" is modified to include information on the rechargeable energy storage system (RESS) *type and the location of the electric power train.*

Paragraph 5.2, amend to read:

5.2. Specifications

The test of the vehicle carried out in accordance with the method described in Annex 3 shall be considered satisfactory if all the conditions set out in paragraphs 5.2.1. to 5.2.8. below are all satisfied at the same time.

New 5.2.8 is inserted to prescribe electrical requirements to fulfil for the electric vehicles.

New paragraphs 5.2.8 to 5.2.8.3

These paragraphs deal with:

- Spillage requirements from RESS
- Cells and RESS locations and retention
- Electrical safety requirements

The control of electrical safety prescriptions is satisfied if at least one the four following requirements is met:

- Isolation resistance
- residual voltage(s) lower the high voltages (if  $> 60\text{ V}$  and  $\leq 1500\text{ V}$  in DC or  $> 30\text{ V}$  and  $\leq 1000\text{ V}$  in AC root mean square (rms) according to definition 2.31.
- Energy on high voltage bus less than 0,2 j.
- Physical barrier protection IPXXB and resistance between the electrical chassis and all exposed conductive parts shall be less than 0.1 ohm.

Annex 1- Communication Form, insert a new paragraph 5.3, to read:

**5.4 RESS location.....**

This information is added in the communication certificate.

Annex 3 - Test procedure- , insert new paragraphs 1.4.4, 1.4.4.1 and 1.4.4.2, to read:

1.4.4. Electric powertrain adjustments

[1.4.4.1. The high voltage system shall be energized.]

1.4.4.2. The RESS shall be at a state of charge which allows the normal operation of the power train recommended by the manufacturer.

These paragraphs describe the test condition of the electric power train.

*Insert a new AnnexII: ELECTRIC SAFETY – TEST PROCEDURES*

This annex describes the test setup, measuring equipment and the different test procedure that can be used for validation of the different options mentioned in paragraph 5.2.8.3.

- Bus voltage
- Isolation resistance
- Electrical energy
- Physical Barrier

Isolation resistance measurement and physical barrier protection requirements are in line with the current amendment proposal for the R 100.