



**Economic and Social
Council**

Distr.
GENERAL

ECE/TRANS/WP.29/GRSP/2009/16
23 September 2009

Original: ENGLISH
ENGLISH AND FRENCH ONLY

ECONOMIC COMMISSION FOR EUROPE

INLAND TRANSPORT COMMITTEE

World Forum for Harmonization of Vehicle Regulations

Working Party on Passive Safety

Forty-sixth session

Geneva, 8-11 December 2009

Item 16 of the provisional agenda

PROPOSAL FOR THE 01 SERIES OF AMENDMENTS TO REGULATION No. 100
(Construction and functional safety of battery electric vehicles)

Submitted by the Chairman of the Informal Group on Electric Safety */

The text reproduced below was prepared by the Chairman of the Informal Group on Electric Safety (ELSA) and aims at extending the scope of the present Regulation from battery electric vehicle to all kinds of power train systems above a certain working voltage level. It is based on a document without symbol (informal document No. GRSP-45-03) distributed during the forty-fifth session of GRSP and on the latest improvements by ELSA at its seventh meeting (10-11 September 2009). The modifications to the current text of Regulation No. 100 are marked in bold or strikethrough characters.

*/ In accordance with the programme of work of the Inland Transport Committee for 2006-2010 (ECE/TRANS/166/Add.1, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance performance of vehicles with respect to passive safety. The present document is submitted in conformity with that mandate.

A. PROPOSAL

Regulation No. 100

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF ~~BATTERY ELECTRIC~~
VEHICLES WITH REGARD TO SPECIFIC REQUIREMENTS FOR ~~THE CONSTRUCTION,~~
~~FUNCTIONAL SAFETY AND HYDROGEN EMISSION~~ **THE ELECTRIC POWER**
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1. SCOPE

The following prescriptions apply to safety requirements with respect to **the electric power train of road vehicles of categories M and N, with a maximum design speed exceeding 25 km/h, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid and the high voltage components and systems which are galvanically connected to the high voltage bus of the electric power train.**

This regulation does not cover post crash safety requirements of road vehicles.

2. DEFINITIONS

For the purpose of this **regulation the following definitions apply:**

- ~~2.1. "Battery electric road vehicle" means a vehicle with bodywork intended for road use, powered exclusively by an electric motor whose traction energy is supplied exclusively by a traction battery installed in the vehicle.~~
- 2.1. "Active driving possible mode" means **the** vehicle mode when application of pressure to the accelerator pedal (or activation of an equivalent control) **or release of the brake system** will cause the **electric power** train to move the vehicle.
- 2.2. "Barrier" means **the part providing protection against direct contact to the live parts from any direction of access.**
- 2.3. "Conductive connection" means **the connection using connectors to an external power supply when the RESS is charged.**
- ~~2.3. "Approval of a type of battery electric road vehicle" means the approval of a type of electric vehicle regarding construction and functional safety requirements specific to the use of electric energy.~~
- ~~2.4. "Traction battery" means the assembly of all battery modules which are electrically connected, for the supply of energy of the power circuit.~~
- ~~2.5. "Battery module" means the smallest single energy storage consisting of one cell or an assembly of cells, electrically connected in serial or in parallel, placed in one container and mechanically associated.~~
- ~~2.6. "Battery pack" means a single mechanical assembly comprising battery modules and retaining frames or trays. A vehicle may have one or several, or no battery pack.~~
- ~~2.7. "Auxiliary battery" means the battery unit whose reserve of energy is used only for the auxiliary network supply.~~
- ~~2.8. "Auxiliary network" means the assembly of auxiliary electric equipment with similar~~

~~functions to the one used on vehicles equipped with an internal combustion engine.~~

- ~~2.9. "On board charger" means an energy electronic converter linked by construction to the vehicle and used for charging the traction battery from an external electric power supply (mains network).~~
- 2.4. **"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.**
- 2.5. **"Direct contact" means the contact of persons or livestock with live parts.**
- 2.6. **"Electrical chassis" means a set made of conductive parts electrically linked together, and all other conductive parts electrically linked to them, whose potential is taken as reference.**
- 2.7. **"Electrical circuit" means an assembly of connected live parts which an electrical current is designed to pass be electrically energized in normal operation.**
- 2.8. **"Electric energy conversion system" means a system that generates and provides electric energy for electric propulsion.**
- 2.9. **"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.**
- 2.10. **"Electronic converter" means a device capable of controlling and/or converting electric power for electric propulsion.**
- 2.11. **"Enclosure" means the part enclosing the internal units and providing protection against direct contact from any direction of access.**
- 2.12. **"Exposed conductive part" means the conductive part which can readily be touched under the provisions of the protection degree IPXXB, and which may become electrically energized under isolation failure conditions.**
- ~~2.12. "Drive train" means specific components of power train: traction motors, electronic control of the traction motors, the associated wiring harness and connectors.~~
- 2.13. **"External electric power supply" means an alternating current (AC) or direct current (DC) electric power supply outside of the vehicle.**
- 2.14. **"High Voltage" means the classification of an electric component or circuit, if its working voltage is > 60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (rms).**

- 2.15. **"High voltage bus" means the electrical circuit, including the coupling system for charging the RESS that operates on high voltage.**
- ~~2.15. "Drive direction control unit" means a specific device physically actuated by the driver in order to select the drive direction (forwards or backwards), in which the vehicle will travel if the accelerator is actuated.~~
- 2.16. **"Indirect contact" means the contact of persons or livestock with exposed conductive parts.**
- 2.17. **"Live parts" means the conductive part(s) intended to be electrically energized in normal use.**
- 2.18. **"Luggage compartment" means the space in the vehicle for luggage accommodation, bounded by the roof, hood, floor, side walls, as well as by the barrier and enclosure provided for protecting the power train from direct contact with live parts, being separated from the passenger compartment by the front bulkhead or the rear bulk head.**
- 2.19. **"On-board isolation resistance monitoring system" means the device which monitors the isolation resistance between the high voltage buses and the electrical chassis.**
- 2.20. **"Open type traction battery" means a liquid type battery requiring refilling with water and generating hydrogen gas released to the atmosphere.**
- 2.21. **"Passenger compartment" means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, window glass, front bulkhead and rear bulkhead, or rear gate, as well as by the barriers and enclosures provided for protecting the power train from direct contact with live parts.**
- 2.22. **"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) or a test wire (IPXXD), as defined in Annex 3.**
- ~~2.22. "Nominal voltage" means the root mean square (r.m.s.) value of the voltage specified by the manufacturer, for which the electrical circuit is designed and to which its characteristics are referred.~~
- 2.23. **"Rechargeable energy storage system (RESS)" means the rechargeable energy storage system that provides electric energy for electric propulsion.**
- 2.24. **"Service disconnect" means the device for deactivation of the electrical circuit when conducting checks and services of the RESS, fuel cell stack, etc.**
- 2.25. **"Solid insulator" means the insulating coating of wiring harnesses provided in order to cover and protect the live parts against direct contact from any**

direction of access; covers for insulating the live parts of connectors, and varnish or paint for the purpose of insulation.

~~2.25. "Key" means any device designed and constructed to provide a method of operating a locking system which is designed and constructed to be operated only by that device.~~

2.26. "Vehicle type" means ~~battery electric road~~ vehicles which do not differ in such essential aspects as:

(a) Installation of the electric power train and the galvanically connected high voltage bus.

(b) Nature and type of electric power train and the galvanically connected high voltage components.

2.27. "Working voltage" means the highest value of an electrical circuit voltage root-mean-square (rms) ~~value of an electrical circuit voltage~~, 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.**

3. APPLICATION FOR APPROVAL

3.1. The application for approval of a vehicle type with regard to specific requirements for the **electric power train** ~~construction and functional safety of battery electric road vehicles~~ **shall** be submitted by vehicle manufacturer or by his duly accredited Representative.

3.2. It **shall** be accompanied by the under-mentioned documents in triplicate and following particulars:

3.2.1. Detailed description of the ~~battery electric road vehicle type as regards to the shape of the bodywork, the electric drive train (motors and controllers), traction battery (type, capacity, battery management)~~ **vehicle type as regards to the electric power train and the galvanically connected high voltage bus.**

3.3. A vehicle representative of the vehicle type to be approved **shall** be submitted to the technical service responsible for conducting the approval tests.

3.4. The competent Authority shall verify the existence of satisfactory arrangements for ensuring effective control of the conformity of production before type approval is granted.

4. APPROVAL

- 4.1. If the vehicle submitted for approval pursuant to this Regulation meets the requirements of Paragraph 5 below and Annexes 3, 4, 5 and 7 to this Regulation, approval of this vehicle type shall be granted.
- 4.2. An approval number shall be assigned to each type approved. Its first two digits (at present **01** for the Regulation in its form) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same number to another vehicle type.
- 4.3. Notice of approval or of refusal or of extension or withdrawal of approval or production definitely discontinued of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a form conforming to the model in Annex 1 to this Regulation.
- 4.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation an international approval mark consisting of:
- 4.4.1. A circle surrounding the Letter "E" followed by the distinguishing number of the country which has granted approval. 1/
- 4.4.2. The number of this Regulation, followed by the Letter "R", a dash and the approval number to the right of the circle described in Paragraph 4.4.1.

1/ 1 for Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Serbia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for the Russian Federation, 23 for Greece, 24 for Ireland, 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32 for Latvia, 33 (vacant), 34 for Bulgaria, 35 (vacant), 36 for Lithuania, 37 for Turkey, **38 (vacant), 39 for Azerbaijan, 40 for The former Yugoslav Republic of Macedonia, 41 (vacant), 42 for the European Community (Approvals are granted by its Member States using their respective ECE symbol), 43 for Japan, 44 (vacant), 45 for Australia, 46 for Ukraine, 47 for South Africa, 48 for New Zealand, 49 for Cyprus, 50 for Malta, 51 for the Republic of Korea, 52 for Malaysia, 53 for Thailand, 54 and 55 (vacant), 56 for Montenegro, 57 (vacant) and 58 for Tunisia.** Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement Concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

4.5. If the vehicle conforms to a vehicle type approved under one or more other Regulations annexed to the Agreement in the country which has granted approval under this Regulation, the symbol prescribed in Paragraph 4.4.1. need not be repeated; in this case the Regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation **shall** be placed in vertical columns to the right of the symbol prescribed in Paragraph 4.4.1.

4.6. The approval mark shall be clearly legible and shall be indelible.

4.7. The approval mark shall be placed on or close to the vehicle data plate affixed by the Manufacturer.

4.8. Annex 2 to this Regulation gives examples of the arrangements of the approval mark.

5. SPECIFICATIONS AND TESTS

~~5.1. Vehicle construction requirements~~

~~5.1.1. Traction battery~~

~~5.1.1.1. Installation of the traction battery in the vehicle shall not allow any potential dangerous accumulation of gas pockets.~~

~~5.1.1.2. Battery compartments containing battery modules which may produce hazardous gases shall be safely ventilated.~~

~~5.1.1.3. The traction battery and the power train shall be protected by properly rated fuses or circuit breakers. The manufacturer shall supply data to the laboratory which allows verification that their calibration ensures opening, if necessary;~~

5.1. Protection against Electrical Shock

These electrical safety requirements apply to high voltage buses under conditions where they are not connected to external high voltage power supplies.

5.1.1. Protection against direct contact

The protection against direct contact with live parts shall comply with paragraphs 5.1.1.1. and 5.1.1.2. These protections (solid insulator, barrier, enclosure, etc.) shall not be able to be opened, disassembled or removed without the use of tools.

5.1.1.1. For protection of live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.

5.1.1.2. For protection of live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB shall be satisfied.

5.1.1.3. Connectors

Connectors (including vehicle inlet) are deemed to meet this requirement if:

(a) they comply with 5.1.1.1. and 5.1.1.2. when separated without the use of tools, or

(b) they are located underneath the floor and are provided with a locking mechanism, or

(c) they are provided with a locking mechanism and other components shall be removed with the use of tools in order to separate the connector, or

(d) the voltage of the live parts becomes equal or below DC 60V or equal or below AC 30V (rms) within 1 second after the connector is separated.

5.1.1.4. Service disconnect

For a service disconnect which can be opened, disassembled or removed without tools, it is acceptable if protection degree IPXXB is satisfied under a condition where it is opened, disassembled or removed without tools.

~~5.1.2.1. Protection against direct contact with live parts of the power train:~~

~~5.1.2.1.1. If the working voltage of the electric circuit is lower than 60 volts DC or 25 volts AC, no requirements are necessary;~~

~~5.1.2.1.2. Direct contact with live parts of the electrical power train whose maximum voltage is at least 60 volts DC or 25 volts AC shall be prevented either by insulation or by the use of covers, protection grills, perforated metal sheets, etc. These protections shall be reliably secured and shall be mechanically resistant. They shall not be able to be opened, disassembled or removed without the use of tools.~~

~~5.1.2.1.3. In passenger and load compartments live parts in any case shall be protected by enclosures having a protection degree of at least IPXXD.~~

~~5.1.2.1.4. Enclosures in other areas of the vehicle shall have a protection degree of at least IPXXB.~~

~~5.1.2.1.5. In the engine compartment the access to live parts shall only be possible with voluntary action.~~

~~5.1.2.1.6. After opening the cover, the access to the parts of the coupling system shall be protected with IPXXB protection.~~

~~5.1.2.1.7. Protection degrees IPXXB and IPXXD are related respectively, to the contact of a jointed test finger and a test wire with hazardous parts (annex 3).~~

5.1.1.5. Vehicle Markings

The symbol shown in Figure 1 shall appear on or near the RESS.

The same symbol shall be visible on enclosures and barriers, which, when removed expose live parts of high voltage circuits.

However, this provision shall not apply to any of the following cases

- (a) where barriers or enclosures cannot be physically accessed ~~disassembled~~, opened or removed, unless other vehicle components are removed with the use of tools**
- (b) where barriers or enclosures are located underneath the vehicle floor.**

The symbol background shall be yellow, the bordering and the arrow shall be black.



Figure 1 — Marking of high voltage equipment

This provision shall not apply to any connectors for high voltage buses.

The outer covering of cables for high voltage buses, not within enclosures shall be identified by orange color.

~~Protection covers of live parts described in paragraph 5.1.2.1.2. shall be marked by a symbol as described in annex 5.~~

5.1.2. Protection against indirect contact

- 5.1.2.1. For protection against electrical shock which could arise from indirect contact, the exposed conductive parts, such as the conductive barrier and enclosure, shall be galvanically connected securely to the electrical chassis by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc. so that no dangerous potentials are produced.**

- 5.1.2.2.** The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2 amperes.

This requirement is satisfied if the galvanic connection has been established by welding.

- 5.1.2.3.** In the case of motor vehicles which are intended to be connected to the grounded external electric power supply through the conductive connection, a device to enable the galvanical connection of the electrical chassis to the earth ground shall be provided.

The device should enable connection to the earth ground before exterior voltage is applied to the vehicle and retain the connection until after the exterior voltage is removed from the vehicle.

Compliance to this requirement may be demonstrated either by using the connector specified by the car manufacturer, or by analysis.

~~5.1.2.2. Protection against indirect contacts with exposed conductive parts of the power train.~~

~~5.1.2.2.1. If the working voltage of the electric circuit is lower than 60 volts DC or 25 volts AC, no requirements are necessary;~~

~~5.1.2.2.2. The design, installation, and manufacture of electric material shall be such that insulation failures are avoided;~~

~~5.1.2.2.3. Protection against indirect contacts shall be ensured by using insulation and additionally, the exposed conductive parts of the on board equipment shall be galvanically connected together. This potential equalisation is obtained by connecting the exposed conductive parts together either by a protective conductor, e.g. wire, ground truss, or directly by the vehicle metallic chassis. Two exposed conductive parts welded together are considered as having no discontinuity points. If there is some discontinuity, this point shall be by-passed by potential equalisation.~~

5.1.3. Isolation resistance

5.1.3.1. Electric power train consisting of separate DC- or AC-buses

If AC high voltage buses and DC high voltage buses are galvanically isolated from each other, isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 ohms/volt of the working voltage for DC buses, and a minimum value of 500 ohms/volt of the working voltage for AC buses.

The measurement shall be conducted according to Annex 4 "isolation resistance measurement method" or a method equivalent to it.

5.1.3.2. Electric power train consisting of combined DC- and AC-buses

If AC high voltage buses and DC high voltage buses are galvanically connected isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 ohms/volt of the working voltage.

However, if all AC high voltage buses are protected by one of the 2 following measures, isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 ohms/volt of the working voltage.

- (a) Double or more layers of solid insulators, barriers or enclosures that meet the requirement in paragraph 5.1.1. independently, for example wiring harness**
- (b) Mechanically robust protections that have sufficient durability over vehicle service life such as motor housings, electronic converter cases or connectors.**

The isolation resistance between the high voltage bus and the electrical chassis may be demonstrated by calculation, measurement or a combination of both. The measurement shall be conducted according to Annex 4 "Isolation Resistance Measurement Method" or a method equivalent to it.

5.1.3.3. Fuel cell vehicles

If the minimum isolation resistance requirement cannot be maintained, then protection shall be achieved by any of the following:

- (a) Double or more layers of solid insulators, barriers or enclosures that meet the requirement in paragraph 5-1-1 independently.**
- (b) On-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value. The isolation resistance between the high voltage bus of the coupling system for charging the RESS, which is not energized besides during charging the RESS, and the electrical chassis need not to be monitored. The function of the on-board isolation resistance monitoring system shall be confirmed as described in Annex 5.**

5.1.3.4. Isolation resistance requirement for the coupling system for charging the RESS

For the vehicle inlet intended to be conductively connected to the grounded external AC power supply and the electrical circuit that is galvanically connected to the vehicle inlet during charging of the RESS, the isolation resistance between the high voltage bus and the electrical chassis shall be at least 1M ohms when the charger coupler is disconnected. During the measurement, the traction battery may be disconnected.

~~5.1.2.3. Insulation resistance~~

~~5.1.2.3.1. The insulation resistance measurement is performed after maintaining the vehicle for a conditioning time of 8 hours with the following conditions:~~

~~temperature: 23 " 5 EC,
humidity: 90 % +10/ 5 %.~~

~~5.1.2.3.2. Using a measuring DC voltage equal to the nominal voltage of the traction battery, insulation resistances between any exposed conductive part and each polarity of the battery shall have a minimum value of 500 S/V of the nominal voltage (annex 4 contains an example of how this test may be conducted).~~

~~5.1.2.3.3. Resistance of the protective conductor:~~

~~The potential equalisation resistance between any two exposed conductive parts shall be lower than 0.1 S. This test shall be performed by a current of at least 0.2 A.~~

~~5.1.2.4. Connection of the vehicle to the mains network:~~

~~5.1.2.4.1. In no case the vehicle shall be capable to move by its own means when it is galvanically connected to an energy supply network or to an off board charger;~~

~~5.1.2.4.2. The components used when charging the battery from an external source shall allow the charging current to be cut in case of disconnection without physical damage;~~

~~5.1.2.4.3. The coupling system parts likely to be live shall be protected against any direct contact in all operating conditions;~~

~~5.1.2.4.4. All exposed conductive parts shall be electrically linked through a conducting wire plugged to earth when charging.~~

5.2. RESS

5.2.1. Protection against excessive current

The RESS shall not overheat.

If the RESS is subject to overheating due to excessive current, it shall be equipped with a protective device such as fuses, circuit breakers or main contactors.

However, the requirement may not apply if the manufacturer supplies data that ensures overheating from excessive current is prevented without the protective device.

5.2.2. Accumulation of gas

Places for containing open type traction battery that may produce hydrogen gas shall be provided with a ventilation fan or a ventilation duct to prevent the accumulation of hydrogen gas.

5.3. Functional safety requirements

At least a momentary indication shall be given to the driver when the vehicle is in "active driving possible mode".

However, this provision does not apply under conditions where an internal combustion engine provides directly or indirectly the vehicle's propulsion power.

When leaving the vehicle, the driver shall be informed by a signal (e.g. optical or audible signal) if the vehicle is still in the active driving possible mode.

If the on-board RESS can be externally charged by the user, vehicle movement by its own propulsion system shall be impossible as long as the connector of the external electric power supply is physically connected to the vehicle inlet.

This requirement shall be demonstrated by using the connector specified by the car manufacturer.

The state of the drive direction control unit shall be identified to the driver.

~~5.2.1 Power on procedure:~~

~~5.2.1.1. The power on procedure shall be applied via a key switch.~~

~~5.2.1.2. It shall not be possible to remove this key in any position that energises the drive train or makes active driving possible.~~

~~5.2.2. Running and stopping conditions:~~

~~5.2.2.1. At least a momentary indication must be given to the driver either:~~

~~(a) when the vehicle is in "active driving possible mode" or,~~

~~(b) when one further action is required to place the vehicle in "active driving possible mode".~~

~~5.2.2.2. When the state of charge of the battery reaches the minimum state of charge value defined by the manufacturer, the user shall be warned to perceive this situation quickly enough to be able to drive the vehicle, on its own power, at least out of the traffic zone.~~

~~5.2.2.3. Unintentional acceleration, deceleration and reversal of the drive train shall be~~

~~prevented. In particular, a failure (e.g. in the power train) shall not cause more than 0,1 m movement of a standing unbraked vehicle.~~

~~5.2.2.4. When leaving the vehicle, the driver shall be informed by an obvious signal (e.g. optical or audible signal) if the drive train is still in the active driving possible mode.~~

~~5.2.3. Reversing~~

~~5.2.3.1. Reversing shall be possible only after operation of a specific control. This action shall require either:~~

~~(a) the combination of two different actuations, or~~

~~(b) an electric switch which allows reverse to be engaged only when the vehicle is moving at a forward speed not exceeding 5 km/h. Above this speed all actions on this device shall be ignored. The device shall have only one stable position.~~

~~5.2.3.2. The state of the drive direction control unit shall be readily identified to the driver.~~

~~5.2.4. Emergency power reduction~~

~~5.2.4.1. If the vehicle is equipped with a device to limit the performance in an emergency (e.g. overheating of a component) the user shall be informed by an obvious signal.~~

5.4. Determination of Hydrogen Emissions

5.4.1. This test shall be carried out on all vehicles equipped with open type traction batteries.

5.4.2. The test **shall be** conducted following the method described in Annex 7 to the present Regulation. The hydrogen sampling and analysis shall be the ones prescribed. Other analysis methods can be approved if it is proven that they give equivalent results.

5.4.3. During a normal charge procedure in the conditions given in Annex 7, hydrogen emissions shall be below 125 g during 5 h, or below $25 \times t_2$ g during t_2 (in h).

5.4.4. During a charge carried out by an on-board charger presenting a failure (conditions given in Annex 7), hydrogen emissions **shall be** below 42 g. Furthermore the on-board charger shall limit this possible failure to 30 minutes.

5.4.5. All the operations linked to the battery charging are controlled automatically, included the stop for charging.

5.4.6. It shall not be possible to take a manual control of the charging phases.

- 5.4.7. Normal operations of connection and disconnection to the mains or power cuts **shall not** affect the control system of the charging phases.
- 5.4.8. Important charging failures shall be permanently signaled to the driver. An important failure is a failure that can lead to a disfunctioning of the on-board charger during charging later on.
- 5.4.9. The manufacturer has to indicate in the owner's manual, the conformity of the vehicle to these requirements.
- 5.4.10. The approval granted to a vehicle type relative to hydrogen emissions can be extended to different vehicle types belonging to the same family, in accordance with the definition of the family given in Annex 7, Appendix 2.

6. MODIFICATION AND EXTENSION OF THE TYPE APPROVAL FOR VEHICLE TYPE

- 6.1. Every modification of the vehicle type shall be notified to the administrative department which approved the vehicle type. The department may then either:
 - 6.1.1. Consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still complies with the requirements or
 - 6.1.2. Require a further test report from the technical service responsible for conducting the tests.
- 6.2. Confirmation or refusal of approval, specifying the alteration, shall be communicated by the procedure specified in Paragraph 4.3. above to the Parties to the Agreement applying this Regulation.
- 6.3. The competent Authority issuing the extension of approval shall assign a series number for such an extension and inform thereof the other Parties to the 1958 Agreement applying the Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

7. CONFORMITY OF PRODUCTION

- 7.1. Every vehicle approved under this Regulation shall be so manufactured as to conform to the type approved by meeting the requirements set out in Paragraph 5 above.
- 7.2. In order to verify that the requirements of Paragraph 7.1 are met, suitable controls of the production shall be carried out.
- 7.3. The holder of the approval shall, in particular:

- 7.3.1. Ensure the existence of procedures for the effective quality control of vehicles;
- 7.3.2. Have access to the testing equipment necessary for checking the conformity of each approved type;
- 7.3.3. Ensure that test result data are recorded and that the annexed documents remain available for a period to be determined in agreement with the administrative department;
- 7.3.4. Analyse the results of each type of test, in order to verify and ensure the consistency of characteristics of the vehicle, making allowance for permissible variations in industrial production;
- 7.3.5. Ensure that for each type of vehicle at least the tests prescribed in Paragraph 5 of this Regulation are carried out;
- 7.3.6. Ensure that any set of samples or test pieces giving evidence of non-conformity with the type of test in question shall give rise to a further sampling and test. All necessary steps shall be taken to re-establish conformity of the corresponding production.
- 7.4. The competent Authority which has granted type approval may at any time verify the conformity control methods applied in each production unit.
 - 7.4.1. At every inspection, the test records and production records shall be presented to the visiting inspector.
 - 7.4.2. The inspector may take samples at random to be tested in the Manufacturer's laboratory. The minimum number of samples may be determined according to the results of the Manufacturer's own checks.
 - 7.4.3. When the quality level appears unsatisfactory or when it seems necessary to verify the validity of the tests carried out in application of Paragraph 7.4.2., the inspector shall select samples to be sent to the technical service which has conducted the type approval tests.
 - 7.4.4. The competent Authority may carry out any test prescribed in this Regulation.
 - 7.4.5. The normal frequency of inspections by the competent Authority shall be one per year. If unsatisfactory results are recorded during one of these visits, the competent Authority shall ensure that all necessary steps are taken to re-establish the conformity of production as rapidly as possible.
8. **PENALTIES FOR NON-CONFORMITY OF PRODUCTION**
 - 8.1. The approval granted in respect of a vehicle type, pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 7 above are not complied with,

or if the vehicle or its components fail to pass the tests provided for in Paragraph 7.3.5. above.

- 8.2. If a Contracting Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation, by means of a communication form conforming to the Model in Annex 1 to this Regulation.

9. **PRODUCTION DEFINITELY DISCONTINUED**

If the holder of the approval completely ceases to manufacture a type of vehicle approved in accordance with this Regulation, he shall so inform the Authority which granted the approval. Upon receiving the relevant communication, that Authority shall inform thereof the other Contracting Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

10. **NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS**

The Contracting Parties to the 1958 Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval or production definitely discontinued, issued in other countries are to be sent.

11. **TRANSITIONAL PROVISIONS**

- 11.1. **As from the official date of entry into force of the 01 series of amendments, no Contracting Party applying this Regulation shall refuse to grant approval under this Regulation as amended by the 01 series of amendments.**

- 11.2. **As from 36 months after the date of entry into force, Contracting Parties applying this Regulation shall grant approvals only if the vehicle type to be approved meets the requirements of this Regulation as amended by the 01 series of amendments.**

- 11.3. **Contracting Parties applying this Regulation shall not refuse to grant extensions of approval to the preceding series of amendments to this Regulation.**

- 11.4. **Contracting Parties applying this Regulation shall continue to grant approvals to those types of vehicles which comply with the requirements of this Regulation as amended by the preceding series of amendments during the 36 months' period which follows the date of entry into force of the 01 series of amendments.**

- 11.5. **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 approvals which were granted in accordance with any of the preceding series of amendments to this Regulation.**

13. Approval granted/extended/refused/withdrawn 2/:
14. Place:
15. Date:
16. Signature:
17. The documents filed with the request for approval or extension may be obtained on request.

Notes:

- 1/ Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).
- 2/ Strike out what does not apply.

Annex 2

ARRANGEMENTS OF APPROVAL MARKS

Model A

(see paragraph 4.4. of this Regulation)

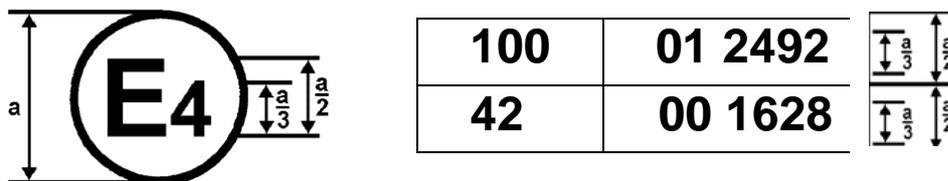


a = 8 mm min.

The above approval mark affixed to a vehicle shows that the road vehicle type concerned has been approved in the Netherlands (E4), pursuant to Regulation No. 100, and under the approval number **012492**. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No. 100 as amended by **01** series of amendments.

Model B

(see paragraph 4.5. of this Regulation)



a = 8 mm min.

The above approval mark affixed to a vehicle shows that the road vehicle concerned has been approved in the Netherlands (E4) pursuant to Regulations Nos. 100 and 42 */. The approval number indicates that, at the dates when the respective approvals were granted, Regulation No. 100 was amended by the **01** series of amendments and Regulation No. 42 was still in its original form.

*/ The latter number is given only as an example.

Annex 3
Extract from the IEC 529 Standard (1989)

PROTECTION AGAINST DIRECT CONTACTS OF PARTS UNDER VOLTAGE

1. Access probes

Access probes to verify the protection of persons against access to live parts are given in table 1.

~~1. DEFINITIONS~~

~~For the purpose of this standard, the following definitions apply:~~

~~1.1. Enclosure~~

~~A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact (IEV 826-03-12).~~

~~Note: This definition taken from the existing International Electrotechnical Vocabulary (IEV) needs the following explanations under the scope of this standard:~~

- ~~(a) Enclosures provide protection of persons (or livestock) against access to hazardous parts.~~
- ~~(b) Barriers, shapes of openings or any other means whether attached to the enclosure or formed by the enclosed equipment suitable to prevent or limit the penetration of the specified test probes are considered as a part of the enclosure, except when they can be removed without the use of a key or tool.~~

~~1.2. Direct contact~~

~~Contact of persons (or livestock) with live parts (IEV 826-03-05).~~

~~Note: This IEV definition is given for information. In this standard "Direct contact" is replaced by "Access to hazardous parts".~~

~~1.3. Degree of protection~~

~~The extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water and verified by standardised test methods.~~

~~1.4. IP code~~

~~A coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection.~~

~~1.5. Hazardous part~~

~~A part that is hazardous to approach or touch.~~

~~1.5.1. Hazardous live part~~

~~A live part which, under certain conditions of external influences, can give an electric shock (see IEC 536, at present Document 64(CO)196).~~

~~1.5.2. Hazardous mechanical part~~

~~A moving part, other than a smooth rotating shaft, that is hazardous to touch.~~

~~1.6. Protection provided by an enclosure against access to hazardous parts.~~

~~The protection of persons against:~~

~~(a) contact with hazardous low-voltage live parts;~~

~~(b) contact with hazardous mechanical parts;~~

~~(c) approach to hazardous high-voltage live parts below adequate clearance inside an enclosure.~~

~~Note: This protection may be provided:~~

~~(a) by means of the enclosure itself;~~

~~(b) by means of barriers as part of the enclosure or distances inside the enclosure.~~

~~1.7. Adequate clearance for protection against access to hazardous parts~~

~~A distance to prevent contact or approach of an access probe to a hazardous part.~~

~~1.8. Access probe~~

~~A test probe simulating in a conventional manner a part of a person or a tool, or the like, held by a person to verify adequate clearance from hazardous parts.~~

~~1.9. Object probe~~

~~A test probe simulating a solid foreign object to verify the possibility of ingress into an enclosure.~~

~~1.10. Opening~~

~~— A gap or aperture in an enclosure which exists or may be formed by the application of a test probe at the specified force.~~

~~2. TESTS FOR PROTECTION AGAINST ACCESS TO HAZARDOUS PARTS INDICATED BY THE ADDITIONAL LETTER~~

~~2.1. Access probes~~

~~Access probes to verify the protection of persons against access to hazardous parts are given in table 1.~~

~~2.2. Test conditions~~

The access probe is pushed against any openings of the enclosure with the force specified in table 1. If it partly or fully penetrates, it is placed in every possible position, but in no case shall the stop face fully penetrate through the opening.

Internal barriers are considered part of the enclosure ~~as defined in paragraph 1.1.~~

~~For tests on low-voltage equipment, a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected between the probe and the hazardous parts inside the enclosure. Hazardous live parts covered only with varnish or paint, or protected by oxidation or by a similar process, are covered by a metal foil electrically connected to those parts which are normally live in operation.~~

~~The signal-circuit method should also be applied to the hazardous moving parts of high-voltage equipment.~~

~~Internal moving parts may be operated slowly, where this is possible.~~

A low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected, if necessary, between the probe and live parts inside the barrier or enclosure.

The signal-circuit method should also be applied to the moving live parts of high voltage equipment.

Internal moving parts may be operated slowly, where this is possible.

~~3. Acceptance conditions~~

The access probe shall not touch live parts.

If this requirement is verified by a signal circuit between the probe and live parts, the lamp shall not light.

In the case of the test for IPXXB, the jointed test finger may penetrate to its 80 mm length, but the stop face (diameter 50 mm x 20 mm) shall not pass through the opening. 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.

In case of the tests for IPXXD, the access probe may penetrate to its full length, but the stop face shall not fully penetrate through the opening.

~~The protection is satisfactory if adequate clearance is kept between the access probe and hazardous parts.~~

~~In the case of the test for the additional letter B, the jointed test finger may penetrate to its 80 mm length, but the stop face (\varnothing 50 mm x 20 mm) shall not pass through the opening. Starting from the straight position, both joints of the test finger shall be successively bent through an angle of up to 90E with respect to the axis of the adjoining section of the finger and shall be placed in every possible position.~~

~~In case of the tests for the additional letter D, the access probe may penetrate to its full length, but the stop face shall not fully penetrate through the opening. See annex A for further clarification.~~

~~Conditions for verification of adequate clearance are identical with those given in paragraph 2.3.1. below.~~

~~2.3.1. For low voltage equipment (rated voltages not exceeding 1,000 V AC and 1,500 V DC):~~

~~The access probe shall not touch hazardous live parts.~~

~~If adequate clearance is verified by a signal circuit between the probe and hazardous parts, the lamp shall not light.~~

Table 1 - Access probes for the tests for protection of persons against access to hazardous parts

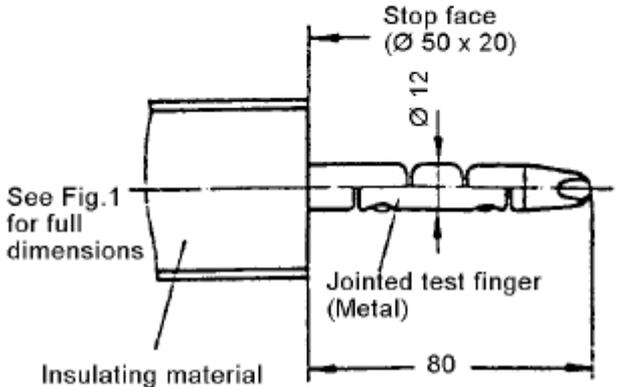
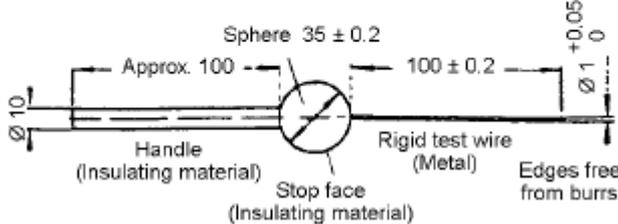
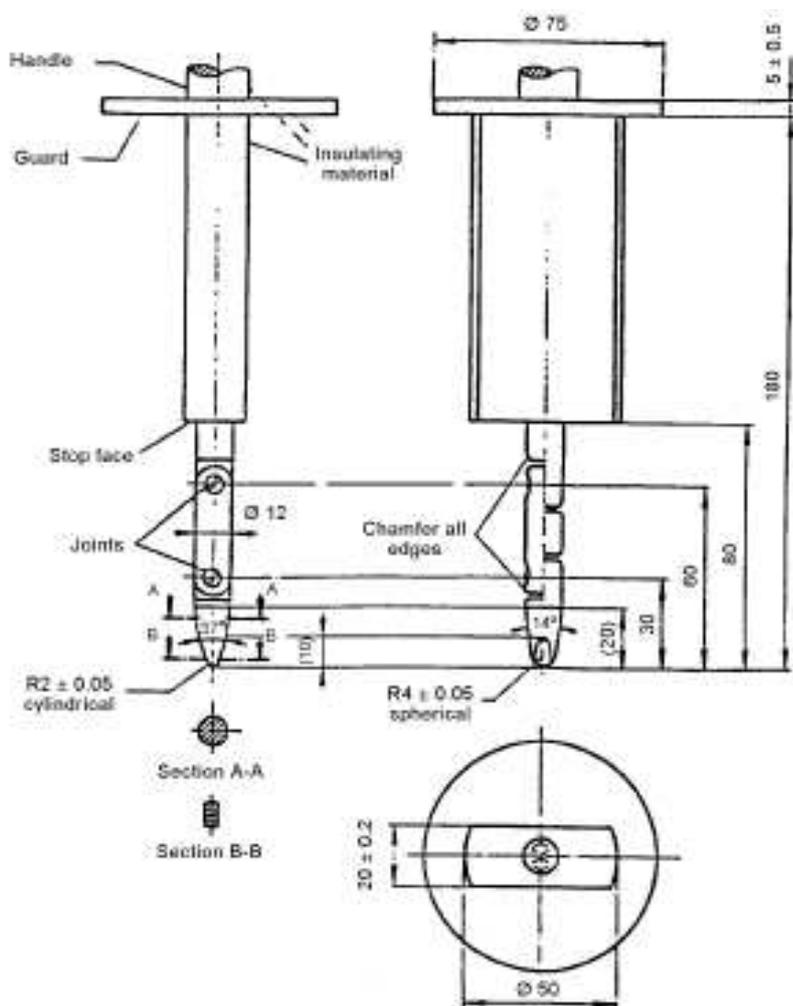
First numeral	Addit. letter	Access probe (Dimensions in mm)	Test force
2	B	<p style="text-align: center;">Jointed test finger</p>  <p style="text-align: center;">Stop face (Ø 50 x 20)</p> <p style="text-align: center;">Ø 12</p> <p>See Fig. 1 for full dimensions</p> <p style="text-align: center;">Jointed test finger (Metal)</p> <p style="text-align: center;">80</p> <p style="text-align: center;">Insulating material</p>	10 N ± 10 %
4, 5, 6	D	<p style="text-align: center;">Test wire 1.0 mm diameter, 100 mm long</p>  <p style="text-align: center;">Sphere 35 ± 0.2</p> <p style="text-align: center;">Approx. 100</p> <p style="text-align: center;">100 ± 0.2</p> <p style="text-align: center;">+0.05 Ø 1 0</p> <p>Ø 10</p> <p style="text-align: center;">Handle (Insulating material)</p> <p style="text-align: center;">Stop face (Insulating material)</p> <p style="text-align: center;">Rigid test wire (Metal)</p> <p style="text-align: center;">Edges free from burrs</p>	1 N ± 10 %

Figure 1 - Jointed test finger



Material: metal, except where otherwise specified

Linear dimensions in millimeters

Tolerances on dimensions without specific tolerance:

(a) on angles: 0/-10°

(b) on linear dimensions: up to 25 mm: 0/-0.05 mm over 25 mm: ±0.2 mm

Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to +10° tolerance.

Annex 4

ISOLATION RESISTANCE MEASUREMENT METHOD

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").

2. Measurement Method

The isolation resistance measurement shall be conducted by selecting an appropriate measurement method from among those listed in Paragraphs 2.1. through 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.

2.1. Measurement method using DC voltage from off-vehicle sources

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.

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.

2.2. Measurement method using the vehicle’s own RESS as DC voltage source

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.

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 MΩ.

2.2.3. Measurement method

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.

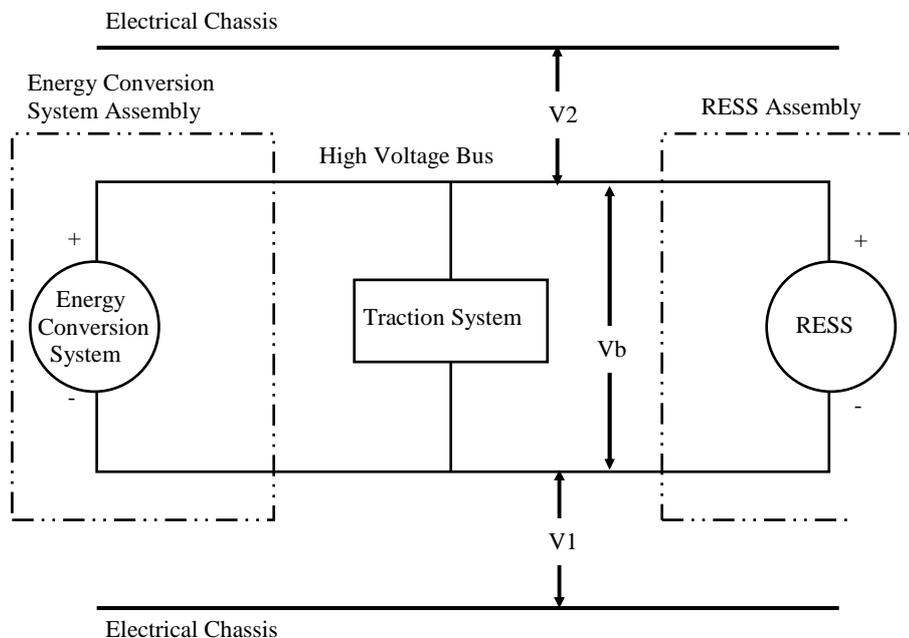


Figure 1: Measurement of V_b , V_1 , V_2

2.2.3.2. Second step

Measure and record the voltage (V1) between the negative side of the high voltage bus and the electrical chassis (see Figure 1):

2.2.3.3. Third step

Measure and record the voltage (V2) between the positive side of the high voltage bus and the electrical chassis (see Figure 1):

2.2.3.4. Fourth step

If V1 is greater than or equal to V2, insert a standard known resistance (Ro) between the negative side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V1') between the negative side of the high voltage bus and the electrical chassis (see Figure 2).

Calculate the electrical isolation (Ri) according to the following formula:

$$R_i = R_o * (V_b / V_1' - V_b / V_1) \quad \text{or} \quad R_i = R_o * V_b * (1 / V_1' - 1 / V_1)$$

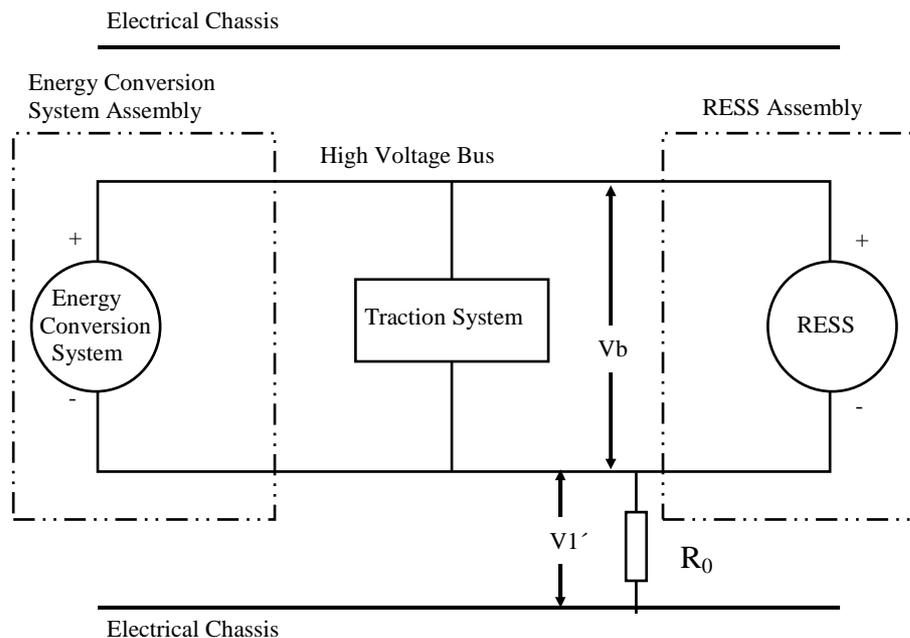


Figure 2: Measurement of V1'

If V2 is greater than V1, insert a standard known resistance (Ro) between the positive side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V2') between the positive side of the high voltage bus and the electrical chassis. (See Figure 3). Calculate the electrical isolation (Ri) 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:

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

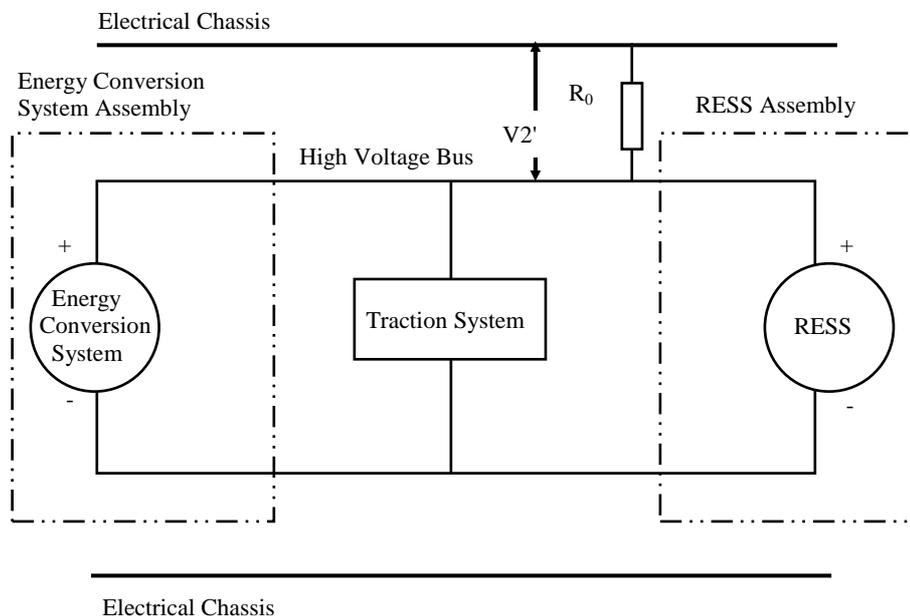


Figure 3: Measurement of V_2'

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_o (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 per cent (in volts). R_o is not required to be precisely this value since the equations are valid for any R_o ; however, a R_o value in this range should provide good resolution for the voltage measurements.]

~~MEASUREMENT OF THE INSULATION RESISTANCE USING THE TRACTION BATTERY~~

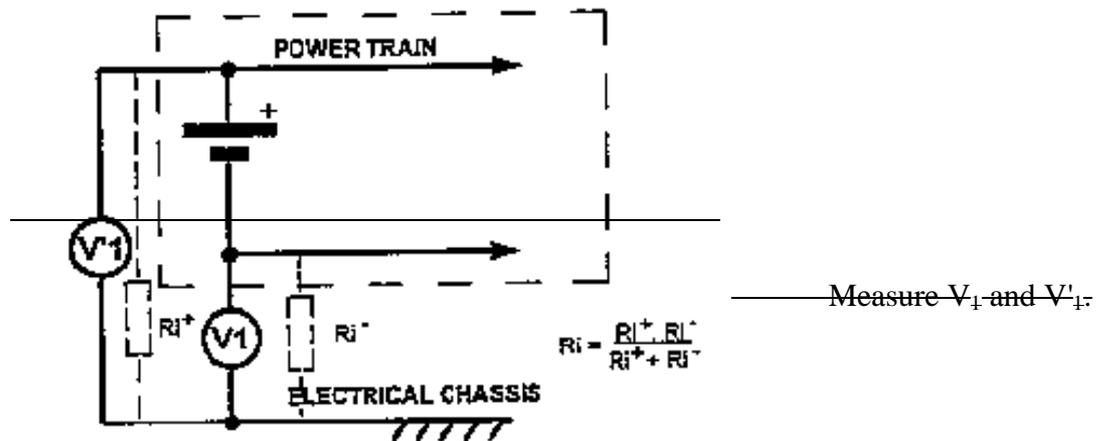
~~1. DESCRIPTION OF THE TEST METHOD~~

~~The traction battery shall be fully charged~~

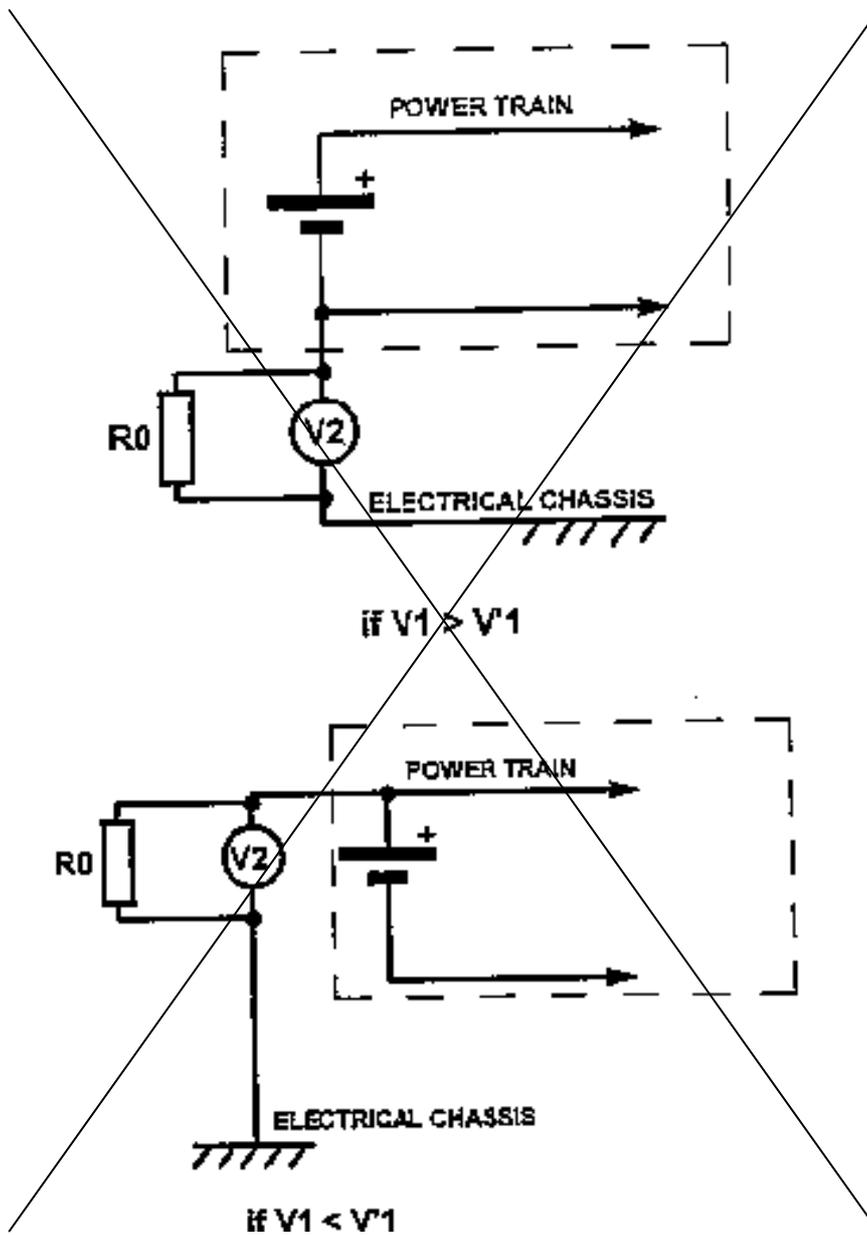
The voltmeter used in this test shall measure DC values and have an internal resistance greater than 10 MS.

Measurement shall be made in two steps:

Step one:



Step two:



where R_0 is a resistance of 500 S/V

The value of the insulation resistance R_i is given by one of the formula:

$$R_i = \frac{V_1 - V_2}{V_2} \times R_0 \text{ or } R_i = \frac{V_1' - V_2}{V_2} \times R_0$$

Annex 5

**CONFIRMATION METHOD FOR FUNCTIONS OF ON-BOARD ISOLATION
RESISTANCE MONITORING SYSTEM**

The function of the on-board isolation resistance monitoring system shall be confirmed by the following method or a method equivalent to it.

Insert a resistor that does not cause the isolation resistance between the terminal being monitored and the electrical chassis to drop below the minimum required isolation resistance value. The warning shall be activated.

~~SYMBOL FOR OF THE INDICATION OF A VOLTAGE
(Reference to ISO 3864 and IEC 417k standards)~~



Black on a yellow ground

Annex 6

ESSENTIAL CHARACTERISTICS OF ROAD VEHICLES OR SYSTEMS

1. General

- 1.1. Make (trade name or mark of **manufacturer**):
- 1.2. ~~Vehicle~~ **Vehicle Type**:
- 1.3. Vehicle category**:
- 1.4. Commercial name(s) if available**:
- 1.5. Manufacturer's name and address:
- 1.6. If applicable, name and address of manufacturer's representative:
- ~~1.5. Brief description of the power circuit components installation or drawings/pictures showing the location of the power circuit components installation:~~
- ~~1.6. Schematic diagram of all electrical functions included in power circuit:~~
- ~~1.7. Working voltage: V~~
- 1.7. Drawing and/or photograph of the vehicle:

2. Electric motor (traction motor)

- 2.1. **Type (winding, excitation)**:
- 2.2. **Maximum hourly output (kW)**:

~~2. Description of motor(s)~~

- ~~2.1. Make:~~
- ~~2.2. Type:~~
- ~~2.3. Working principle:~~
- ~~2.3.1. Direct current/alternative current/number of phases 1/~~
- ~~2.3.2. Excitation: separate/shunt/series/compound 1/~~
- ~~2.3.3. Synchron/asynchron 1/~~
- ~~2.3.4. Cooling system: air/liquid 1/~~

~~3. Description of transmission~~

- ~~3.1. Type: manual/automatic/none/others (to specify): 1/~~
- ~~3.2. Transmission ratios:~~
- ~~3.3. Dimension of tyres:~~

3. Traction Battery (if RESS is battery)

- 3.1. Trade name and mark of the battery:
- 3.2. Indication of all types of electro-chemical couples used cells**:
- 3.3. Nominal voltage (V):
- 3.4. Number of battery cells:
- ~~4.2.3. Number of battery modules:~~

- 3.5. **Gas combination rate (in per cent):**
- 3.6. Type(s) of ventilation for battery module/pack: 1/.....
- 3.7. Type of cooling system (if any):
- 3.8. **Capacity (Ah):**
- ~~4.5. Brief description of maintenance procedure (if any):~~
- ~~4.6. Battery energy: kW.h~~
- ~~4.7. End of discharge voltage value:..... V~~

4. Fuel Cell (if any)

- 4.1. **Trade name and mark of the fuel cell:**
- 4.2. **Types of fuel cell:**
- 4.3. **Nominal voltage (V):**
- 4.4. **Number of cells:**
- 4.5. **Type of cooling system (if any):**
- 4.6. **Max Power(kW):**

~~5. Power train electronic converters and power auxiliary equipment~~

- ~~5.1. Brief description of each electronic converter and auxiliary equipment:~~
- ~~5.2. Make of electronic converter assembly:~~
- ~~5.3. Type of electronic converter assembly:~~
- ~~5.4. Make of each auxiliary equipment:~~
- ~~5.5. Type of each auxiliary equipment:~~
- ~~5.6. Charger : on board/external 1/~~
- ~~5.7. Specification of mains:~~
 - ~~5.7.1. Type of mains: single phase/three phase 1/~~
 - ~~5.7.2. Voltage: V~~

5. Fuse and/or circuit breaker

- 5.1. Type:
- 5.2. Diagram showing the functional range:

6. Power wiring harness

- 6.1. Type:

7. Protection against Electric Shock

- 7.1. **Description of the Protection Concept:**

8. Additional data

- 8.1. **Brief description of the power circuit components installation or drawings/pictures showing the location of the power circuit components installation:**

- 8.2 Schematic diagram of all electrical functions included in power circuit:
- 8.3 Working voltage (V):

Annex 7

DETERMINATION OF HYDROGEN EMISSIONS
DURING THE CHARGE PROCEDURES OF THE TRACTION BATTERY

1. INTRODUCTION

This annex describes the procedure for the determination of hydrogen emissions during the charge procedures of the traction battery of all ~~battery electric~~ road vehicles, according to paragraph 5.4. of this Regulation.

2. DESCRIPTION OF TEST

The hydrogen emission test (Figure 7.1) is conducted in order to determine hydrogen emissions during the charge procedures of the traction battery with the on-board charger. The test consists in the following steps:

- (a) vehicle preparation,
- (b) discharge of the traction battery,
- (c) determination of hydrogen emissions during a normal charge,
- (d) determination of hydrogen emissions during a charge carried out with the on-board charger failure.

3. VEHICLE

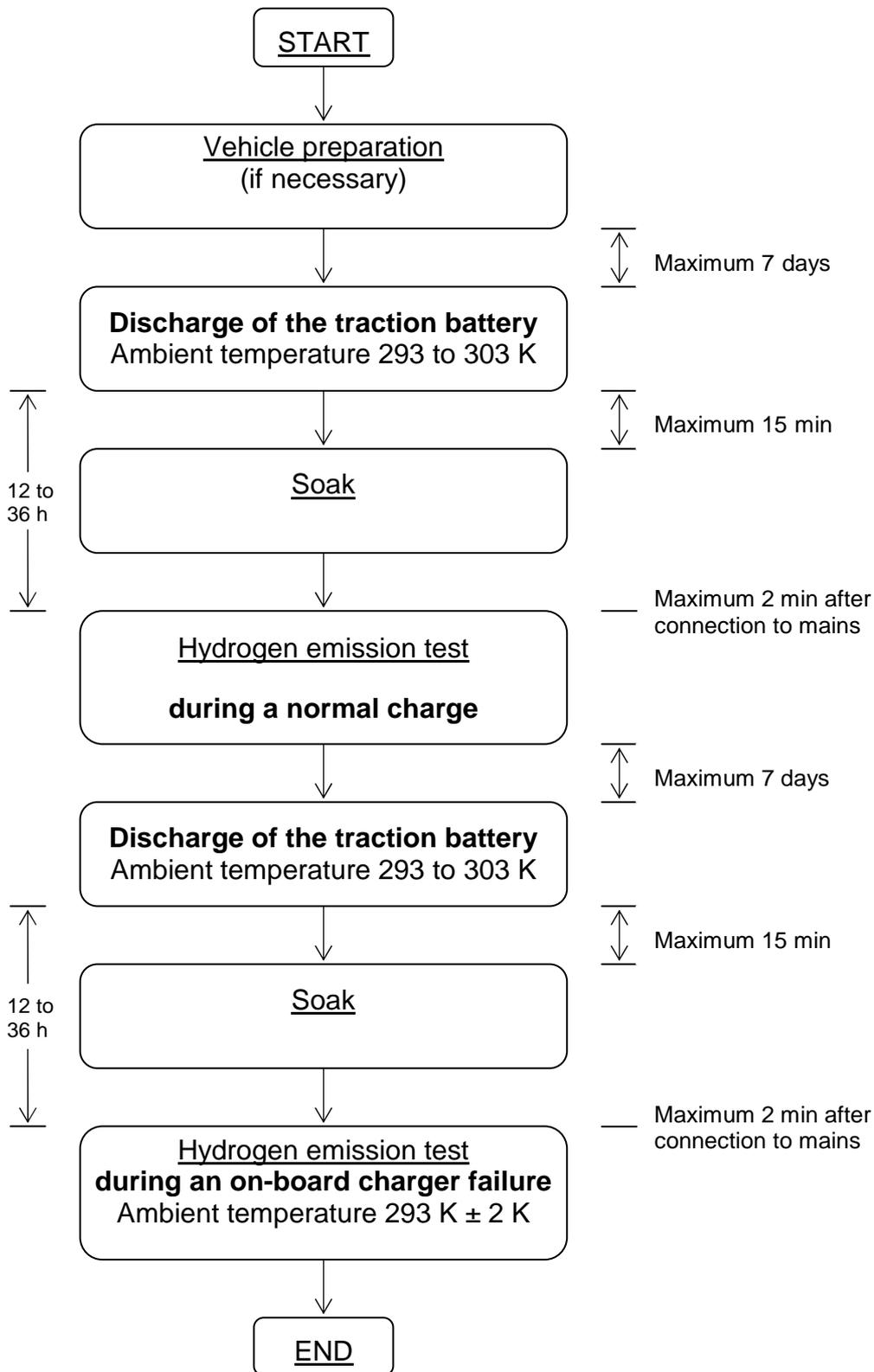
3.1. The vehicle **shall** be in good mechanical condition and have been driven at 300 km during seven days before the test. The vehicle **shall** be equipped with the traction battery subject to the test of hydrogen emissions, over this period.

3.2. If the battery is used at a temperature above the ambient temperature, the operator **shall** follow the manufacturer's procedure in order to keep the traction battery temperature in normal functioning range.

The manufacturer's representative **shall** be able to certify that the temperature conditioning system of the traction battery is neither damaged nor presenting a capacity defect.

Figure 7.1

Determination of hydrogen emissions during the charge procedures of the traction battery



4. TEST EQUIPMENT FOR HYDROGEN EMISSION TEST

4.1. Chassis dynamometer.

The chassis dynamometer **shall** meet the requirements of the 05 series of amendments to Regulation No. 83.

4.2. Hydrogen emission measurement enclosure.

The hydrogen emission measurement enclosure **shall** be a gas-tight measuring chamber able to contain the vehicle under test. The vehicle **shall** be accessible from all sides and the enclosure when sealed **shall** be gas-tight in accordance with appendix 1 to this annex. The inner surface of the enclosure **shall** be impermeable and non-reactive to hydrogen. The temperature conditioning system **shall** be capable of controlling the internal enclosure air temperature to follow the prescribed temperature throughout the test, with an average tolerance of ± 2 K over the duration of the test.

To accommodate the volume changes due to enclosure hydrogen emissions, either a variable-volume or another test equipment may be used. The variable-volume enclosure expands and contracts in response to the hydrogen emissions in the enclosure. Two potential means of accommodating the internal volume changes are movable panels, or a bellows design, in which impermeable bags inside the enclosure expand and contract in response to internal pressure changes by exchanging air from outside the enclosure. Any design for volume accommodation **shall** maintain the integrity of the enclosure as specified in Appendix 1 to this annex.

Any method of volume accommodation **shall** limit the differential between the enclosure internal pressure and the barometric pressure to a maximum value of ± 5 hPa.

The enclosure **shall** be capable of latching to a fixed volume. A variable volume enclosure **shall** be capable of accommodating a change from its "nominal volume" (see Annex 7, Appendix 1, paragraph 2.1.1.), taking into account hydrogen emissions during testing.

4.3. Analytical systems.

4.3.1. Hydrogen analyzer.

4.3.1.1. The atmosphere within the chamber is monitored using a hydrogen analyser (electrochemical detector type) or a chromatograph with thermal conductivity detection. Sample gas **shall** be drawn from the mid-point of one side-wall or roof of the chamber and any bypass flow **shall** be returned to the enclosure, preferably to a point immediately downstream of the mixing fan.

4.3.1.2. The hydrogen analyser **shall** have a response time to 90 per cent of final reading of less than 10 seconds. Its stability **shall** be better than 2 per cent of full scale at zero

and at 80 per cent \pm 20 per cent of full scale, over a 15-minute period for all operational ranges.

4.3.1.3. The repeatability of the analyser expressed as one standard deviation **shall** be better than 1 per cent of full scale, at zero and at 80 per cent \pm 20 per cent of full scale on all ranges used.

4.3.1.4. The operational ranges of the analyser **shall** be chosen to give best resolution over the measurement, calibration and leak checking procedures.

4.3.2. Hydrogen analyser data recording system

The hydrogen analyser **shall** be fitted with a device to record electrical signal output, at a frequency of at least once per minute. The recording system **shall** have operating characteristics at least equivalent to the signal being recorded and **shall** provide a permanent record of results. The recording **shall** show a clear indication of the beginning and end of the normal charge test and charging failure operation.

4.4. Temperature recording

4.4.1. The temperature in the chamber is recorded at two points by temperature sensors, which are connected so as to show a mean value. The measuring points are extended approximately 0.1 m into the enclosure from the vertical centre line of each side-wall at a height of 0.9 ± 0.2 m.

4.4.2. The temperatures of the battery modules are recorded by means of the sensors.

4.4.3. Temperatures **shall**, throughout the hydrogen emission measurements, be recorded at a frequency of at least once per minute.

4.4.4. The accuracy of the temperature recording system **shall** be within ± 1.0 K and the temperature **shall** be capable of being resolved to ± 0.1 K.

4.4.5. The recording or data processing system **shall** be capable of resolving time to ± 15 seconds.

4.5. Pressure recording

4.5.1. The difference Δp between barometric pressure within the test area and the enclosure internal pressure **shall**, throughout the hydrogen emission measurements, be recorded at a frequency of at least once per minute.

4.5.2. The accuracy of the pressure recording system **shall** be within ± 2 hPa and the pressure **shall** be capable of being resolved to ± 0.2 hPa.

4.5.3. The recording or data processing system **shall** be capable of resolving time to ± 15 seconds.

4.6. Voltage and current intensity recording

- 4.6.1. The on-board charger voltage and current intensity (battery) **shall**, throughout the hydrogen emission measurements, be recorded at a frequency of at least once per minute.
- 4.6.2. The accuracy of the voltage recording system **shall** be within ± 1 V and the voltage **shall** be capable of being resolved to ± 0.1 V.
- 4.6.3. The accuracy of the current intensity recording system **shall** be within ± 0.5 A and the current intensity **shall** be capable of being resolved to ± 0.05 A.
- 4.6.4. The recording or data processing system **shall** be capable of resolving time to ± 15 seconds.

4.7. Fans

The chamber **shall** be equipped with one or more fans or blowers with a possible flow of 0.1 to 0.5 m³/second in order to thoroughly mix the atmosphere in the enclosure. It **shall** be possible to reach a homogeneous temperature and hydrogen concentration in the chamber during measurements. The vehicle in the enclosure **shall** not be subjected to a direct stream of air from the fans or blowers.

4.8. Gases

- 4.8.1. The following pure gases **shall** be available for calibration and operation:

- (a) purified synthetic air (purity <1 ppm C1 equivalent; <1 ppm CO; <400 ppm CO₂; <0.1 ppm NO); oxygen content between 18 and 21 per cent by volume,
- (b) hydrogen (H₂), 99.5 per cent minimum purity.

- 4.8.2. Calibration and span gases **shall** contain mixtures of hydrogen (H₂) and purified synthetic air. The real concentrations of a calibration gas **shall** be within ± 2 per cent of the nominal values. The accuracy of the diluted gases obtained when using a gas divider **shall** be within ± 2 per cent of the nominal value. The concentrations specified in appendix 1 may also be obtained by a gas divider using synthetic air as the dilution gas.

5. TEST PROCEDURE

The test consists in the five following steps:

- (a) vehicle preparation,
- (b) discharge of the traction battery,

- (c) determination of hydrogen emissions during a normal charge,
- (d) discharge of the traction battery,
- (e) determination of hydrogen emissions during a charge carried out with the on-board charger failure.

If the vehicle has to be moved between two steps, it **shall** be pushed to the following test area.

5.1. Vehicle preparation

The ageing of traction battery **shall** be checked, proving that the vehicle has performed at least 300 km during seven days before the test. During this period, the vehicle **shall** be equipped with the traction battery submitted to the hydrogen emission test. If this cannot be demonstrated then the following procedure will be applied.

5.1.1. Discharges and initial charges of the battery

The procedure starts with the discharge of the traction battery of the vehicle while driving on the test track or on a chassis dynamometer at a steady speed of 70 per cent \pm 5 per cent of the maximum speed of the vehicle during 30 minutes.

Discharging is stopped:

- (a) when the vehicle is not able to run at 65 per cent of the maximum thirty minutes speed, or
- (b) when an indication to stop the vehicle is given to the driver by the standard on-board instrumentation, or
- (c) after having covered the distance of 100 km.

5.1.2. Initial charge of the battery

The charge is carried out:

- (a) with the on-board charger,
- (b) in an ambient temperature between 293 K and 303 K.

The procedure excludes all types of external chargers.

The end of traction battery charge criteria corresponds to an automatic stop given by the on-board charger.

This procedure includes all types of special charges that could be automatically or manually initiated like, for instance, the equalisation charges or the servicing charges.

5.1.3. Procedure from paragraphs 5.1.1. to 5.1.2. **shall** be repeated two times.

5.2. Discharge of the battery

The traction battery is discharged while driving on the test track or on a chassis dynamometer at a steady speed of 70 per cent \pm 5 per cent from the maximum thirty minutes speed of the vehicle.

Stopping the discharge occurs:

- (a) when an indication to stop the vehicle is given to the driver by the standard on-board instrumentation, or
- (b) when the maximum speed of the vehicle is lower than 20 km/h.

5.3. Soak

Within fifteen minutes of completing the battery discharge operation specified in 5.2., the vehicle is parked in the soak area. The vehicle is parked for a minimum of 12 hours and a maximum of 36 hours, between the end of the traction battery discharge and the start of the hydrogen emission test during a normal charge. For this period, the vehicle **shall** be soaked at $293\text{ K} \pm 2\text{ K}$.

5.4. Hydrogen emission test during a normal charge.

5.4.1. Before the completion of the soak period, the measuring chamber **shall** be purged for several minutes until a stable hydrogen background is obtained. The enclosure mixing fan(s) **shall** also be turned on at this time.

5.4.2. The hydrogen analyser **shall** be zeroed and spanned immediately prior to the test.

5.4.3. At the end of the soak, the test vehicle, with the engine shut off and the test vehicle windows and luggage compartment opened **shall** be moved into the measuring chamber.

5.4.4. The vehicle **shall** be connected to the mains. The battery is charged according to normal charge procedure as specified in paragraph 5.4.7 below.

5.4.5. The enclosure doors are closed and sealed gas-tight within two minutes from electrical interlock of the normal charge step.

5.4.6. The start of a normal charge for hydrogen emission test period begins when the chamber is sealed. The hydrogen concentration, temperature and barometric pressure are measured to give the initial readings $C_{\text{H}_2\text{i}}$, T_{i} and P_{i} for the normal charge test.

These figures are used in the hydrogen emission calculation (paragraph 6.). The ambient enclosure temperature T **shall** not be less than 291 K and no more than 295 K during the normal charge period.

5.4.7. Procedure of normal charge

The normal charge is carried out with the on-board charger and consists of the following steps:

- (a) Charging at constant power during t_1 .
- (b) Over-charging at constant current during t_2 . Over-charging intensity is specified by manufacturer and corresponds to the one used during equalisation charging.

The end of traction battery charge criteria corresponds to an automatic stop given by the on-board charger to a charging time of $t_1 + t_2$. This charging time will be limited to $t_1 + 5$ h, even if a clear indication is given to the driver by the standard instrumentation that the battery is not yet fully charged.

5.4.8. The hydrogen analyser **shall** be zeroed and spanned immediately before the end of the test.

5.4.9. The end of the emission sampling period occurs $t_1 + t_2$ or $t_1 + 5$ h after the beginning of the initial sampling, as specified in paragraph 5.4.6. The different times elapsed are recorded. The hydrogen concentration, temperature and barometric pressure are measured to give the final readings C_{H_2f} , T_f and P_f for the normal charge test, used for the calculation in paragraph 6.

5.5. Hydrogen emission test with the on-board charger failure

5.5.1. Within seven days maximum after having completed the prior test, the procedure starts with the discharge of the traction battery of the vehicle according to paragraph 5.2.

5.5.2. The steps of the procedure in paragraph 5.3 **shall** be repeated.

5.5.3. Before the completion of the soak period, the measuring chamber **shall** be purged for several minutes until a stable hydrogen background is obtained. The enclosure mixing fan(s) **shall** also be turned on at this time.

5.5.4. The hydrogen analyser **shall** be zeroed and spanned immediately prior to the test.

5.5.5. At the end of the soak, the test vehicle, with the engine shut off and the test vehicle windows and luggage compartment opened **shall** be moved into the measuring chamber.

- 5.5.6. The vehicle **shall** be connected to the mains. The battery is charged according to failure charge procedure as specified in paragraph 5.5.9. below.
- 5.5.7. The enclosure doors are closed and sealed gas-tight within two minutes from electrical interlock of the failure charge step.
- 5.5.8. The start of a failure charge for hydrogen emission test period begins when the chamber is sealed. The hydrogen concentration, temperature and barometric pressure are measured to give the initial readings C_{H_2i} , T_i and P_i for the failure charge test.

These figures are used in the hydrogen emission calculation (paragraph 6). The ambient enclosure temperature T **shall** not be less than 291 K and no more than 295 K during the charging failure period.

5.5.9. Procedure of charging failure

The charging failure is carried out with the on-board charger and consists of the following steps:

- (a) Charging at constant power during t'_1 .
- (b) Charging at maximum current during 30 minutes. During this phase, the on-board charger is blocked at maximum current.

5.5.10. The hydrogen analyser **shall** be zeroed and spanned immediately before the end of the test.

5.5.11. The end of test period occurs $t'_1 + 30$ minutes after the beginning of the initial sampling, as specified in paragraph 5.5.8. The times elapsed are recorded. The hydrogen concentration, temperature and barometric pressure are measured to give the final readings C_{H_2f} , T_f and P_f for the charging failure test, used for the calculation in paragraph 6.

6. CALCULATION

The hydrogen emission tests described in paragraph 5 allow the calculation of the hydrogen emissions from the normal charge and charging failure phases. Hydrogen emissions from each of these phases are calculated using the initial and final hydrogen concentrations, temperatures and pressures in the enclosure, together with the net enclosure volume.

The formula below is used:

$$M_{H_2} = k \times V \times 10^{-4} \times \left(\frac{(1 + \frac{V_{out}}{V}) \times C_{H_2f} \times P_f}{T_f} - \frac{C_{H_2i} \times P_i}{T_i} \right)$$

where:

M_{H_2} = hydrogen mass, in grams

C_{H_2} = measured hydrogen concentration in the enclosure, in ppm volume

V = net enclosure volume in cubic metres (m^3) corrected for the

volume of the vehicle, with the windows and the luggage compartment open.
If the volume of the vehicle is not determined a volume of 1.42 m^3 is subtracted.

V_{out} = Compensation volume in m^3 , at the test temperature and pressure

T = ambient chamber temperature, in K

P = absolute enclosure pressure, in kPa

k = 2.42

where: i is the initial reading

f is the final reading

6.1. Results of test.

The hydrogen mass emissions for the vehicle are:

MN = hydrogen mass emission for normal charge test, in grams

MD = hydrogen mass emission for charging failure test, in grams

Annex 7 - Appendix 1

CALIBRATION OF EQUIPMENT
FOR HYDROGEN EMISSION TESTING

1. CALIBRATION FREQUENCY AND METHODS

All equipment **shall** be calibrated before its initial use and then calibrated as often as necessary and in any case in the month before type approval testing. The calibration methods to be used are described in this appendix.

2. CALIBRATION OF THE ENCLOSURE

2.1. Initial determination of enclosure internal volume

2.1.1. Before its initial use, the internal volume of the chamber **shall** be determined as follows. The internal dimensions of the chamber are carefully measured, taking into account any irregularities such as bracing struts. The internal volume of the chamber is determined from these measurements.

The enclosure **shall** be latched to a fixed volume when the enclosure is held at an ambient temperature of 293 K. This nominal volume **shall** be repeatable within ± 0.5 per cent of the reported value.

2.1.2. The net internal volume is determined by subtracting 1.42 m^3 from the internal volume of the chamber. Alternatively the volume of the test vehicle with the luggage compartment and windows open may be used instead of the 1.42 m^3 .

2.1.3. The chamber **shall** be checked as in paragraph 2.3. If the hydrogen mass does not agree with the injected mass to within ± 2 per cent then corrective action is required.

2.2. Determination of chamber background emissions

This operation determines that the chamber does not contain any materials that emit significant amounts of hydrogen. The check **shall** be carried out at the enclosure's introduction to service, after any operations in the enclosure which may affect background emissions and at a frequency of at least once per year.

2.2.1. Variable-volume enclosure may be operated in either latched or unlatched volume configuration, as described in paragraph 2.1.1. Ambient temperature **shall** be maintained at $293 \text{ K} \pm 2 \text{ K}$, throughout the 4-hour period mentioned below.

2.2.2. The enclosure may be sealed and the mixing fan operated for a period of up to 12 hours before the four-hour background-sampling period begins.

- 2.2.3. The analyser (if required) **shall** be calibrated, then zeroed and spanned.
- 2.2.4. The enclosure **shall** be purged until a stable hydrogen reading is obtained, and the mixing fan turned on if not already on.
- 2.2.5. The chamber is then sealed and the background hydrogen concentration, temperature and barometric pressure are measured. These are the initial readings C_{H_2i} , T_i and P_i used in the enclosure background calculation.
- 2.2.6. The enclosure is allowed to stand undisturbed with the mixing fan on for a period of four hours.
- 2.2.7. At the end of this time the same analyser is used to measure the hydrogen concentration in the chamber. The temperature and the barometric pressure are also measured. These are the final readings C_{H_2f} , T_f and P_f .
- 2.2.8. The change in mass of hydrogen in the enclosure **shall** be calculated over the time of the test in accordance with paragraph 2.4 and **shall** not exceed 0.5 g.

2.3. Calibration and hydrogen retention test of the chamber

The calibration and hydrogen retention test in the chamber provides a check on the calculated volume (paragraph 2.1) and also measures any leak rate. The enclosure leak rate **shall** be determined at the enclosure's introduction to service, after any operations in the enclosure which may affect the integrity of the enclosure, and at least monthly thereafter. If six consecutive monthly retention checks are successfully completed without corrective action, the enclosure leak rate may be determined quarterly thereafter as long as no corrective action is required.

- 2.3.1. The enclosure **shall** be purged until a stable hydrogen concentration is reached. The mixing fan is turned on, if not already switched on. The hydrogen analyser is zeroed, calibrated if required, and spanned.
- 2.3.2. The enclosure **shall** be latched to the nominal volume position.
- 2.3.3. The ambient temperature control system is then turned on (if not already on) and adjusted for an initial temperature of 293 K.
- 2.3.4. When the enclosure temperature stabilizes at $293\text{ K} \pm 2\text{ K}$, the enclosure is sealed and the background concentration, temperature and barometric pressure measured. These are the initial readings C_{H_2i} , T_i and P_i used in the enclosure calibration.
- 2.3.5. The enclosure **shall** be unlatched from the nominal volume.
- 2.3.6. A quantity of approximately 100 g of hydrogen is injected into the enclosure. This mass of hydrogen **shall** be measured to an accuracy of ± 2 per cent of the measured value.

- 2.3.7. The contents of the chamber **shall** be allowed to mix for five minutes and then the hydrogen concentration, temperature and barometric pressure are measured. These are the final readings C_{H2f} , T_f and P_f for the calibration of the enclosure as well as the initial readings C_{H2i} , T_i and P_i for the retention check.
- 2.3.8. On the basis of the readings taken in paragraphs 2.3.4 and 2.3.7 and the formula in paragraph 2.4, the mass of hydrogen in the enclosure is calculated. This **shall** be within ± 2 per cent of the mass of hydrogen measured in paragraph 2.3.6.
- 2.3.9. The contents of the chamber **shall** be allowed to mix for a minimum of 10 hours. At the completion of the period, the final hydrogen concentration, temperature and barometric pressure are measured and recorded. These are the final readings C_{H2f} , T_f and P_f for the hydrogen retention check.
- 2.3.10. Using the formula in paragraph 2.4, the hydrogen mass is then calculated from the readings taken in paragraphs 2.3.7 and 2.3.9. This mass may not differ by more than 5 per cent from the hydrogen mass given by paragraph 2.3.8.

2.4. Calculation

The calculation of net hydrogen mass change within the enclosure is used to determine the chamber's hydrocarbon background and leak rate. Initial and final readings of hydrogen concentration, temperature and barometric pressure are used in the following formula to calculate the mass change.

$$M_{H2} = k \times V \times 10^{-4} \times \left(\frac{\left(1 + \frac{V_{out}}{V}\right) \times C_{H2f} \times P_f}{T_f} - \frac{C_{H2i} \times P_i}{T_i} \right)$$

where:

M_{H2} = hydrogen mass, in grams

C_{H2} = measured hydrogen concentration into the enclosure, in ppm volume

V = enclosure volume in cubic metres (m^3) as measured in paragraph 2.1.1.

V_{out} = compensation volume in m^3 , at the test temperature and pressure

T = ambient chamber temperature, in K

P = absolute enclosure pressure, in kPa

k = 2.42

where: i is the initial reading

f is the final reading

3. CALIBRATION OF THE HYDROGEN ANALYZER

The analyzer should be calibrated using hydrogen in air and purified synthetic air. See paragraph 4.8.2. of annex 7.

Each of the normally used operating ranges are calibrated by the following procedure.

- 3.1. Establish the calibration curve by at least five calibration points spaced as evenly as possible over the operating range. The nominal concentration of the calibration gas with the highest concentrations to be at least 80 per cent of the full scale.
- 3.2. Calculate the calibration curve by the method of least squares. If the resulting polynomial degree is greater than 3, then the number of calibration points **shall** be at least the number of the polynomial degree plus 2.
- 3.3. The calibration curve **shall** not differ by more than 2 per cent from the nominal value of each calibration gas.
- 3.4. Using the coefficients of the polynomial derived from paragraph 3.2. above, a table of analyzer readings against true concentrations **shall** be drawn by steps no greater than 1 per cent of full scale. This is to be carried out for each analyzer range calibrated.

This table **shall** also contain other relevant data such as:

- (a) Date of calibration.
 - (b) Span and zero potentiometer readings (where applicable).
 - (c) Nominal scale.
 - (d) Reference data of each calibration gas used.
 - (e) The real and indicated value of each calibration gas used together with the percentage differences.
 - (f) Calibration pressure of analyzer.
- 3.5. Alternative methods (e.g. computer, electronically controlled range switch) can be used if it is proven to the technical service that these methods give equivalent accuracy.

Annex 7 - Appendix 2

ESSENTIAL CHARACTERISTICS OF THE VEHICLE FAMILY

1. PARAMETERS DEFINING THE FAMILY RELATIVE TO HYDROGEN EMISSIONS

The family may be defined by basic design parameters which **shall** be common to vehicles within the family. In some cases there may be interaction of parameters. These effects **shall** also be taken into consideration to ensure that only vehicles with similar hydrogen emission characteristics are included within the family.

2. To this end, those vehicle types whose parameters described below are identical are considered to belong to the same hydrogen emissions.

Traction battery:

- (a) Trade name or mark of the battery.
- (b) Indication of all types of electro-chemical couples used.
- (c) Number of battery cells.
- (d) Number of battery modules.
- (e) Nominal voltage of the battery (V).
- (f) Battery energy (kWh).
- (g) Gas combination rate (in per cent).
- (h) Type(s) of ventilation for battery module(s) or pack.
- (i) Type of cooling system (if any).

On-board charger:

- (a) Make and type of different charger parts.
- (b) Output nominal power (kW).
- (c) Maximum voltage of charge (V).
- (d) Maximum intensity of charge (A).

- (e) Make and type of control unit (if any).
- (f) Diagram of operating, controls and safety.
- (g) Characteristics of charge periods.

B. JUSTIFICATION

This proposal aims to adapt Regulation No. 100 to the technical progress. The main objective is to extend the scope of the Regulation from battery electric vehicle to all kinds of power train systems above a certain working voltage level.

The activities of ELSA are based upon the work of a Global Technical Regulation of Hydrogen and Fuel Cell Vehicles (HFCV GTR). A section for the HFCV GTR with the title "Electric Safety Provisions" will be developed. This section will have two sub-sections with entitled "Electric safety provisions during in-use" and "Electric safety provisions post-crash". WP.29 requested ELSA that once the technical requirements of the sub-sections are defined and agreed, the formal integration into the 1958 Agreement and the 1998 Agreement will be conducted separately. This proposal is to amend Regulation No. 100 regarding "in-use" under the 1958 agreement.
