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Road Vehicles - Electric vehicle Safety performance and Environmental Requirements

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Road Vehicles - Electric Vehicle Safety Performance and Environmental Requirements

1. Scope

This Ethiopian standard specifies safety performance, power consumption, and environmental considerations of Electric Vehicle (EV). These standards are designed to ensure that EVs are safe for drivers, passengers, and pedestrians, operate efficiently, and minimize their environmental impact.

2. NORMATIVE REFERENCES

The following referenced documents are indispensable for the application of this Ethiopian Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ES ISO 6469-1, Electrically propelled road vehicles - Safety specifications - Part 1: On-board rechargeable energy storage system REESS)

ES ISO 6469-2, Electrically propelled road vehicles - Safety specifications - Part 2: Vehicle operational safety

ES ISO 6469-3, Electrically propelled road vehicles - Safety specifications - Part 3: Electrical Safety

ES ISO 6469-4, Electrically propelled road vehicles - Safety specifications - Part 4: Post crash electrical safety

ES ISO 17409, Electrically propelled road vehicles Conductive power transfer Safety requirements

ES ISO/TR 8713, Electrically propelled road vehicles - Vocabulary

ES ISO 15118-1, Road vehicles - Vehicle to grid communication interface - Part 1: General information and use-case definition

ES ISO15118-2, Road vehicles - Vehicle to grid communication interface - Part 2: Network and application protocol requirements

ES ISO 5118-3, Road vehicles - Vehicle to grid Communication Interface - Part 3: Physical and data link layer requirements

ES ISO 5118-4, Road vehicles - Vehicle to grid communication interface - Part 4: Network and application protocol conformance test

ES ISO15118-5, Road vehicles - Vehicle to grid communication interface - Part 5: Physical layer and data link layer conformance test

ES ISO 26262 series , Road vehicles - Functional safety

ES ISO 6722-1, Road vehicles - 60 V and 600 V single-core cables - Part 1: Dimensions, test methods and requirements for copper conductor cables

ES ISO 12405-4, Electrically propelled road vehicles -Test specification for lithium-ion traction battery packs and systems - Part 4: Performance testing
ES IEC 61851-1:2017, Electric vehicle conductive charging system - Part 1: General requirements

ES IEC 61851-21, Electric vehicle conductive charging system - Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply

ES IEC 61851-21-1, Electric vehicle conductive charging system - Part 21-1 Electric vehicle on-board charger EMC requirements for conductive connection to a.c./d.c. supply

ES IEC 61851-21-2, Electric vehicle conductive charging system - Part 21-2: EMC requirements for OFF board electric vehicle charging systems

ES IEC 61851-23, Electric vehicles conductive charging system - Part 23: DC electric vehicle charging station

ES IEC 61851-24, Electric vehicles conductive charging system - Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging

ES IEC 62196-1, Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1: General requirements

ES IEC 62196-2, Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories

ES IEC 62196-3, Plugs, socket-outlets, and vehicle couplers - conductive charging of electric vehicles - Part 3: Dimensional compatibility and interchangeability requirements for dedicated d.c. and combined a.c./d.c. pin and contact-tube vehicle couplers

ES IEC 62660-2, Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing

ES IEC 62660-3, Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements of cells and modules

ES IEC 62752:2016, In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD).

ES UNECE R 100 Part 1: Requirements of a vehicle with regard to specific requirements for the electric power train

ES UNECE R136 Part I: Requirements of a vehicle with regard to its electrical safety.

3. Terms and Definitions

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

3.1.
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.

3.2.
Aqueous electrolyte
means an electrolyte based on water solvent for the compounds (e.g. acids, bases) providing conducting ions after its dissociation.

3.3.
Automatic disconnect
means a device that when triggered, conductively separates the electric energy sources from the rest of the high voltage circuit of the electric power train.

3.4.
Breakout harness
means connector wires that are connected for testing purposes to the REESS on the traction side of the automatic disconnect.

3.5.
Cell
means a single encased electrochemical unit containing one positive and one negative terminal, which exhibits a voltage differential across its two terminals and used as rechargeable energy storage device.

3.6.
Conductive connection
means the connection using connectors to an external power supply when the rechargeable energy storage system (REESS) is charged.

3.7.
Connector
means the device providing mechanical connection and disconnection of high voltage electrical conductors to a suitable mating component including its housing

3.8.
Coupling system for charging the Rechargeable Electrical Energy Storage System (REESS)
means the electrical circuit used for charging the REESS from an external electric power supply including the vehicle inlet.
3.9.
C Rate of n C
is defined as the constant current of the Tested-Device, which takes 1/n hours to charge or discharge the Tested-Device between 0 per cent SOC and 100 per cent SOC.
3.10.
Direct contact
means the contact of persons with high voltage live parts.

3.11.
Electric energy conversion system
means a system (e.g. fuel cell) that generates and provides electric energy for electrical propulsion.
3.12.
Electric power train
means the electrical circuits which includes the traction motor(s), and may also include the REESS, the electric energy conversion system, the electronic converters, the associated wiring harness and connectors, and the coupling system for charging the REESS.
3.13.
Electrical chassis
means a set made of conductive parts electrically linked together, whose electrical potential is taken as reference.
3.14.
Electrical circuit
means an assembly of connected high voltage live parts which is designed to be electrically energized in normal operation.
3.15.
Electrical protection barrier
means the part providing protection against any direct contact to the high voltage live parts.
3.16.
Electrolyte leakage
means the escape of electrolyte from the REESS in the form of liquid.
3.17.
Electronic converter
means a device capable of controlling and/or converting electric power for electrical propulsion.
3.18.
Enclosure
means the part enclosing the internal units and providing protection against any direct contact.
3.19.
Explosion
means the sudden release of energy sufficient to cause pressure waves and/or projectiles that may cause structural and/or physical damage to the surrounding of the Tested-Device.

3.20.
Exposed conductive part
means the conductive part which can be touched under the provisions of the protection degree IPXXB, and which is not normally energized, but which can become electrically energized under isolation failure conditions. This includes parts under a cover that can be removed without using tools.
3.21.
External electric power supply
means an alternating current (AC) or direct current (DC) electric power supply outside of the vehicle.
3.22.
Fire
means the emission of flames from a Tested-Device. Sparks and arcing shall not be considered as flames.
3.23.
Flammable electrolyte
means an electrolyte that contains substances classified as Class 3 "flammable liquid" under "UN Recommendations on the Transport of Dangerous Goods - Model Regulations (Revision 17 from June 2011), Volume I, Chapter 2.3"
3.24.
High voltage
means the classification of an electric component or circuit, if its working voltage is > 60 V and ≤ 1,500 V DC or > 30 V and ≤ 1,000 V AC root mean square (rms).
3.25.
High voltage bus
means the electrical circuit, including the coupling system for charging the REESS, that operates on high voltage. Where electrical circuits, that are galvanically connected to each other and fulfilling the specific voltage condition, only the components or parts of the electric circuit that operate on high voltage are classified as a high voltage bus.
3.26.
Indirect contact
means the contact of persons with exposed conductive parts.
3.27.
Live parts
means conductive part(s) intended to be electrically energized under normal operating conditions.
3.28.
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 occupants from direct contact with high voltage live parts, being separated from the passenger compartment by the front bulkhead or the rear bulk head.
3.29.
Manufacturer
means the person or body who is responsible to the approval authority for all aspects of the approval process and for ensuring conformity of production. It is not essential that the person or

body is directly involved in all stages of the construction of the vehicle or component which is the subject of the approval process.

3.30.

Non-aqueous electrolyte

means an electrolyte not based on water as the solvent.

3.31.

Normal operating conditions

includes operating modes and conditions that can reasonably be encountered during typical operation of the vehicle including driving at legally posted speeds, parking and standing in traffic, as well as, charging using chargers that are compatible with the specific charging ports installed on the vehicle. It does not include, conditions where the vehicle is damaged, either by a crash, road debris or vandalization, subjected to fire or water submersion, or in a state where service and or maintenance is needed or being performed.

3.32.

On-board isolation resistance monitoring system

means the device which monitors the isolation resistance between the high voltage buses and the electrical chassis.

3.33.

Open-type traction battery

means a type of battery requiring filling with liquid and generating hydrogen gas that is released into the atmosphere.

3.34.

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 electrical protection barriers and enclosures provided for protecting the occupants from direct contact with high voltage live parts.

3.35.

Protection degree IPXXB

means protection from contact with high voltage live parts provided by either an electrical protection barrier or an enclosure and tested using a Jointed Test Finger (IPXXB) as described in clause 6.1.3.

3.36.

Protection degree IPXXD

means protection from contact with high voltage live parts provided by either an electrical protection barrier or an enclosure and tested using a Test Wire (IPXXD) as described in clause 6.1.3.

3.37.

Rechargeable Electrical Energy Storage System (REESS)

means the rechargeable electric energy storage system that provides electric energy for electrical propulsion.

A battery whose primary use is to supply power for starting the engine and/or lighting and/or other vehicle auxiliaries systems is not considered as a REESS.

The REESS may include the necessary ancillary systems for physical support, thermal management, electronic controls and casing.

3.38.
REESS subsystem
means any assembly of REESS components which stores energy. A REESS subsystem may or may not include entire management system of the REESS.
3.39.
Rupture
means opening(s) through the casing of any functional cell assembly created or enlarged by an event, large enough for a 12 mm diameter test finger (IPXXB) to penetrate and make contact with live parts (see clauses 6.1.3., 6.1.6.2.4. and 8.1.3.)
3.40.
Service disconnect
means the device for deactivation of the electrical circuit when conducting checks and services of the REESS, fuel cell stack, etc.
3.41.
Solid insulator
means the insulating coating of wiring harnesses, provided in order to cover and prevent the high voltage live parts from any direct contact.
3.42.
Specific voltage condition
means the condition that the maximum voltage of a galvanically connected electrical circuit between a DC live part and any other live part (DC or AC) is ≤ 30 V AC (rms) and ≤ 60 V DC.

Note: When a DC live part of such an electrical circuit is connected to chassis and the specific voltage condition applies, the maximum voltage between any live part and the electrical chassis is ≤ 30 V AC (rms) and ≤ 60 V DC.
3.43.
State of charge (SOC)
means the available electrical charge in a Tested-Device expressed as a percentage of its rated capacity.
3.44.
Tested-Device
means either complete REESS or REESS subsystem that is subjected to the tests prescribed by this regulation.

3.45.
Thermal event
means the condition when the temperature within the REESS is significantly higher (as defined by the manufacturer) than the maximum operating temperature.
3.46.
Thermal runaway
means an uncontrolled increase of cell temperature caused by exothermic reactions inside the cell.

3.47.
Thermal propagation
means the sequential occurrence of thermal runaway within a battery system triggered by thermal runaway of a cell in that battery system.

3.48.
Vehicle connector
means the device which is inserted into the vehicle inlet to supply electric energy to the vehicle from an external electric power supply.

3.49.
Vehicle inlet
means the device on the externally chargeable vehicle into which the vehicle connector is inserted for the purpose of transferring electric energy from an external electric power supply.

3.50.
Venting
means the release of excessive internal pressure from cell or battery in a manner intended by design to preclude rupture or explosion.

3.51.
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 condition. If the electrical circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.

3.52. Light Electric vehicles

3.52.1.
High voltage sub-systems
As the name suggests, these systems on an electric vehicle need high amounts of power to work. These include the AC/DC power charger, battery charging module, high voltage battery pack, DC-DC converters, and electric motor. All these systems make the propulsion system of a modern electric vehicle and enable your EV to move using high voltages.

3.52.2.
Low voltage sub-systems
Unlike the high power sub-system that enables your electric vehicle to move, the low voltage systems handle everything other than moving the vehicle. Therefore, everything from the wipers, doors, airbags, keyless entry, horns, and more are part of the low-voltage sub-system. These sub-systems are similar to the ones found on a conventional vehicle powered by an internal combustion engine and need a low voltage to be operated

3.53.
Light electric vehicles (LEVs)
Means e-bikes, e-rickshaws and other types of e-three-wheelers and four-wheelers with space for carry-on items such as the ones used for material handling in industrial surroundings (off-highway EVs) or for passenger transportation with any sort of baggage .

3.54.

Low power LEVs as electric vehicles

Means a vehicle with the power range from 1 kW to 10 kW and the voltage classes between 24 V and 72 V.

3.55.

High power Light electric vehicles

Means electric vehicles with power range from 10 kW to over 30 kW and voltage class between 48 V and 144 V.The category mostly covers four-wheelers with space for carry-on items such as the ones used for material handling in industrial surroundings (off-highway EVs) or for passenger transportation with any sort of baggage.

4. General requirements

4.1.Safety

These requirements shall reduce deaths and injuries during a crash, during electric shock, which occur because of electrolyte spillage from propulsion batteries, intrusion of propulsion battery system components into the occupant compartment and electric shock.

4.1.1. EV batteries used for vehicle categories specified in Ethiopian standards for conventional vehicle categories shall have higher energy density (Wh/kg).

4.1.2. Light Electric vehicles (LEVs) batteries shall deliver adequate ranges in everyday electric driving.

4.1.3. Low power LEVs Battery management, motor control and protection systems performance and safety shall be checked by the authorized body.

4.1.4. High power LEVs Battery management, motor control, Air conditioning and protection systems performance and safety shall be checked by the authorized body.

4.1.5. High power LEVs cover electric vehicles with power range from 10 kW to over 30 kW and voltage class between 48 V and 144 V.

4.1.6. The battery chargers shall be designed with the appropriate charging algorithms for the corresponding battery stacks chosen by the Light Electric Vehicle manufacturer for reducing the risk of hazardous damage or fire and the products and/ or modules of battery charger shall be checked by the authorized body.

4.1.7. Electric cars, Minibus and Bus electric power train shall comply with UNECE R100 Part1.

4.1.8. Electric cars, Minibus and Bus electric vehicle Rechargeable Electrical Energy Storage System (REESS) safety requirements shall comply with UNECE R100 Part II.

4.1.9. Two wheelers and light weight four wheelers electric power train shall comply with UNECE R136 Part 1.

4.1.10. Two wheelers and light weight four wheelers electric vehicle Rechargeable Electrical Energy Storage System (REESS) safety requirements shall comply with UNECE R136 Part II

4.2. The vehicles prescribed in clause 2.2.(a) shall meet the requirements of clause s 5.1. and 5.2. using the test conditions and procedures in clause 6.1.

4.3. The REESS for the vehicles prescribed in clause 2.2.(a), regardless of its nominal voltage or working voltage, shall meet the requirements of clause s 5.4. and 5.5. using the test conditions and procedures in clause 6.2. The REESS shall be installed on the vehicles that meet the requirement of clause 5.3.

4.4. The vehicles prescribed in clause 2.2.(b) shall meet the requirements of clauses 7.1. using the test conditions and procedures in clause 8.1.

4.5. The REESS for the vehicles prescribed in clause 2.2. (b), regardless of its nominal voltage or working voltage, shall meet the requirements of clause s 7.3. and 7.4. using the test conditions and procedures in clause 8.2. The REESS shall be installed on the vehicles that meet the requirement of clause 7.2.

4.6. Each Contracting Party under the UN 1998 Agreement may maintain its existing national crash tests (e.g. frontal, side, rear, or rollover) and shall use the provisions of clause 5.2. for compliance.

5. Performance requirements

5.1. Electric energy consumption, C

5.1.1. All cars should be equipped with the electrical car performance label.

5.1.2. The performance values shall be specified at the standard conditions and at a temperature of 45 degree Celsius for outdoor test based on a declaration and on the responsibility of the manufacturer.

5.1.3. The energy consumption C is the Energy required to travel X km in standardized conditions, shall be calculated using the formula:

$$C = \frac{E}{D}$$

Expressed in Watt-hours per kilometer (Wh/Km) . Rounded to the nearest whole number

E= energy in Wh

D= test is the distance covered during the test (Km)

C = electric energy consumption (Wh/km) shall be not more than 300 Wh/km.

5.2. Range:

5.2.1. The maximum distance an electrified vehicle can travel using battery power over a designated test sequence on a fully charged traction battery, to the end of the test sequence expressed in kilometers (km) shall be specified by the manufacturer.

5.2.2. It should be at least 150 KM for vehicles gross vehicle weight less than 3.5 tones.

5.2.3. It should be at least 300 KM for vehicles gross vehicle weight greater than 3.5 tones.

5.2.4. It shall be at least 50 KM for Light Electric vehicles (LEVs) whose vehicles gross vehicle weight less than 1.134 tones.

5.3. Requirements of a vehicle with regard to its electrical safety - in-use.

5.3.1. Protection against electric shock.

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

5.3.1.1. Protection against direct contact.

High voltage live parts shall comply with clause s 5.3.1.1.1. and 5.3.1.1.2. for protection against direct contact. Electrical protection barriers, enclosures, solid insulators and connectors shall not be opened, disassembled or removed without the use of tools.

However, connectors (including the vehicle inlet) are allowed to be separated without the use of tools, if they meet one or more of the following requirements:

a) They comply with clause s 5.3.1.1.1. and 5.3.1.1.2. when separated; or
b) They are provided with a locking mechanism (at least two distinct actions are needed to separate the connector from its mating component). Additionally, other components, not being part of the connector, shall be removable only with the use of tools in order to be able to separate the connector; or
c) The voltage of the live parts becomes equal or below 60V DC or equal or below 30V AC (rms) within 1 s after the connector is separated.

5.3.1.1.1. For high voltage live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.

5.3.1.1.2. For high voltage live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB shall be provided.

5.3.1.1.3. Service disconnect.

For a high voltage service disconnect which can be opened, disassembled or removed without tools, protection degree IPXXB shall be satisfied when it is opened, disassembled or removed without tools.

5.3.1.1.4. Marking.

5.3.1.1.4.1. The symbol shown in Figure 1 shall be present on or near the REESS having high voltage capability. The symbol background shall be yellow, the bordering and the arrow shall be black.

This requirement shall also apply to a REESS which is part of a galvanically connected electrical circuit where the specific voltage condition is not fulfilled, independent of the maximum voltage of the REESS.

Figure 1 Marking of high voltage equipment

5.3.1.1.4.2. The symbol shall be visible on enclosures and electrical protection barriers, which, when removed, expose live parts of high voltage circuits. This provision is optional to any connectors for high voltage buses. This provision shall not apply to the case where electrical protection barriers or enclosures cannot be physically accessed, opened, or removed; unless other vehicle components are removed with the use of tools.

5.3.1.1.4.3. Cables for high voltage buses which are not located within enclosures shall be identified by having an outer covering with the colour orange.

5.3.1.2. Protection against indirect contact.

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

5.3.1.2.2. The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 Ω when there is current flow of at least 0.2 A.

The resistance between any two simultaneously reachable exposed conductive parts of the electrical protection barriers that are less than 2.5 m from each other shall not exceed 0.2 Ω. This resistance may be calculated using the separately measured resistances of the relevant parts of electric path.

This requirement is satisfied if the connection has been established by welding. In case of doubts or the connection is established by other means than welding, a measurement shall be made by using one of the test procedures described in clause 6.1.4.

5.3.1.2.3. 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 conductive connection of the electrical chassis to the earth ground for the external electric power supply shall be provided.

The device shall 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, by visual inspection or drawings.

5.3.1.2.4. Isolation resistance.

This clause shall not apply to electrical circuits that are galvanically connected to each other, where the DC part of these circuits is connected to the electrical chassis and the specific voltage condition is fulfilled.

5.3.1.2.4.1. Electric power train consisting of separate Direct Current or Alternating Current buses.

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

The measurement shall be conducted according to 6.1.1.

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

If AC high voltage buses and DC high voltage buses are conductively connected, isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 Ω/V of the working voltage.

However, if all AC high voltage buses are protected by one of the two following measures, isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage:

a. At least two or more layers of solid insulators, electrical protection barriers or enclosures that meet the requirement in clause 5.3.1.1. independently, for example wiring harness, or
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 clause 6.1.1.

5.3.1.2.4.3. Fuel cell vehicles.

In fuel cell vehicles, DC high voltage buses shall have an on-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value of 100 Ω/V. The function of the on-board isolation resistance monitoring system shall be confirmed as described in clause 6.1.2.

The isolation resistance between the high voltage bus of the coupling system for charging the REESS, which is not energized in conditions other than that during the charging of the REESS, and the electrical chassis need not to be monitored.

5.3.1.2.4.4. Isolation resistance requirement for the coupling system for charging the REESS.

For the vehicle inlet intended to be conductively connected to the external AC electric power supply and the electrical circuit that is conductively connected to the vehicle inlet during charging the REESS, the isolation resistance between the high voltage bus and the electrical chassis shall comply with the requirements of clause 5.3.1.2.4.1. when the vehicle connector is disconnected and the isolation resistance is measured at the high voltage live parts (contacts) of the vehicle inlet. During the measurement, the REESS may be disconnected.

The measurement shall be conducted according to clause 6.1.1.

5.3.1.3. Protection against water effects.

The vehicles shall maintain isolation resistance after exposure to water (e.g. washing, driving through standing water). This clause shall not apply to electrical circuits that are galvanically connected to each other, where the DC part of these circuits is connected to the electrical chassis and the specific voltage condition is fulfilled.

5.3.1.3.1. The vehicle manufacturer can choose to comply with requirements specified in clause 5.3.1.3.2. or those specified in clause 5.3.1.3.3.

5.3.1.3.2. The vehicle manufacturers shall provide evidence and/or documentation to the regulatory or testing entity as applicable on how the electrical design or the components of the vehicle located outside the passenger compartment or externally attached, after water exposure remain safe and comply with the requirements described in Annex 2. If the evidence and/or documentation provided is not satisfactory the regulatory or testing entity as applicable shall require the manufacturer to perform a physical component test based on the same specifications as those described in Annex 2.

5.3.1.3.3. If the test procedures specified in clause 6.1.5. are performed, just after each exposure, and with the vehicle still wet, the vehicle shall then comply with isolation resistance test given in clause 6.1.1., and the isolation resistance requirements given in clause 5.3.1.2.4. shall be met. In addition, after a 24 hour pause, the isolation resistance test specified in clause 6.1.1. shall again be performed, and the isolation resistance requirements given in clause 5.3.1.2.4. shall be met.

5.3.1.3.4. Each Contracting Party may elect to adopt the following requirement as an alternative to the requirements in clause 5.3.1.3.1.

If an isolation resistance monitoring system is provided, and the isolation resistance less than the requirements given in clause 5.3.1.2.4. is detected, a warning shall be indicated to the driver. The function of the on-board isolation resistance monitoring system shall be confirmed as described in clause 6.1.2.

5.3.2. Functional safety.

5.3.2.1. At least a momentary indication shall be given to the driver each time when the vehicle is first placed in "active driving possible mode" after manual activation of the propulsion system.

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

5.3.2.2. 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.

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

5.3.2.4. If the REESS can be externally charged, vehicle movement by its own propulsion system shall be impossible as long as the vehicle connector is physically connected to the vehicle inlet.

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

5.4. Requirements of a vehicle with regard to its electrical safety - post-crash

5.4.1. General principle

The requirements of clause 5.4.2. shall be checked in accordance with the methods set out in clause 6.1.6.

These requirements can be met by a separate crash test from that for the evaluation of occupant protection performance under the relevant crash regulations. This is only possible, if the electrical components do not influence the occupant protection performance.

5.4.2. Protection against electric shock.

After the crash test, at least one of the four criteria specified in clause s 5.4.2.1.to 5.4.2.4. shall be met.

If the vehicle has an automatic disconnect function or device(s) that conductively divide the electric power train circuit during driving condition, at least one of the following criteria shall apply to the disconnected circuit or to each divided circuit individually after the disconnect function is activated.

However, criteria defined in clause 5.4.2.4. shall not apply if more than a single potential of a part of the high voltage bus are not protected under the conditions of protection degree IPXXB.

In the case that the crash test is performed under the condition that part(s) of the high voltage system are not energized and with the exception of any coupling system for charging the REESS which is not energized during driving condition, the protection against electric shock shall be proved by either clause 5.4.2.3. or clause 5.4.2.4. for the relevant part(s).

5.4.2.1. Absence of high voltage.

The voltages Vb, V1 and V2 of the high voltage buses shall be equal or less than 30 V AC (rms) or 60 V DC within 60 s after the impact when measured in accordance with clause 6.1.6.2.2.

5.4.2.2. Low electrical energy.

The Total Energy (TE) of unidirectional single impulse currents in the form of rectangular and sinusoidal impulses or capacitor discharges from high voltage electrical components shall be less than 0.2 J when measured and calculated in accordance with formula (a) of clause 6.1.6.2.3.

Alternatively, the TE may be calculated by the measured voltage Vb of the high voltage bus and the capacitance of the X-capacitors (Cx) specified by the manufacturer according to formula (b) of clause 6.1.6.2.3.

The energy stored in the Y-capacitors (TEy1, TEy2) shall also be less than 0.2 J. This shall be calculated by measuring the voltages V1 and V2 of the high voltage buses and the electrical chassis, and the capacitance of the Y-capacitors specified by the manufacturer according to formula (c) of clause 6.1.6.2.3.

5.4.2.3. Physical protection.

For protection against direct contact with high voltage live parts, the protection degree IPXXB shall be provided.

The assessment shall be conducted in accordance with clause 6.1.6.2.4.

In addition, for protection against electric shock which could arise from indirect contact, the resistance between all exposed conductive parts of electrical protection barriers/enclosures and electrical chassis shall be lower than 0.1 Ω and the resistance between any two simultaneously reachable exposed conductive parts of electrical protection barriers/enclosures that are less than 2.5 m from each other shall be less than 0.2 Ω when there is current flow of at least 0.2 A.

These requirements are satisfied if the connection has been established by welding. In case of doubt or the connection is established by mean other than welding, measurements shall be made by using one of the test procedures described in clause 6.1.4.

The voltage between all exposed conductive parts of electrical protection barriers/enclosures and electrical chassis and the voltage between any two simultaneously reachable exposed conductive parts of electrical protection barriers/enclosures that are less than 2.5 m from each other shall be less than or equal to 30 V AC (rms) or 60 V DC as measured in accordance with clause 6.1.6.2.4.1.

5.4.2.4. Isolation resistance.

The criteria specified in the clause s 5.5.2.4.1. and 5.5.2.4.2. below shall be met.

The measurement shall be conducted in accordance with clause 6.1.6.2.5.

5.4.2.4.1. Electrical power train consisting of separate DC- and AC-buses

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

5.4.2.4.2. Electrical power train consisting of combined DC- and AC-buses.

If the AC high voltage buses and the DC high voltage buses are conductively connected, they shall meet one of the following requirements:

a. Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 Ω/V of the working voltage;
b. Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage and the AC bus meets the physical protection as described in clause 5.4.2.3;
c. Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage and the AC bus meets the absence of high voltage as described in clause 5.4.2.1.

5.5. Requirements with regard to installation and functionality of REESS in a vehicle

5.5.1. Installation of REESS on a vehicle.

For installation of REESS on a vehicle, the requirement of either clause 5.5.1.1. or clause 5.5.1.2. shall be satisfied. In addition, the requirement of 5.5.1.3 shall be satisfied.

5.5.1.1. The REESS shall comply with the respective requirements of clause s 5.6. and 5.5., taking account of the installed conditions on a specific type of vehicle.

5.5.1.2. For a REESS which satisfies the requirements of clause s 5.6. and 5.7. independently from the type of vehicles, the REESS shall be installed on the vehicle in accordance with the instructions provided by the manufacturer of the REESS.

5.5.1.3. The components of the REESS installation shall be adequately protected by parts of the frame or bodywork against contact with possible obstacles on the ground. Such protection shall not be required if the components beneath the vehicle are further from the ground than the part of the frame or bodywork in front of them.

5.5.2. Warning in the event of operational failure of vehicle controls that manage REESS safe operation.

The vehicle shall provide a warning to the driver when the vehicle is in active driving possible mode in the event of operational failure of the vehicle controls that manage the safe operation of the REESS. Vehicle manufacturers shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle:

5.5.2.1. A system diagram that identifies all the vehicle controls that manage REESS operations. The diagram must identify what components are used to generate a warning due to operational failure of vehicle controls to conduct one or more basic operations.

5.5.2.2. A written explanation describing the basic operation of the vehicle controls that manage REESS operation. The explanation must identify the components of the vehicle control system, provide description of their functions and capability to manage the REESS, and provide a logic diagram and description of conditions that would lead to triggering of the warning.

In case of optical warning, the tell-tale shall, when illuminated, be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions.

This tell-tale shall be activated as a check of lamp function either when the propulsion system is turned to the "On" position, or when the propulsion system is in a position between "On" and "Start" that is designated by the manufacturer as a check position. This requirement does not apply to the tell-tale or text shown in a common space.

5.5.3. Warning in the case of a thermal event within the REESS.

The vehicle shall provide a warning to the driver in the case of a thermal event in the REESS (as specified by the manufacturer) when the vehicle is in active driving possible mode. Vehicle manufacturers shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle:

5.5.3.1. The parameters and associated threshold levels that are used to indicate a thermal event (e.g. temperature, temperature rise rate, SOC level, voltage drop, electrical current, etc.) to trigger the warning.

5.5.3.2. A system diagram and written explanation describing the sensors and operation of the vehicle controls to manage the REESS in the event of a thermal event.

In case of optical warning, the tell-tale shall, when illuminated, be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions.

This warning tell-tale shall be activated as a check of lamp function either when the propulsion system is turned to the "On" position, or when the propulsion system is in a position between "On" and "Start" that is designated by the manufacturer as a check position. This requirement does not apply to the optical signal or text shown in a common space.

5.5.4. Warning in the event of low energy content of REESS.

For BEVs (vehicles in which propulsion system are powered only by a REESS), a warning to the driver in the event of low REESS state of charge shall be provided. Based on engineering judgment, the manufacturer shall determine the necessary level of REESS energy remaining, when the driver warning is first provided.

In case of optical warning, the tell-tale shall, when illuminated, be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions.

5.6. Requirements with regard to the safety of REESS in-use

5.6.1. General principle.

The requirements of clause s 5.6.2. to 5.6.12. shall be checked in accordance with the methods set out in clause 6.2.

5.6.2. Vibration.

The test shall be conducted in accordance with clause 6.2.2.

During the test, there shall be no evidence of rupture (applicable to high voltage REESS only), electrolyte leakage, venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.3. Thermal shock and cycling.

The test shall be conducted in accordance with clause 6.2.3.

During the test, there shall be no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.4. Fire resistance.

The test shall be conducted in accordance with clause 6.2.4.

This test is required for REESS containing flammable electrolyte.

This test is not required when the REESS as installed in the vehicle, is mounted such that the lowest surface of the casing of the REESS is more than 1.5 m above the ground. At the choice of the manufacturer, this test may be performed where the lower surface of the REESS's is higher than 1.5 m above the ground. The test shall be carried out on one test sample.

During the test, the Tested-Device shall exhibit no evidence of explosion.

5.6.5. External short circuit protection.

The test shall be conducted in accordance with clause 6.2.5.

During the test there shall be no evidence of; electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested Device.

The short circuit protection control of the REESS shall terminate the short circuit current, or the temperature measured on the casing of the Tested-Device or the REESS shall be stabilized, such that the temperature gradient varies by less than 4 °C through 2 hours after introducing the short circuit.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.6. Overcharge protection.

The test shall be conducted in accordance with clause 6.2.6.

During the test there shall be no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.7. Over-discharge protection.

The test shall be conducted in accordance with clause 6.2.7.

During the test there shall be no evidence of; electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.8. Over-temperature protection.

The test shall be conducted in accordance with clause 6.2.8.

During the test there shall be no evidence of; electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.9. Overcurrent protection.

The test shall be conducted in accordance with clause 6.2.9.

During the test there shall be no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

The overcurrent protection control of the REESS shall terminate charging or the temperature measured on the casing of the REESS shall be stabilized, such that the temperature gradient varies by less than 4 °C through 2 hours after the maximum overcurrent charging level is reached.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 6.1.1. shall not be less than 100 Ω/V.

5.6.10. Low-temperature protection.

Vehicle manufacturers must make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentations explaining safety performance of the system level or sub-system level of the vehicle to demonstrate that the vehicle monitors and appropriately controls REESS operations at low temperatures at the safety boundary limits of the REESS:

a. A system diagram;
b. Written explanation on the lower boundary temperature for safe operation of REESS;
c. Method of detecting REESS temperature;
d. Action taken when the REESS temperature is at or lower than the lower boundary for safe operation of the REESS.

5.6.11. Management of gases emitted from REESS.

5.6.11.1. Under vehicle operation including the operation with a failure, the vehicle occupants shall not be exposed to any hazardous environment caused by emissions from REESS.

5.6.11.2. For the open-type traction battery, requirement of clause 5.6.11.1. shall be verified by following test procedure.

5.6.11.2.1. The test shall be conducted following the method described in Annex 1 of this 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.

5.6.11.2.2. During a normal charge procedure in the conditions given in Annex 1, hydrogen emissions shall be below 125 g during 5 hours, or below 25 x t2 g during t2 (in h) where t2 is the time of overcharging at constant current.

5.6.11.2.3. During a charge carried out by a charger presenting a failure (conditions given in Annex 1), hydrogen emissions shall be below 42 g. Furthermore, the charger shall limit this possible failure to 30 minu

5.6.11.2.4. For REESS other than open-type traction battery, the requirement of clause 5.6.11.1. is deemed to be satisfied, if all requirements of the following tests are met: para. 6.2.2. (vibration), para. 6.2.3. (thermal shock and cycling), para. 6.2.5. (external short circuit protection), para. 6.2.6. (overcharge protection), para. 6.2.7. (over-discharge protection), para. 6.2.8. (over-temperature protection) and para. 6.2.9. (overcurrent protection).

5.6.12. Thermal propagation.

For the vehicles equipped with a REESS containing flammable electrolyte, the vehicle occupants shall not be exposed to any hazardous environment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway. To ensure this, the requirements of clause s 5.6.12.1. and 5.6.12.2. shall be satisfied.1

5.6.12.1. The vehicle shall provide an advance warning indication to allow egress or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway such as fire, explosion or smoke. This requirement is deemed to be satisfied if the thermal propagation does not lead to a hazardous situation for the vehicle occupants. This warning shall have characteristics in accordance with clause 5.5.3.2. The vehicle manufacturer shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle:

5.6.12.1.1. The parameters (for example, temperature, voltage or electrical current) which trigger the warning indication.

5.6.12.1.2. Description of the warning system.

5.6.12.2. The vehicle shall have functions or characteristics in the cell, REESS or vehicle intended to protect vehicle occupants (as described in clause 5.6.12.) in conditions caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway. Vehicle manufacturers shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle (see also clause 196 in Part 1, section E):

5.6.12.2.1. A risk reduction analysis using appropriate industry standard methodology (for example, IEC 61508, ISO 26262, or similar), which documents the risk to vehicle occupants caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway and documents the reduction of risk resulting from implementation of the identified risk mitigation functions or characteristics.

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1 In regions applying type-approval testing the manufacturer will be accountable for the verity and integrity of documentation submitted, assuming full responsibility for the safety of occupants against adverse effects arising from thermal propagation caused by internal short circuit. In regions applying self-certification responsibility is automatically borne by the manufacturer.

5.6.12.2.2. A system diagram of all relevant physical systems and components. Relevant systems and components are those which contribute to protection of vehicle occupants from hazardous effects caused by thermal propagation triggered by a single cell thermal runaway.

5.6.12.2.3. A diagram showing the functional operation of the relevant systems and components, identifying all risk mitigation functions or characteristics.

5.6.12.2.4. For each identified risk mitigation function or characteristic:

5.6.12.2.4.1. A description of its operation strategy;

5.6.12.2.4.2. Identification of the physical system or component which implements the function;

5.6.12.2.4.3. One or more of the following engineering documents relevant to the manufacturers design which demonstrates the effectiveness of the risk mitigation function:

a. Tests performed including procedure used and conditions and resulting data;

b. Analysis or validated simulation methodology and resulting data.

5.7. Requirements with regard to the safety of REESS – post-crash

If any vehicle crash test under this regulation is conducted, the requirements of clause s 5.7.1.1. to 5.7.1.3. shall be satisfied.

These requirements can be met by a separate crash test from that for the evaluation of occupant protection performance under the relevant crash regulations. This is only possible, if the electrical components do not influence the occupant protection performance.

However, if the REESS satisfies the requirements of clause 5.7.2., the requirements of this clause are considered as satisfied for the respective direction of the crash test.

5.7.1. Vehicle based test

5.7.1.1. Electrolyte leakage.

5.7.1.1.1. In case of aqueous electrolyte REESS.

For a period from the impact until 60 minutes after the impact, there shall be no electrolyte leakage from the REESS into the passenger compartment and no more than 7 per cent by volume of the REESS electrolyte with a maximum of 5.0 l leaked from the REESS to the outside of the passenger compartment. The leaked amount of electrolyte can be measured by usual techniques of determination of liquid volumes after its collection. For containers containing Stoddard, coloured coolant and electrolyte, the fluids shall be allowed to separate by specific gravity then measured.

5.7.1.1.2. In case of non-aqueous electrolyte REESS.

For a period from the impact until 60 minutes after the impact, there shall be no liquid electrolyte leakage from the REESS into the passenger compartment, luggage compartment and no liquid electrolyte leakage to outside the vehicle. This requirement shall be verified by visual inspection without disassembling any part of the vehicle.

5.7.1.2. REESS retention.

REESS shall remain attached to the vehicle by at least one component anchorage, bracket, or any structure that transfers loads from REESS to the vehicle structure, and REESS located outside the passenger compartment shall not enter the passenger compartment.

5.7.1.3. Fire hazard.

For a period of 1 hour after the crash test, there shall be no evidence of fire or explosion of the REESS.

5.7.2. REESS-component based test.

5.7.2.1. Mechanical impact.

At the choice of the manufacturer, the REESS shall satisfy either the requirements of clause 5.7.1. or clause 5.7.2.

If the vehicle complies with the requirements of clause 5.7.1., the REESS of the vehicle is considered to be in compliance with this clause 5.7.2.1.

The approval of a REESS tested under clause 5.7.1. shall be limited to the specific vehicle type.

5.7.2.2. Mechanical shock.

The test shall be conducted in accordance with clause 6.2.10.

During the test, there shall be no evidence of electrolyte leakage, fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test.

An appropriate coating, if necessary, may be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

After the test, the Tested-Device shall be retained by its mounting and its components shall remain inside its boundaries.

For a high voltage REESS, the isolation resistance of the Tested-Device shall ensure at least 100 Ω/V for the whole REESS measured after the test in accordance with clause 6.1.1., or the protection IPXXB shall be fulfilled for the Tested-Device when assessed in accordance with clause 6.1.6.2.4.

5.7.2.3. Mechanical integrity.

The test shall be conducted in accordance with clause 6.2.11.

The REESS certified according to this clause shall be mounted in a position which is between the two planes; (a) a vertical plane perpendicular to the centre line of the vehicle located 420 mm rearward from the front edge of the vehicle, and (b) a vertical plane perpendicular to the centre line of the vehicle located 300 mm forward from the rear edge of the vehicle.

The crush force specified in clause 6.2.11.3.2.1. may be replaced with the value declared by the manufacturer, where the crush force shall be documented in the relevant administration document as a mounting restriction, which shall also be referred to in compliance assessments for the vehicle. In this case, the vehicle manufacture who uses such REESS shall demonstrate that the contact force to the REESS will not exceed the figure declared by the REESS manufacturer. Such force shall be determined by the vehicle manufacturer using test data obtained from either actual or simulated crash tests as specified in the applicable crash regulations in relevant impact directions.

Manufacturers may use forces derived from data obtained from alternative crash test procedures, but these forces shall be equal to or greater than the forces that would result from using data in accordance with the applicable crash regulations.

During the test, there shall be no evidence of electrolyte leakage, fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test.

An appropriate coating, if necessary, may be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

For a high voltage REESS, the isolation resistance of the Tested-Device shall ensure at least 100 Ω/V for the whole REESS measured in accordance with clause 6.1.1., or the protection IPXXB shall be fulfilled for the Tested-Device when assessed in accordance with clause 6.1.6.2.4.

6. Test procedures

6.1. Test procedures for electrical safety.

6.1.1. Isolation resistance measurement method.

6.1.1.1. General.

The isolation resistance for each high voltage bus of the vehicle is measured or shall be determined by calculating the measurement values of each part or component unit of a high voltage bus.

6.1.1.2. Measurement method.

The isolation resistance measurement is conducted by selecting an appropriate measurement method from among those listed in clause s 6.1.1.2.1. to 6.1.1.2.2., depending on the electrical charge of the live parts or the isolation resistance.

Megohmmeter or oscilloscope measurements are appropriate alternatives to the procedure described below for measuring isolation resistance. In this case, it may be necessary to deactivate the on-board isolation resistance monitoring system.

The range of the electrical circuit to be measured is clarified in advance, using electrical circuit diagrams. If the high voltage buses are conductively isolated from each other, isolation resistance shall be measured for each electrical circuit.

If the operating voltage of the Tested-Device (Vb, Figure 2) cannot be measured (e.g. due to disconnection of the electric circuit caused by main contactors or fuse operation), the test may be performed with a modified Test-Device to allow measurement of the internal voltages (upstream the main contactors).

Moreover, modifications 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 and change in software.

In cases where the measured values are not stable due to the operation of the on-board isolation resistance monitoring system, necessary modifications for conducting the measurement may be carried out by stopping the operation of the device concerned or by removing it. Furthermore, when the device is removed, a set of drawings will be used to prove that the isolation resistance between the live parts and the electrical chassis remains unchanged.

These modifications shall not influence the test results.

Utmost care shall be exercised to avoid short circuit and electric shock since this confirmation might require direct operations of the high-voltage circuit.

6.1.1.2.1. Measurement method using DC voltage from external sources.

6.1.1.2.1.1. 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.

6.1.1.2.1.2. **Measurement method.**

An isolation resistance test instrument is connected between the live parts and the electrical chassis. The isolation resistance is subsequently 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 conductively 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 components disconnected.

6.1.1.2.2. Measurement method using the vehicle's own REESS as DC voltage source.

6.1.1.2.2.1. Test vehicle conditions.

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

6.1.1.2.2.2. Measurement instrument.

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

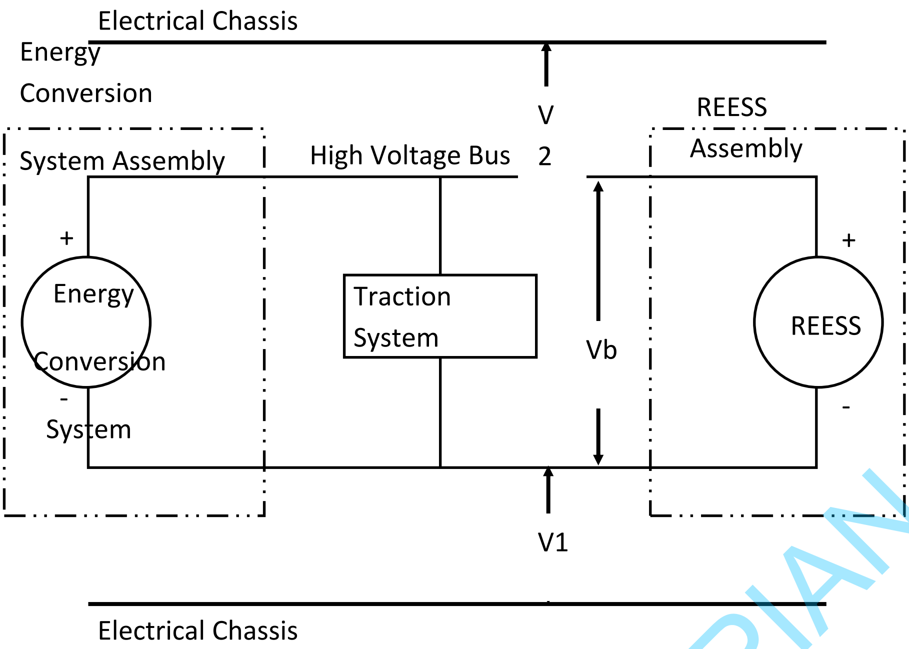
6.1.1.2.2.3. Measurement method.

6.1.1.2.2.3.1. First step.

The voltage is measured as shown in Figure 2 and the high voltage bus voltage (Vb) is recorded. Vb shall be equal to or greater than the nominal operating voltage of the REESS and/or energy conversion system as specified by the vehicle manufacturer.

Figure 2

Measurement of Vb, V1, V2



6.1.1.2.2.3.2. Second step.

The voltage (V1) between the negative side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 2).

6.1.1.2.2.3.3. Third step.

The voltage (V2) between the positive side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 2).

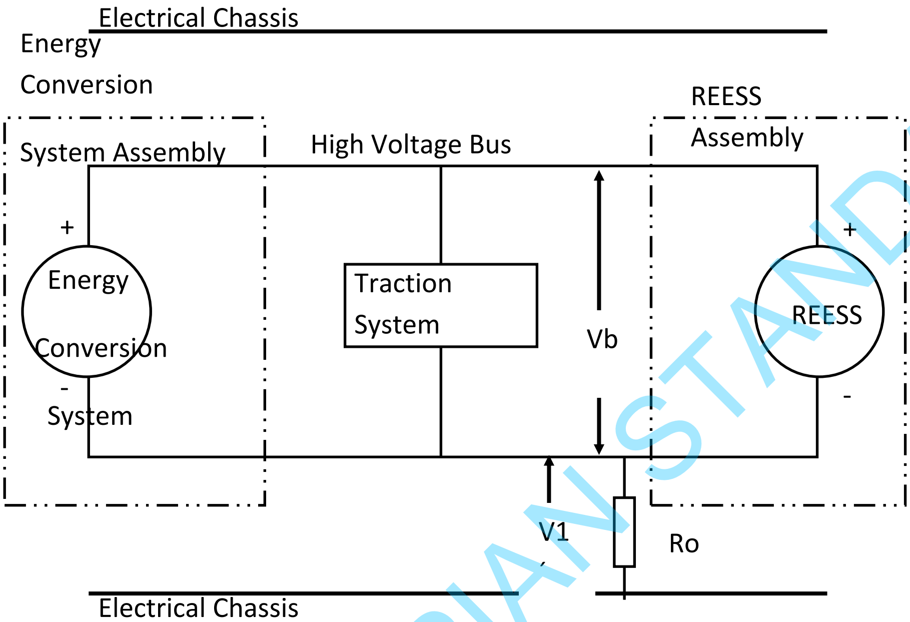
6.1.1.2.2.3.4. Fourth step.

If V1 is greater than or equal to V2, a standard known resistance (Ro) is inserted between the negative side of the high voltage bus and the electrical chassis. With Ro installed, the voltage (V1') between the negative side of the high voltage bus and the electrical chassis is measured (see Figure 3).

The electrical isolation (Ri) is calculated according to the following formula:

Ri = Ro*(Vb/V1' – Vb/V1) or Ri = Ro*Vb*(1/V1' – 1/V1)

Figure 3



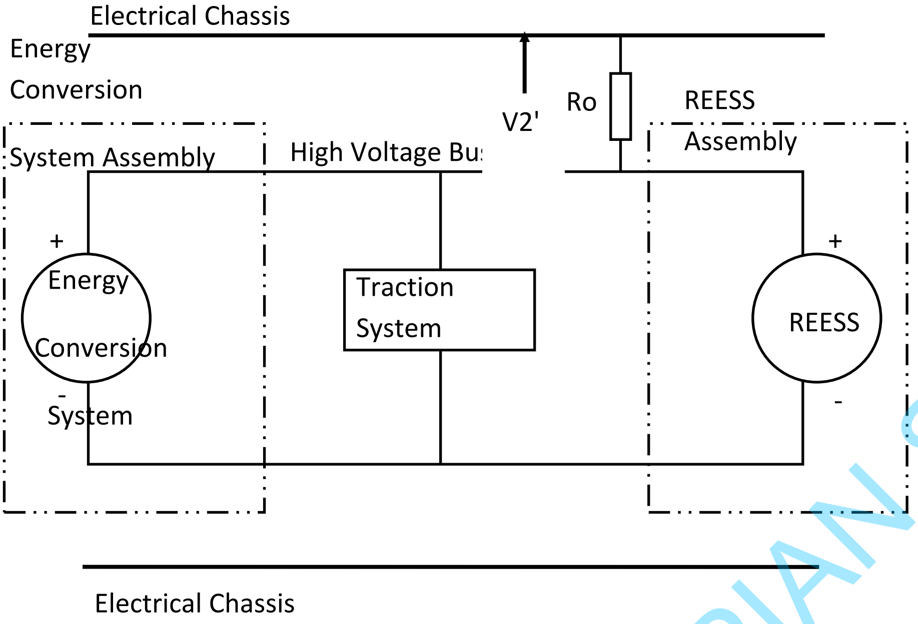
Measurement of V1'

If V2 is greater than V1, a standard known resistance (Ro) is inserted between the positive side of the high voltage bus and the electrical chassis. With Ro installed, the voltage (V2') between the positive side of the high voltage bus and the electrical chassis is measured. (See Figure 4). The electrical isolation (Ri) is calculated according to the formula shown below. This electrical isolation value (in Ω) is divided by the nominal operating voltage of the high voltage bus (in V). The electrical isolation (Ri) is calculated according to the following formula:

Ri = Ro*(Vb/V2' – Vb/V2) or Ri = Ro*Vb*(1/V2' – 1/V2)

Figure 4

Measurement of V2'



6.1.1.2.2.3.5. Fifth step.

The electrical isolation value Ri (in Ω) divided by the working voltage of the high voltage bus (in V) results in the isolation resistance (in Ω/V).

(Note 1: The standard known resistance Ro (in Ω) is the value of the minimum required isolation resistance (in Ω/V) multiplied by the working voltage of the vehicle plus/minus 20 per cent (in V). Ro is not required to be precisely this value since the equations are valid for any Ro; however, a Ro value in this range should provide good resolution for the voltage measurements.)

6.1.2. Confirmation method for functions of on-board isolation resistance monitoring system.

The on-board isolation resistance monitoring system specified in clause 5.3.1.2.4.3. for fuel cell vehicles and that specified in clause 5.3.1.3.4 for protection against water effects shall be tested using the following procedure.

a. Determine the isolation resistance, Ri, of the electric power train with the electrical isolation monitoring system using the procedure outlined clause 6.1.1.
b. If the minimum isolation resistance value required in accordance with clause s 5.3.1.2.4.1. or 5.3.1.2.4.2. is 100 Ω/V, insert a resistor with resistance Ro between the positive terminal of the electric power train and the electrical chassis. The magnitude of the resistor, Ro, shall be such that:

1/(1/(95xV) – 1/Ri) ≤ Ro < 1/(1/(100xV) – 1/Ri)

where V is the working voltage of the electric power train.

c. If the minimum isolation resistance value required in accordance with clause s 5.3.1.2.4.1. or 5.3.1.2.4.2. is 500 Ω/V, insert a resistor with resistance Ro between the positive terminal of the electric power train and the electrical chassis. The magnitude of the resistor, Ro, shall be such that:

1/(1/(475xV) – 1/Ri) ≤ Ro < 1/(1/(500xV) – 1/Ri)

where V is the working voltage of the electric power train.

6.1.3. Protection against direct contact to live parts.

6.1.3.1. Access probes.

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

6.1.3.2. 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 electrical protection barriers are considered part of the enclosure.

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

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

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

6.1.3.3. Acceptance conditions.

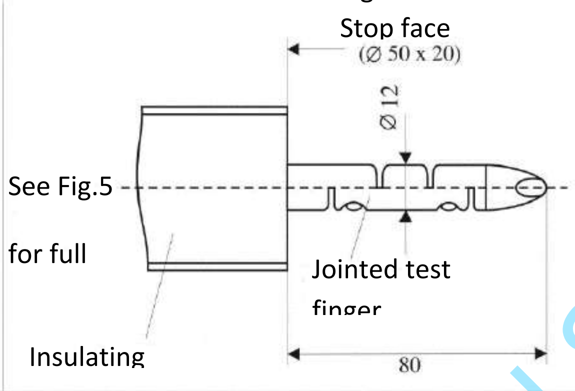
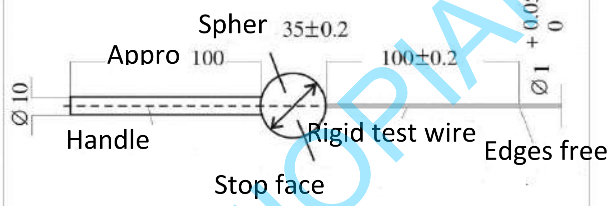
The access probe shall not touch live parts.

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 protection degree 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 are successively bent through an angle of up to 90 degree with respect to the axis of the adjoining section of the finger and are placed in every possible position.

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

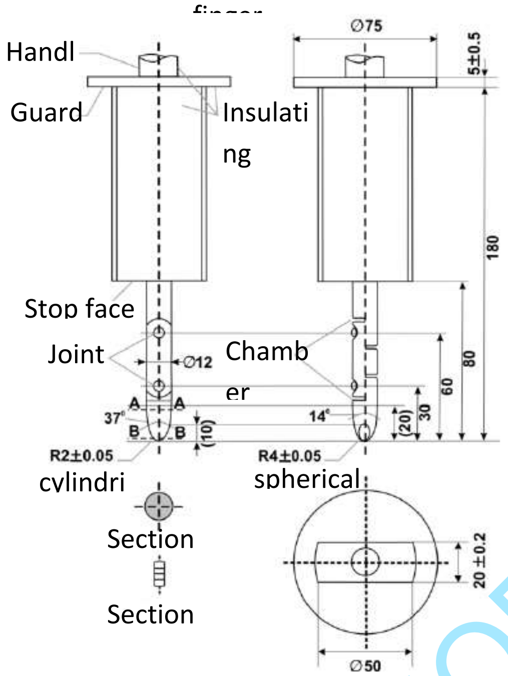
Table 1

<table>
<tr><th>First</th><th>Addit.</th><th>Access probe</th><th>Test force</th></tr>
<tr><td>2</td><td>B</td><td>Jointed test finger

</td><td>10 N±10%</td></tr>
<tr><td>4, 5, 6</td><td>D</td><td>Test wire 1.0 mm diameter, 100

</td><td>1N±10%</td></tr>
</table>

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

Figure 5

Access probe	
IPXXB	Jointed text finger



Jointed Test Finger

Material: metal, except where otherwise specified

Linear dimensions in mm.

Tolerances on dimensions without specific tolerance:

a. on angles: 0/10 seconds;
b. on linear dimensions:
   i. up to 25 mm: 0/-0.05;
   ii. over 25 mm: ±0.2.

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

6.1.4. Test method for measuring electric resistance:

a. Test method using a resistance tester.

The resistance tester is connected to the measuring points (typically, electrical chassis and electro conductive enclosure/electrical protection barrier) and the resistance is measured using a resistance tester that meets the specification that follows:

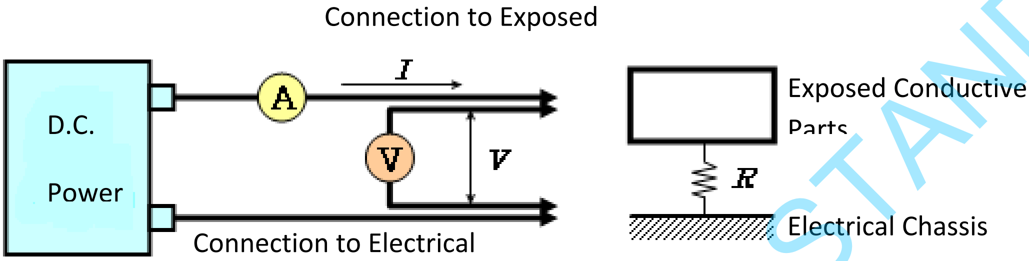
i. Resistance tester: Measurement current at least 0.2 A;
ii. Resolution: 0.01 Ω or less;

iii. The resistance R shall be less than 0.1 Ω.

b. Test method using DC power supply, voltmeter and ammeter.

Example of the test method using DC power supply, voltmeter and ammeter is shown below.

Figure 6



Example of test method using DC power supply

6.1.4.1. Test Procedure.

The DC power supply, voltmeter and ammeter are connected to the measuring points (Typically, electrical chassis and electro conductive enclosure/electrical protection barrier).

The voltage of the DC power supply is adjusted so that the current flow becomes at least 0.2 A.

The current "I" and the voltage "V" are measured.

The resistance "R" is calculated according to the following formula:

$$R = V / I$$

The resistance R shall be less than 0.1 Ω.

Note: If lead wires are used for voltage and current measurement, each lead wire shall be independently connected to the electrical protection barrier/enclosure/electrical chassis. Terminal can be common for voltage measurement and current measurement.

6.1.5. Test procedure for Protection against water effects.

6.1.5.1. Washing.

This test is intended to simulate the normal washing of vehicles, but not specific cleaning using high water pressure or underbody washing.

The areas of the vehicle regarding this test are border lines, i.e. a seal of two parts such as flaps, glass seals, outline of opening parts, outline of front grille and seals of lamps.

All border lines shall be exposed and followed in all directions with the water stream using a hose nozzle and conditions in accordance with IPX5 as specified in Annex 2.

6.1.5.2. Driving through standing water.

The vehicle shall be driven in a wade pool, with 10 cm water depth, over a distance of 500 m at a speed of 20 km/h, in a time of approximately 1.5 min. If the wade pool used is less than 500 m in length, then the vehicle shall be driven through it several times. The total time, including the periods outside the wade pool, shall be less than 10 min.

6.1.6. Test conditions and test procedure regarding post-crash.

6.1.6.1. Test conditions.

6.1.6.1.1. General.

The test conditions specified in clause s 6.1.6.1.2. to 6.1.6.1.4. are used.

6.1.6.1.2. Electric power train adjustment.

6.1.6.1.2.1. The SOC of the REESS shall be adjusted in accordance with the clause 6.2.1.2.

6.1.6.1.2.2. The electric power train shall be energized with or without the operation of the original electrical energy sources (e.g. engine-generator, REESS or electric energy conversion system), however:

6.1.6.1.2.2.1. It is permissible to perform the test with all or parts of the electric power train not being energized insofar as there is no negative influence on the test result. For parts of the electric power train not energized, the protection against electric shock shall be proved by either physical protection or isolation resistance and appropriate additional evidence.

6.1.6.1.2.2.2. If the electric power train is not energized and an automatic disconnect is provided, it is permissible to perform the test with the automatic disconnect being triggered. In this case it shall be demonstrated that the automatic disconnect would have operated during the impact test. This includes the automatic activation signal as well as the conductive separation considering the conditions as seen during the impact.

6.1.6.1.3. Contracting Parties may allow modifications to the fuel system so that an appropriate amount of fuel can be used to run the engine or the electric energy conversion system.

6.1.6.1.4. The vehicle conditions other than specified in clause s 6.1.6.1.1. to 6.1.6.1.3. are in accordance with the crash test protocols of the Contracting Parties.

6.1.6.2. Test procedures for the protection of the occupants from high voltage and electrolyte leakage.

This section describes test procedures to demonstrate compliance with the electrical safety requirements of clause s 5.4.2. and 5.7.1.

Before the vehicle impact test conducted, the high voltage bus voltage (Vb) (see Figure 7) is measured and recorded to confirm that it is within the operating voltage of the vehicle as specified by the vehicle manufacturer.

6.1.6.2.1. Test set-up 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 REESS or the electric energy conversion system and the high-voltage bus of the REESS or the electric energy conversion system is protected according to protection degree IPXXB following the impact test, measurements may only be taken between the device performing the disconnect function and electrical loads.

The voltmeter used in this test measures DC values and have an internal resistance of at least 10 MΩ.

6.1.6.2.2. Voltage measurement.

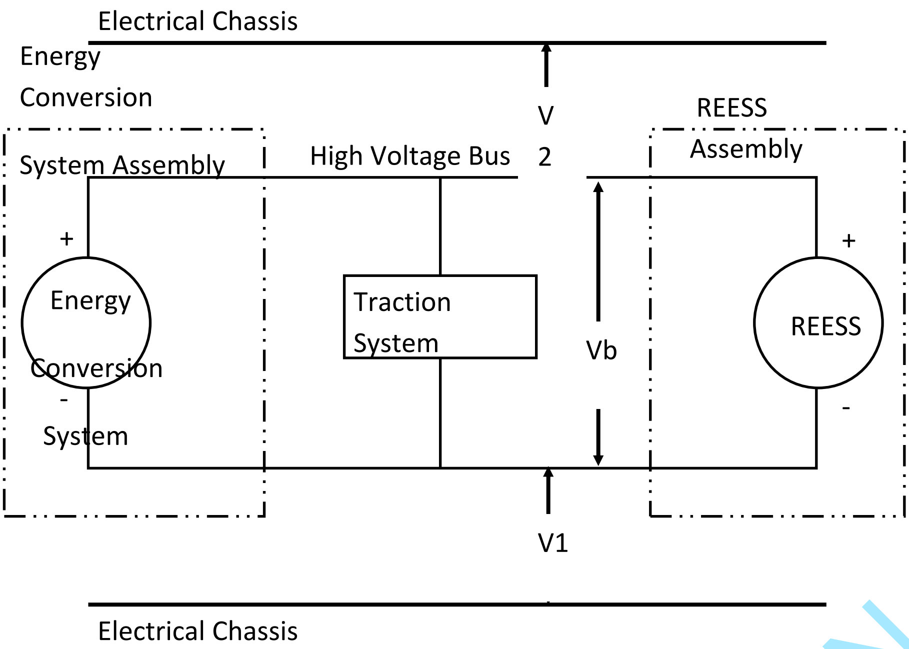
After the impact test, determine the high voltage bus voltages (Vb, V1, V2) (see Figure 7).

The voltage measurement is made no earlier than 10 s, but not later than 60 s after the impact.

This procedure is not applicable if the test is performed under the condition where the electric power train is not energized.

Figure 7

Measurement of Vb, V1, V2



6.1.6.2.3. Assessment procedure for low electrical energy.

Prior to the impact a switch S1 and a known discharge resistor Re is connected in parallel to the relevant capacitance (Figure 8).

a) Not earlier than 10 s and not later than 60 s after the impact the switch S1 shall be closed while the voltage Vb and the current Ie are measured and recorded. The product of the voltage Vb and the current Ie shall be integrated over the period of time, starting from the moment when the switch S1 is closed (tc) until the voltage Vb

$$TE = \int_{tc}^{th} V_b \times I_e dt$$

falls to zero (th). The resulting integration equals the total energy (TE) in J.

b) When Vb is measured at a point in time between 10 s and 60 s after the impact and the capacitance of the X-capacitors (Cx) is specified by the manufacturer, total energy (TE) shall be calculated according to the following formula:

TE = 0.5 x Cx x Vb2

c) When V1 and V2 (see Figure 8) are measured at a point in time between 10 s and 60 s after the impact and the capacitances of the Y-capacitors (Cy1, Cy2) are specified by the manufacturer, total energy (TEy1, TEy2) shall be calculated according to the following formulas:

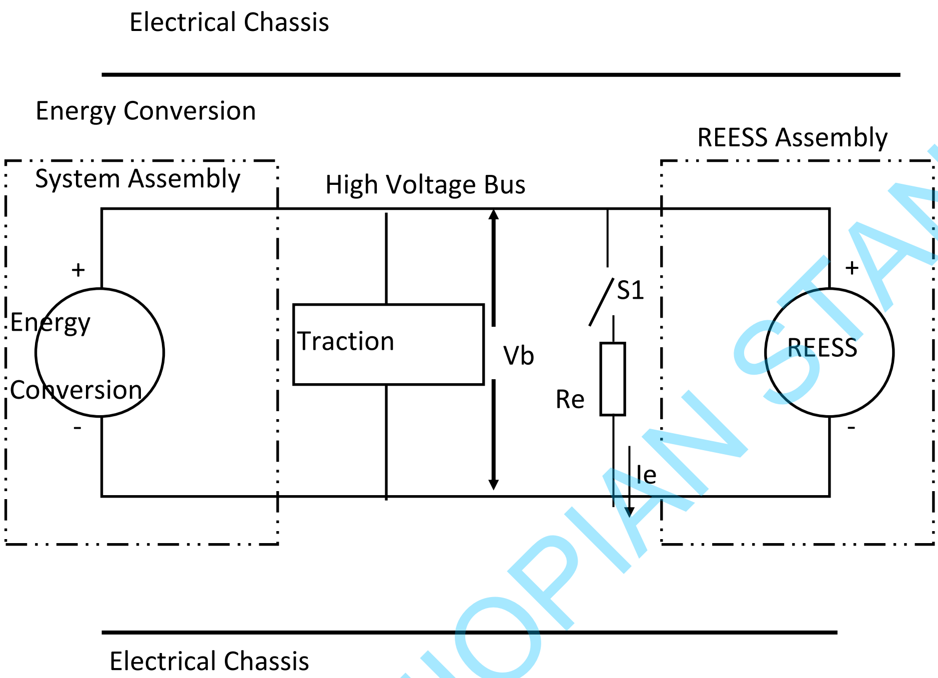
TEy1 = 0.5 x Cy1 x V12

TEy2 = 0.5 x Cy2 x V22

This procedure is not applicable if the test is performed under the condition where the electric power train is not energized.

Figure 8

Example of measurement of high voltage bus energy stored in X-capacitors



6.1.6.2.4. Physical protection.

Following the vehicle crash test, any parts surrounding the high voltage components shall be opened, disassembled or removed to the extent possible without the use of tools. All remaining surrounding parts are considered as the physical protection.

The Jointed Test Finger described in clause 6.1.3. is inserted into any gaps or openings of the physical protection with a test force of 10 N ± 10 per cent for electrical safety assessment. If partial or full penetration into the physical protection by the Jointed Test Finger occurs, the Jointed Test Finger shall be placed in every position as specified below.

Starting from the straight position, both joints of the test finger are rotated progressively through an angle of up to 90° with respect to the axis of the adjoining section of the finger and are placed in every possible position.

Internal electrical protection barriers are considered part of the enclosure.

If appropriate, a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp is connected between the Jointed Test Finger and high voltage live parts inside the electrical protection barrier or enclosure.

The requirements of clause 5.4.2.3. are met if the Jointed Test Finger described in clause 6.1.3. is unable to contact high voltage live parts.

If necessary a mirror or a fiberscope may be used in order to inspect whether the Jointed Test Finger touches the high voltage buses.

If this requirement is verified by a signal circuit between the Jointed Test Finger and high voltage live parts, the lamp shall not light.

6.1.6.2.4.1. Voltage between exposed conductive barriers.

The voltage difference between exposed conductive parts of electrical protection barriers and the electrical chassis shall be measured. The voltage difference between two simultaneously reachable exposed conductive parts of electrical protection barriers/enclosures shall be measured or calculated using other measured voltages.

6.1.6.2.5. Isolation resistance.

The measurement shall be conducted according to clause 6.1.1. with the following precaution.

All measurements for calculating voltage(s) and electrical isolation are made after a minimum of 10 s after the impact.

6.1.6.2.6. Electrolyte leakage.

An appropriate coating, if necessary, may be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

6.2. Test procedures for REESS.

6.2.1. General procedures.

6.2.1.1. Procedure for conducting a standard cycle.

Procedure for conducting a standard cycle for a complete REESS, REESS subsystem(s), or complete vehicle.

A standard cycle shall start with a standard discharge and is followed by a standard charge. The standard cycle shall be conducted at an ambient temperature of 20 ± 10 °C.

Standard discharge:

Discharge rate: The discharge procedure including termination criteria shall be defined by the manufacturer. If not specified, then it shall be a discharge with 1C current for a complete REESS and REESS subsystems.

Discharge limit (end voltage): Specified by the manufacturer.

For a complete vehicle, discharge procedure using a dynamometer shall be defined by the manufacturer. Discharge termination will be according to vehicle controls.

Rest period after discharge: minimum 15 min

Standard charge:

The charge procedure shall be defined by the manufacturer. If not specified, then it shall be a charge with C/3 current. Charging is continued until normally terminated. Charge termination shall be according to clause 6.2.1.2.2. for REESS or REESS subsystem.

For a complete vehicle that can be charged by an external source, charge procedure using an external electric power supply shall be defined by the manufacturer. For a complete vehicle that can be charged by on-board energy sources, a charge procedure using a dynamometer shall be defined by the manufacturer. Charge termination will be according to vehicle controls.

6.2.1.2. Procedures for SOC adjustment.

6.2.1.2.1. The adjustment of SOC shall be conducted at an ambient temperature of 20 ± 10 °C for vehicle-based tests and 22 ± 5 °C for component-based tests.

6.2.1.2.2. The SOC of the Tested-Device shall be adjusted according to one of the following procedures as applicable. Where different charging procedures are possible, the REESS shall be charged using the procedure which yields the highest SOC:

a. For a vehicle with a REESS designed to be externally charged, the REESS shall be charged to the highest SOC in accordance with the procedure specified by the manufacturer for normal operation until the charging process is normally terminated.

b. For a vehicle with a REESS designed to be charged only by an energy source on the vehicle, the REESS shall be charged to the highest SOC which is achievable with normal operation of the vehicle. The manufacturer shall advise on the vehicle operation mode to achieve this SOC.

c. In case that the REESS or REESS sub-system is used as the Tested-Device, the Tested-Device shall be charged to the highest SOC in accordance with the procedure specified by the manufacturer for normal use operation until the charging process is normally terminated. Procedures specified by the manufacturer for manufacturing, service or maintenance may be considered as appropriate if they achieve an equivalent SOC as for that under normal operating conditions. In case the Tested-Device does not control SOC by itself, the SOC shall be charged to not less than 95 per cent of the maximum normal operating SOC defined by the manufacturer for the specific configuration of the Tested-Device.

6.2.1.2.3. When the vehicle or REESS subsystem is tested, the SOC shall be no less than 95 per cent of the SOC according to clause s 6.2.1.2.1. and 6.2.1.2.2. for REESS designed to be externally charged and shall be no less than 90 per cent of SOC according to clause s 6.2.1.2.1. and 6.2.1.2.2. for REESS designed to be charged only by an energy source on the vehicle. The SOC will be confirmed by a method provided by the manufacturer.

6.2.2. Vibration test.

6.2.2.1. Purpose.

The purpose of this test is to verify the safety performance of the REESS under a vibration environment which the REESS will likely experience during the normal operation of the vehicle.

6.2.2.2. Installations.

6.2.2.2.1. This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management control unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

6.2.2.2.2. The Tested-Device shall be firmly secured to the platform of the vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the Tested-Device.

The Test-Device should be mounted with its original mounting points and holders as mounted in the vehicle. The holders should be firmly secured to the platform of the vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the holders of the Tested-Device.

6.2.2.3. Procedures.

6.2.2.3.1. General test conditions.

The following conditions shall apply to the Tested-Device:

a. The test shall be conducted at an ambient temperature of 22 ± 5 °C;
b. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 6.2.1.2.;
c. At the beginning of the test, all protection devices which affect the function(s) of the Tested-Device that are relevant to the outcome of the test shall be operational.

6.2.2.3.2. Test procedures.

The Tested-Device shall be subjected to a vibration having a sinusoidal waveform with a logarithmic sweep between 7 Hz and 50 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours in the vertical direction of the mounting orientation of the REESS as specified by the manufacturer.

The correlation between frequency and acceleration shall be as shown in Table 2:

Table 2

Frequency and acceleration

Frequency (Hz)	Acceleration (m/s2)
7 - 18	10
18 - 30	gradually reduced from 10 to 2
30 - 50	2

At the request of the manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

At the choice of the manufacturer, a vibration test profile determined by the vehicle manufacturer verified for the vehicle application may be used as a substitute for the frequency - acceleration correlation of Table 2. The REESS certified according to this condition shall be limited to the installation for a specific vehicle type.

After the vibration profile, a standard cycle as described in clause 6.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

6.2.3. Thermal shock and cycling test.

6.2.3.1. Purpose.

The purpose of this test is to verify the resistance of the REESS to sudden changes in temperature. The REESS shall undergo a specified number of temperature cycles, which start at ambient temperature followed by high and low temperature cycling. It simulates a rapid environmental temperature change which a REESS would likely experience during its life.

6.2.3.2. Installations.

This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

6.2.3.3. Procedures.

6.2.3.3.1. General test conditions.

The following conditions shall apply to the Tested-Device at the start of the test:

a. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 6.2.1.2.;
b. All protection devices, which would affect the function of the Tested-Device and which are relevant to the outcome of the test shall be operational.

6.2.3.3.2. Test procedure.

The Tested-Device shall be stored for at least 6 hours at a test temperature equal to 60 ± 2 °C or higher if requested by the manufacturer, followed by storage for at least 6 hours at a test temperature equal to -40 ± 2 °C or lower if requested by the manufacturer. The maximum time interval between test temperature extremes shall be 30 minutes. This procedure shall be repeated until a minimum of 5 total cycles are completed, after which the Tested-Device shall be stored for 24 hours at an ambient temperature of 22 ± 5 °C.

After the storage for 24 hours, a standard cycle as described in clause 6.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

6.2.4. Fire resistance test.

6.2.4.1. Purpose.

The purpose of this test is to verify the resistance of the REESS, against exposure to fire from outside of the vehicle due to e.g. a fuel spill from a vehicle (either the vehicle itself or a nearby vehicle). This situation should leave the driver and passengers with enough time to evacuate.

6.2.4.2. Installations.

6.2.4.2.1. This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer. Where the relevant REESS subsystems are distributed throughout the vehicle, the test may be conducted on each relevant REESS subsystem.

6.2.4.3. Procedures.

6.2.4.3.1. General test conditions.

The following requirements and conditions shall apply to the test:

a. The test shall be conducted at a temperature of at least 0 °C;
b. At the beginning of the test, the SOC shall be adjusted according to clause 6.2.1.2.;
c. At the beginning of the test, all protection devices which affect the function of the Tested-Device and are relevant for the outcome of the test shall be operational.

6.2.4.3.2. Test procedure.

A vehicle based test or a component based test shall be performed at the discretion of the manufacturer.

6.2.4.3.2.1. Vehicle based test (according to test procedure described in clause 6.2.4.3.3.).

The Tested-Device shall be mounted in a testing fixture simulating actual mounting conditions as far as possible; no combustible material should be used for this with the exception of material that is part of the REESS. The method whereby the Tested-Device is fixed in the fixture shall correspond to the relevant specifications for its installation in a vehicle. In the case of a REESS designed for a specific vehicle use, vehicle parts which affect the course of the fire in any way shall be taken into consideration.

6.2.4.3.2.2. Component based test (according to test procedure described in clause 6.2.4.3.3. (Gasoline pool fire) or clause 6.2.4.3.4. (LPG burner)).

In case of component based test, the manufacturer may choose either Gasoline pool fire test or LPG burner test.

6.2.4.3.3. Gasoline pool fire test set up for both vehicle-based and component-based test.

The Tested-Device shall be placed on a grating table positioned above the fire source, in an orientation according to the manufacturer's design intent.

The grating table shall be constructed by steel rods, diameter 6-10 mm, with 4-6 cm in between. If needed the steel rods could be supported by flat steel parts.

The flame to which the Tested-Device is exposed shall be obtained by burning commercial fuel for positive-ignition engines (hereafter called "fuel") in a pan. The quantity of fuel shall be sufficient to permit the flame, under free-burning conditions, to burn for the whole test procedure.

The fire shall cover the whole area of the pan during whole fire exposure. The pan dimensions shall be chosen so as to ensure that the sides of the Tested-Device are exposed to the flame. The pan shall therefore exceed the horizontal projection of the Tested-Device by at least 20 cm, but not more than 50 cm. The sidewalls of the pan shall not project more than 8 cm above the level of the fuel at the start of the test.

6.2.4.3.3.1. The pan filled with fuel shall be placed under the Tested-Device in such a way that the distance between the level of the fuel in the pan and the bottom of the Tested-Device corresponds to the design height of the Tested-Device above the road surface at the unladed mass if clause 6.2.4.3.2.1. is applied or approximately 50 cm if clause 6.2.4.3.2.2. is applied. Either the pan, or the testing fixture, or both, shall be freely movable.

6.2.4.3.3.2. During phase C of the test, the pan shall be covered by a screen. The screen shall be placed 3 cm +/- 1 cm above the fuel level measured prior to the ignition of the fuel. The screen shall be made of a refractory material, as prescribed in Figure 13. There shall be no gap between the bricks and they shall be supported over the fuel pan in such a manner that the holes in the bricks are not obstructed. The length and width of the frame shall be 2 cm to 4 cm smaller than the interior dimensions of the pan so that a gap of 1 cm to 2 cm exists between the frame and the wall of the pan to allow ventilation. Before the test the screen shall be at least at the ambient temperature. The firebricks may be wetted in order to guarantee repeatable test conditions.

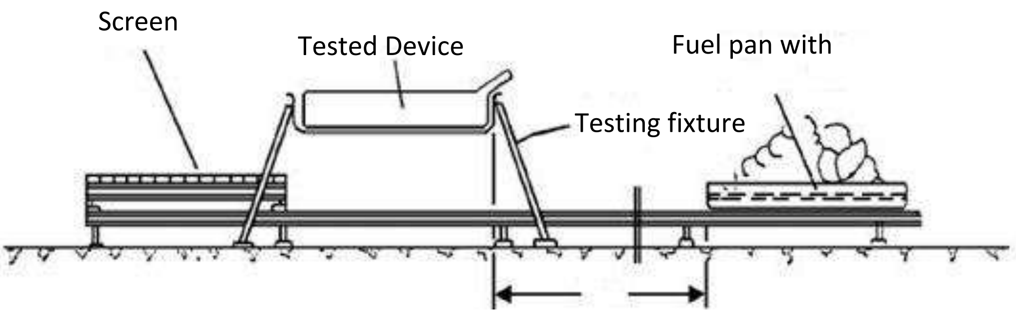
6.2.4.3.3.3. If the tests are carried out in the open air, sufficient wind protection shall be provided and the wind velocity at pan level shall not exceed 2.5 km/h.

6.2.4.3.3.4. The test shall comprise three phases B-D, if the fuel is at a temperature of at least 20 °C. Otherwise, the test shall comprise four phases A-D.

6.2.4.3.3.4.1. Phase A: Pre-heating (Figure 9).

The fuel in the pan shall be ignited at a distance of at least 3 m from the Tested-Device. After 60 seconds pre-heating, the pan shall be placed under the Tested-Device. If the size of the pan is too large to be moved without risking liquid spills etc. then the Tested-Device and test rig can be moved over the pan instead.

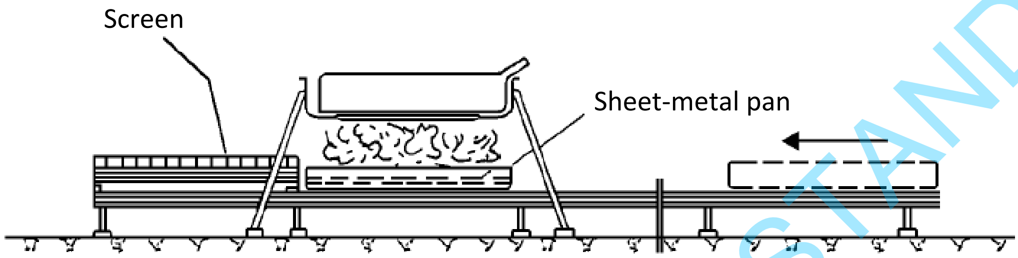
Figure 9- Phase A: Pre-heating



6.2.4.3.3.4.2. Phase B: Direct exposure to flame (Figure 10)

The Tested-Device shall be exposed to the flame from the freely burning fuel for 70 seconds.

Figure 10- Phase B: Direct exposure to flame

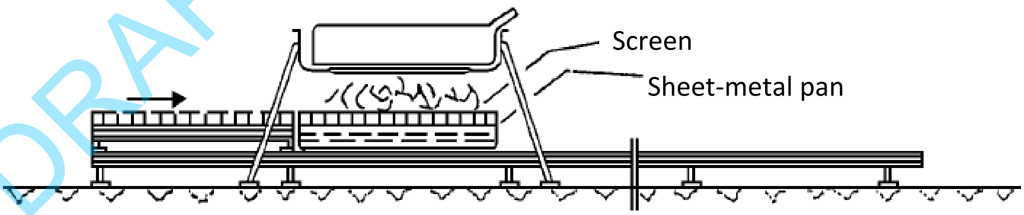


6.2.4.3.3.4.3. Phase C: Indirect exposure to flame (Figure 11).

As soon as phase B has been completed, the screen shall be placed between the burning pan and the Tested-Device. The Tested-Device shall be exposed to this reduced flame for a further 60 seconds.

As a compliance alternative to conducting Phase C of the test, Phase B may, at the choice of the manufacturer, be continued for an additional 60 seconds.

Figure 11- Phase C: Indirect exposure to flame



6.2.4.3.3.4.4. Phase D: End of test (Figure 12).

The burning pan covered with the screen shall be moved back to the position described in phase A. No extinguishing of the Tested-Device shall be done. After removal of the pan, the Tested-Device shall be observed until such time as the surface temperature of the Tested-Device has decreased to ambient temperature or has been decreasing for a minimum of 3 hours.

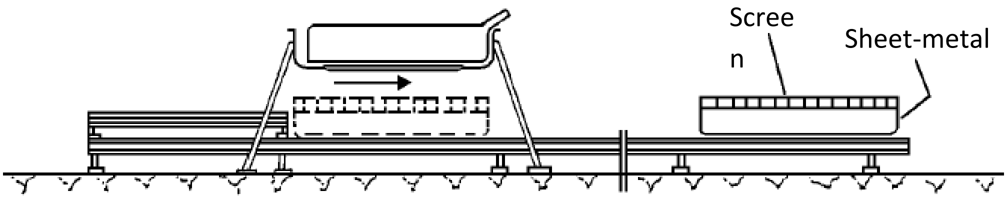
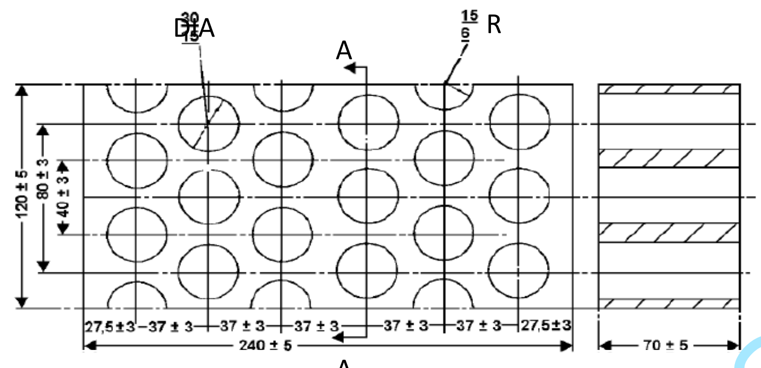


Figure 12- Phase D: End of test

Figure 13- Dimension of Firebricks



(Dimensions

Section A-A

Fire resistance	(Seger-Kegel) SK 30
Al2O3 content	30 - 33 per cent
Open porosity (Po)	20 - 22 per cent vol.
Density	1,900 - 2,000 kg/m3
Effective holed area	44.18 per cent

6.2.4.3.4. LPG burner fire test set up for component based test.

6.2.4.3.4.1. The Tested-Device shall be placed on a test equipment, in the position that the manufacturer's design intends.

6.2.4.3.4.2. LPG burner shall be used to produce flame to which the Tested-Device is exposed. The height of the flame shall be about 60 cm or more, without the Tested-Device.

6.2.4.3.4.3. The flame temperature shall be measured continuously by temperature sensors. An average temperature shall be calculated, at least every second for the duration of the whole fire exposure, as the arithmetic average of temperatures measured by all temperature sensors fulfilling the location requirements described in clause 6.2.4.3.4.4.

6.2.4.3.4.4. All temperature sensors shall be installed at a height of 5 ± 1 cm below the lowest point of the Tested-Device's external surface when oriented as described in clause 6.2.4.3.4.1. At least one temperature sensor shall be located at the centre of Tested-Device, and at least four temperature sensors shall be located within 10 cm from the edge of the Tested-Device towards its centre with nearly equal distance between the sensors.

6.2.4.3.4.5. The bottom of Tested-Device shall be exposed to the even flame directly and entirely by fuel combustion. LPG burner flame shall exceed the horizontal projection of the Tested-Device by at least 20 cm.

6.2.4.3.4.6. The Tested-Device shall be exposed to flame for 2 minutes after the averaged temperature reaches 800 °C within 30 seconds. The averaged temperature shall be maintained at 800-1,100 °C for 2 minutes.

6.2.4.3.4.7. After direct exposure to flame the Tested-Device shall be observed until such time as the surface temperature of the Tested-Device has decreased to ambient temperature or has been decreasing for a minimum of 3 hours.

6.2.5. External short circuit protection.

6.2.5.1. Purpose.

The purpose of this test is to verify the performance of the short circuit protection to prevent the REESS from any further related severe events caused by short circuit current.

6.2.5.2. Installations.

This test shall be conducted either with a complete vehicle or with the complete REESS or with the REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the Tested-Device shall be able to deliver the nominal voltage of the complete REESS and the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device at the request of the manufacturer.

For a test with a complete vehicle, the manufacturer may provide information to connect a breakout harness to a location just outside the REESS that would permit applying a short circuit to the REESS.

6.2.5.3. Procedures.

6.2.5.3.1. General test conditions.

The following condition shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C or at a higher temperature if requested by the manufacturer;
b. At the beginning of the test, the SOC shall be adjusted according to clause 6.2.1.2.;
c. For testing with a complete REESS or REESS subsystem(s), at the beginning of the test, all protection devices which would affect the function of the

Tested-Device and which are relevant to the outcome of the test shall be operational;

d. For testing with a complete vehicle, a breakout harness is connected to the manufacturer specified location and vehicle protections systems relevant to the outcome of the test shall be operational.

6.2.5.3.2. Short circuit.

At the start of the test all, relevant main contactors for charging and discharging shall be closed to represent the active driving possible mode as well as the mode to enable external charging. If this cannot be completed in a single test, then two or more tests shall be conducted.

For testing with a complete REESS or REESS subsystem(s), the positive and negative terminals of the Tested-Device shall be connected to each other to produce a short circuit. The connection used for creating the short circuit (including the cabling) shall have a resistance not exceeding 5 mΩ.

For testing with a complete vehicle, the short circuit is applied through the breakout harness. The connection used for creating the short circuit (including the cabling) shall have a resistance not exceeding 5 mΩ.

The short circuit condition shall be continued until the protection function operation of the REESS terminates the short circuit current, or for at least 1 hr after the temperature measured on the casing of the Tested-Device or the REESS has stabilized, such that the temperature gradient varies by less than 4 °C through 2 hours.

6.2.5.3.3. Standard Cycle and observation period.

Directly after the termination of the short circuit a standard cycle as described in clause 6.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

6.2.6. Overcharge protection test.

6.2.6.1. Purpose.

The purpose of this test is to verify the performance of the overcharge protection to prevent the REESS from any further related severe events caused by a too high SOC.

6.2.6.2. Installations.

This test shall be conducted, under standard operating conditions, either with a complete vehicle or with the complete REESS. Ancillary systems that do not influence the test results may be omitted from the Tested-Device.

The test may be performed with a modified Tested-Device provided these modifications shall not influence the test results.

6.2.6.3. **Procedures.**

6.2.6.3.1. **General test conditions.**

The following requirements and conditions shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C or at a higher temperature if requested by the manufacturer;
b. The SOC of REESS shall be adjusted around the middle of normal operating range by normal operation recommended by the manufacturer such as driving the vehicle or using an external charger. The accurate adjustment is not required as long as the normal operation of the REESS is enabled;
c. For vehicle-based test of vehicles with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), fill the fuel to allow the operation of such energy conversion systems;
d. At the beginning of the test, all protection devices which would affect the function of the Tested-Device and which are relevant to the outcome of the test shall be operational. All relevant main contactors for charging shall be closed.

6.2.6.3.2. **Charging**.

The procedure for charging the REESS for vehicle-based test shall be in accordance with clause s 6.2.6.3.2.1. and 6.2.6.3.2.2. and shall be selected as appropriate for the relevant mode of vehicle operation and the functionality of the protection system. Alternatively, the procedure for charging the REESS for vehicle-based test shall be in accordance with clause 6.2.6.3.2.3. For component-based test, the charging procedure shall be in accordance with clause 6.2.6.3.2.4.

6.2.6.3.2.1. **Charge by vehicle operation.**

This procedure is applicable to the vehicle-based tests in active driving possible mode:

a. For vehicles that can be charged by on-board energy sources (e.g. energy recuperation, on-board energy conversion systems), the vehicle shall be driven on a chassis dynamometer. The vehicle operation on a chassis dynamometer (e.g. simulation of continuous down-hill driving) that will deliver as high charging current as reasonably achievable shall be determined, if necessary, through consultation with the manufacturer.
b. The REESS shall be charged by the vehicle operation on a chassis dynamometer in accordance with clause 6.2.6.3.2.1.(a). The vehicle operation on the chassis dynamometer shall be terminated when the vehicle's overcharge protection controls terminates the REESS charge current or the temperature of the REESS is stabilized such that the temperature varies by a gradient of less than 2 °C through 1 hour. Where an automatic interrupt function vehicle's overcharge protection control fails to operate, or if there is no such control function, the charging shall be continued until the REESS temperature reaches 10 °C above its maximum operating temperature specified by the manufacturer.

c. Immediately after the termination of charging, one standard cycle as described in clause 6.2.1.1. shall be conducted, if it is not prohibited by the vehicle, with vehicle operation on a chassis dynamometer.

6.2.6.3.2.2. Charge by external electricity supply (vehicle-based test).

This procedure is applicable to vehicle-based test for externally chargeable vehicles:

a. The vehicle inlet for normal use, if it exists, shall be used for connecting the external electricity supply equipment. The charge control communication of the external electricity supply equipment shall be altered or disabled to allow the charging specified in clause 6.2.6.3.2.2.(b) below;

b. The REESS shall be charged by the external electricity supply equipment with the maximum charge current specified by the manufacturer. The charging shall be terminated when the vehicle's overcharge protection control terminates the REESS charge current. Where vehicle's overcharge protection control fails to operate, or if there is no such control, the charging shall be continued until the REESS temperature reaches 10 °C above its maximum operating temperature specified by the manufacturer. In the case where charge current is not terminated and where the REESS temperature remains less than 10 °C above the maximum operating temperature, vehicle operation shall be terminated 12 hours after the start of charging by external electricity supply equipment;

c. Immediately after the termination of charging, one standard cycle as described in clause 6.2.1.1. shall be conducted, if it is not prohibited by the vehicle, with vehicle operation on a chassis dynamometer for discharging and with external electricity supply equipment for charging.

6.2.6.3.2.3. Charge by connecting breakout harness (vehicle-based test).

This procedure is applicable to vehicle-based tests for both externally chargeable vehicles and vehicles that can be charged only by on-board energy sources and for which the manufacturer provides information to connect a breakout harness to a location just outside the REESS that permits charging of the REESS:

a. The breakout harness is connected to the vehicle as specified by the manufacturer. The trip current/voltage setting of the external charge-discharge equipment shall be at least 10 per cent higher than the current/voltage limit of the Tested-Device. The external electricity supply equipment is connected to the breakout harness. The REESS shall be charged by the external electricity power supply with the maximum charge current specified by the manufacturer;

b. The charging shall be terminated when the vehicle's overcharge protection control terminates the REESS charge current. Where vehicle's overcharge protection control fails to operate, or if there is no such control, the charging shall be continued until the REESS temperature is 10 °C above its maximum operating temperature specified by the manufacturer. In the case where charge current is not terminated and where the REESS temperature remains less than 10 °C above the maximum operating temperature, vehicle operation shall be terminated 12 hours after the start of charging by external electricity supply equipment;

c. Immediately after the termination of charging, one standard cycle as described in clause 6.2.1.1. (for a complete vehicle) shall be conducted, if it is not prohibited by the vehicle.

6.2.6.3.2.4. Charge by external electricity supply (component-based test).

This procedure is applicable to component-based test:

a. The external charge/discharge equipment shall be connected to the main terminals of the REESS. The charge control limits of the test equipment shall be disabled;
b. The REESS shall be charged by the external charge/discharge equipment with the maximum charge current specified by the manufacturer. The charging shall be terminated when the REESS overcharge protection control terminates the REESS charge current. Where overcharge protection control of the REESS fails to operate, or if there is no such control, the charging shall be continued until the REESS temperature reaches 10 °C above its maximum operating temperature specified by the manufacturer. In the case where charge current is not terminated and where the REESS temperature remains less than 10 °C above the maximum operating temperature, vehicle operation shall be terminated 12 hours after the start of charging by external electricity supply equipment;
c. Immediately after the termination of charging, one standard cycle as described in clause 6.2.1.1. shall be conducted, if it is not prohibited by the REESS, with external charge-discharge equipment.

6.2.6.4. The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

6.2.7. Over-discharge protection test.

6.2.7.1. Purpose.

The purpose of this test is to verify the performance of the over-discharge protection to prevent the REESS from any severe events caused by a too low SOC.

6.2.7.2. Installations.

This test shall be conducted, under standard operating conditions, either with a complete vehicle or with the complete REESS. Ancillary systems that do not influence the test results may be omitted from the Tested-Device.

The test may be performed with a modified Tested-Device provided these modifications shall not influence the test results.

6.2.7.3. Procedures.

6.2.7.3.1. General test conditions.

The following requirements and condition shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C or at a higher temperature if requested by the manufacturer;
b. The SOC of REESS shall be adjusted at the low level, but within normal operating range, by normal operation recommended by the manufacturer, such as driving the vehicle or using an external charger. Accurate adjustment is not required as long as the normal operation of the REESS is enabled;
c. For vehicle-based test of vehicles with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), adjust the fuel level to nearly empty but enough so that the vehicle can enter into active driving possible mode;
d. At the beginning of the test, all protection devices which would affect the function of the Tested-Device and which are relevant for the outcome of the test shall be operational.

6.2.7.3.2. Discharging.

The procedure for discharging the REESS for vehicle-based test shall be in accordance with clause s 6.2.7.3.2.1. and 6.2.7.3.2.2. Alternatively, the procedure for discharging the REESS for vehicle-based test shall be in accordance with clause 6.2.7.3.2.3. For component-based test, the discharging procedure shall be in accordance with clause 6.2.7.3.2.4.

6.2.7.3.2.1. Discharge by vehicle driving operation.

This procedure is applicable to the vehicle-based tests in active driving possible mode:

a. The vehicle shall be driven on a chassis dynamometer. The vehicle operation on a chassis dynamometer (e.g. simulation of continuous driving at steady speed) that will deliver as constant discharging power as reasonably achievable shall be determined, if necessary, through consultation with the manufacturer;
b. The REESS shall be discharged by the vehicle operation on a chassis dynamometer in accordance with clause 6.2.7.3.2.1.(a). The vehicle operation on the chassis dynamometer shall be terminated when the vehicle's over-discharge protection control terminates REESS discharge current or the temperature of the REESS is stabilized such that the temperature varies by a gradient of less than 4°C through 2 hours. Where an over-discharge protection control fails to operate, or if there is no such control, then the discharging shall be continued until the REESS is discharged to 25 per cent of its nominal voltage level;
c. Immediately after the termination of discharging, one standard charge followed by a standard discharge as described in clause 6.2.1.1. shall be conducted if it is not prohibited by the vehicle.

6.2.7.3.2.2. Discharge by auxiliary electrical equipment (vehicle-based test).

This procedure is applicable to the vehicle-based tests in stationary condition:

a. The vehicle shall be switched in to a stationary operation mode that allow consumption of electrical energy from REESS by auxiliary electrical equipment. Such an operation mode shall be determined, if necessary, through consultation with the manufacturer. Equipments (e.g. wheel chocks) that prevent the vehicle movement may be used as appropriate to ensure the safety during the test;
b. The REESS shall be discharged by the operation of electrical equipment, air-conditioning, heating, lighting, audio-visual equipment, etc., that can be switched on under the conditions given in clause 6.2.7.3.2.2.(a). The operation shall be terminated when the vehicle's over-discharge protection control terminates REESS discharge current or the temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 h. Where an over-discharge protection control fails to operate, or if there is no such control, then the discharging shall be continued until the REESS is discharged to 25 per cent of its nominal voltage level;
c. Immediately after the termination of discharging, one standard charge followed by a standard discharge as described in clause 6.2.1.1. shall be conducted if it is not prohibited by the vehicle.

6.2.7.3.2.3. Discharge of REESS using discharge resistor (vehicle-based test).

This procedure is applicable to vehicles for which the manufacturer provides information to connect a breakout harness to a location just outside the REESS that permits discharging the REESS:

(a) Connect the breakout harness to the vehicle as specified by the manufacturer. Place the vehicle in active driving possible mode;

(b) A discharge resistor is connected to the breakout harness and the REESS shall be discharged at a discharge rate under normal operating conditions in accordance with manufacturer provided information. A resistor with discharge power of 1 kW may be used;

(c) The test shall be terminated when the vehicle's over-discharge protection control terminates REESS discharge current or the temperature of the REESS is stabilized such that the temperature varies by a gradient of less than 4 °C through 2 hours. Where an automatic discharge interrupt function fails to operate, or if there is no such function, then the discharging shall be continued until the REESS is discharged to 25 per cent of its nominal voltage level;

(d) Immediately after the termination of discharging, one standard charge followed by a standard discharge as described in clause 6.2.1.1. shall be conducted if it is not prohibited by the vehicle.

6.2.7.3.2.4. Discharge by external equipment (component-based test).

This procedure is applicable to component-based test:

a. All relevant main contactors shall be closed. The external charge-discharge shall be connected to the main terminals of the Tested-Device;
b. A discharge shall be performed with a stable current within the normal operating range as specified by the manufacturer;
c. The discharging shall be continued until the Tested-Device (automatically) terminates REESS discharge current or the temperature of the Tested-Device is stabilized such that the temperature varies by a gradient of less than 4 °C through 2 hours. Where an automatic interrupt function fails to operate, or if there is no such function, then the discharging shall be continued until the Tested-Device is discharged to 25 per cent of its nominal voltage level;
d. Immediately after the termination of the discharging, one standard charge followed by a standard discharge as described in clause 6.2.1.1. shall be conducted if not inhibited by the Tested-Device.

6.2.7.4. The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

6.2.8. Over-temperature protection test.

6.2.8.1. Purpose.

The purpose of this test is to verify the performance of the protection measures of the REESS against internal overheating during operation. In the case that no specific protection measures are necessary to prevent the REESS from reaching an unsafe state due to internal over-temperature, this safe operation must be demonstrated.

6.2.8.2. The test may be conducted with a complete REESS according to clause s 6.2.8.3. and 6.2.8.4. or with a complete vehicle according to clause s 6.2.8.5. and 6.2.8.6.

6.2.8.3. Installation for test conducted using a complete REESS.

6.2.8.3.1. Ancillary systems that do not influence to the test results may be omitted from the Tested-Device. The test may be performed with a modified Tested-Device provided these modifications shall not influence the test results.

6.2.8.3.2. Where a REESS is fitted with a cooling function and where the REESS will remain functional in delivering its normal power without a cooling function system being operational, the cooling system shall be deactivated for the test.

6.2.8.3.3. The temperature of the Tested-Device shall be continuously measured inside the casing in the proximity of the cells during the test in order to monitor the changes of the temperature. The on-board sensors, if existing, may be used with compatible tools to read the signal.

6.2.8.3.4. The REESS shall be placed in a convective oven or climatic chamber. If necessary, for conduction the test, the REESS shall be connected to the rest of vehicle control system with extended cables. An external charge/discharge equipment may be connected under supervision by the vehicle manufacturer.

6.2.8.4. Test procedures for test conducted using a complete REESS.

6.2.8.4.1. At the beginning of the test, all protection devices which affect the function of the Tested-Device and are relevant to the outcome of the test shall be operational, except for any system deactivation implemented in accordance with clause 6.2.8.3.2.

6.2.8.4.2. The Tested-Device shall be continuously charged and discharged by the external charge/discharge equipment with a current that will increase the temperature of cells as rapidly as possible within the range of normal operation as defined by the manufacturer until the end of the test. Alternatively, the charge and discharge may be conducted by vehicle driving operations on chassis dynamometer where the driving operation shall be determined through consultation with the manufacturer to achieve the conditions above.

6.2.8.4.3. The temperature of the chamber or oven shall be gradually increased, from 20 ± 10 °C or at higher temperature if requested by the manufacturer, until it reaches the temperature determined in accordance with clause 6.2.8.4.3.1. or clause 6.2.8.4.3.2. below as applicable, and then maintained at a temperature that is equal to or higher than this, until the end of the test.

6.2.8.4.3.1. Where the REESS is equipped with protective measures against internal overheating, the temperature shall be increased to the temperature defined by the manufacturer as being the operational temperature threshold for such protective measures, to insure that the temperature of the Tested-Device will increase as specified in clause 6.2.8.4.2.

6.2.8.4.3.2. Where the REESS is not equipped with any specific measures against internal over-heating the temperature shall be increased to the maximum operational temperature specified by the manufacturer.

6.2.8.4.4. The test will end when one of the followings is observed:

a. The Tested-Device inhibits and/or limits the charge and/or discharge to prevent the temperature increase;

b. The temperature of the Tested-Device is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours;

c. Any failure of the acceptance criteria prescribed in clause 5.6.8.

6.2.8.5. Installation for test conducted using a complete vehicle.

6.2.8.5.1. 6.2.8.5.1. Based on information from the manufacturer, for an REESS fitted with a cooling function the cooling system shall be disabled or in a state of significantly reduced operation (for an REESS that will not operate if the cooling system is disabled) for the test.

6.2.8.5.2. The temperature of the REESS shall be continuously measured inside the casing in the proximity of the cells during the test in order to monitor the changes of the temperature using on-board sensors and compatible tools according to manufacturer provided information to read the signals.

6.2.8.5.3. For vehicles with on-board energy conversion systems, adjust the fuel level to nearly empty but so that the vehicle can enter into active driving possible mode.

6.2.8.5.4. The vehicle shall be placed in in a climate control chamber set to a temperature between 40 °C to 45 °C for at least 6 hours.

6.2.8.6. Test procedures for test conducted using a complete vehicle.

6.2.8.6.1. The vehicle shall be continuously charged and discharged in a manner that will increases the temperature of REESS cells as rapidly as possible within the range of normal operation as defined by the manufacturer until the end of the test.

The charge and discharge will be conducted by vehicle driving operations on chassis dynamometer where the driving operation shall be determined through consultation with the manufacturer to achieve the conditions above.

For a vehicle that can be charged by an external power supply, the charging may be conducted using an external power supply if more rapid temperature increase is expected.

6.2.8.6.2. The test will end when one of the followings is observed:

a. The vehicle terminates the charge and/or discharge;
b. The temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours;
c. Any failure of the acceptance criteria prescribed in clause 5.6.8.;
d. 3 hours elapse from the time of starting the charge/discharge cycles in clause 6.2.8.6.1.

6.2.9. Overcurrent protection test.

6.2.9.1. Purpose.

The purpose of this test is to verify the performance of the overcurrent protection during DC external charging to prevent the REESS from any severe events caused by excessive levels of charge current as specified by the manufacturer.

6.2.9.2. Test conditions:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C;
b. The SOC of REESS shall be adjusted around the middle of normal operating range by normal operation recommended by the manufacturer such as driving the vehicle or using an external charger. The accurate adjustment is not required as long as the normal operation of the REESS is enabled;
c. The overcurrent level (assuming failure of external DC electricity supply equipment) and maximum voltage (within normal range) that can be applied shall be determined, if necessary, through consultation with the manufacturer.

6.2.9.3. The overcurrent test shall be conducted in accordance with clause 6.2.9.4. or clause 6.2.9.5., as applicable and in accordance with manufacturer information.

6.2.9.4. Overcurrent during charging by external electricity supply.

This test procedure is applicable to vehicle-based test for vehicles that have the capability of charging by DC external electricity supply:

a. The DC charging vehicle inlet shall be used for connecting the external DC electricity supply equipment. The charge control communication of the external electricity supply equipment is altered or disabled to allow the overcurrent level determined through consultation with the manufacturer;
b. Charging of the REESS by the external DC electricity supply equipment shall be initiated to achieve the highest normal charge current specified by the manufacturer. The charge current is then increased over 5 s from the highest normal charge current to the overcurrent level determined in accordance with clause 6.2.9.2.(c) above. Charging is then continued at this overcurrent level;
c. The charging shall be terminated when the functionality of the vehicle's overcurrent protection terminates the REESS charge current or the temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours;
d. Immediately after the termination of charging, one standard cycle as described in clause 6.2.1.1. shall be conducted, if it is not prohibited by the vehicle.

6.2.9.5. Overcurrent during charging using breakout harness.

This test procedure is applicable to vehicles that have the capability of charging by DC external electricity supply and for which the manufacturer provides information to connect a breakout harness to a location just outside the REESS that permits charging of the REESS:

a. The breakout harness is connected to the vehicle as specified by the manufacturer;
b. The external electricity supply equipment along with the overcurrent supply is connected to the breakout harness and charging of the REESS is initiated to achieve the highest normal charge current specified by the manufacturer;
c. The charge current is then increased over 5 seconds from the highest normal charge current to the overcurrent level determined in accordance with clause 6.2.9.2.(c) above. Charging is then continued at this overcurrent level;
d. The charging shall be terminated when the functionality of the vehicle's overcurrent protection terminates charging or the temperature of the Tested-Device is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours;
e. Immediately after the termination of charging, one standard cycle as described in clause 6.2.1.1. shall be conducted, if it is not prohibited by the vehicle.

6.2.9.6. The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

6.2.10. Mechanical shock test.

6.2.10.1. Purpose.

The purpose of this test is to verify the safety performance of the REESS under inertial loads which may occur during a vehicle crash.

6.2.10.2. Installations.

6.2.10.2.1. This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

6.2.10.2.2. The Tested-Device shall be connected to the test fixture only by the intended mountings provided for the purpose of attaching the REESS or REESS subsystem to the vehicle.

6.2.10.3. Procedures.

6.2.10.3.1. General test conditions and requirements.

The following condition shall apply to the test:

a. the test shall be conducted at an ambient temperature of 20 ± 10 °C;
b. at the beginning of the test, the SOC shall be adjusted in accordance with the clause 6.2.1.2.;
c. at the beginning of the test, all protection devices which affect the function of the Tested-Device and which are relevant to the outcome of the test, shall be operational.

6.2.10.3.2. Test procedure.

The Tested-Device shall be decelerated or accelerated in compliance with the acceleration corridors which are specified in Figure 14 and Tables 3 or 4. The manufacturer shall decide whether the tests shall be conducted in either the positive or negative direction or both.

For each of the test pulses specified, a separate Tested-Device may be used.

The test pulse shall be within the minimum and maximum value as specified in Tables 3 or 4. A higher shock level and /or longer duration as described in the maximum value in Tables 3 or 4 can be applied to the Tested-Device if recommended by the manufacturer.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

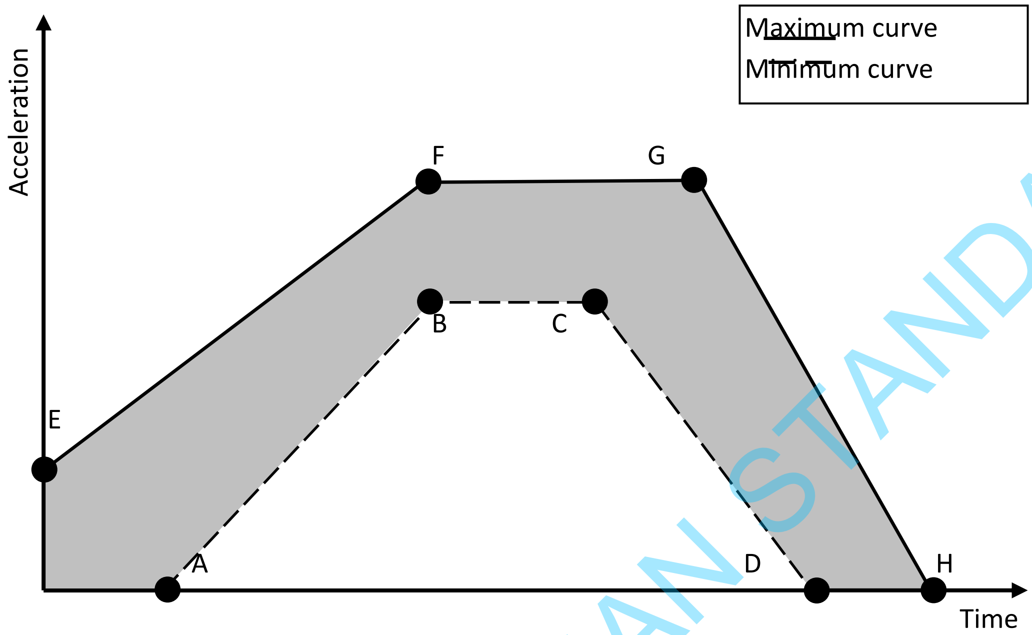


Figure 14- Generic description of test pulses

Table 3

Values for category 1-1 vehicles and category 2 vehicles with GVM≤3.5t

Point	Time (ms)	Acceleration (g)	
		Longitudinal	Transverse
A	20	0	0
B	50	20	8
C	65	20	8
D	100	0	0
E	0	10	4.5
F	50	28	15
G	80	28	15
H	120	0	0

Table 4

Values for category 1-2 vehicles and category 2 vehicles with GVM>3.5t

Point	Time (ms)	Acceleration (g)	
		Longitudinal	Transverse
A	20	0	0
B	50	10	5
C	65	10	5
D	100	0	0
E	0	5	2.5
F	50	17	10
G	80	17	10
H	120	0	0

6.2.11. Mechanical integrity test.

6.2.11.1. Purpose.

The purpose of this test is to verify the safety performance of the REESS under contact loads which may occur during vehicle crash situation.

6.2.11.2. Installations.

6.2.11.2.1. This test shall be conducted with either the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated to the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

6.2.11.2.2. The Tested-Device shall be connected to the test fixture as recommended by the manufacturer.

6.2.11.3. Procedures.

6.2.11.3.1. General test conditions.

The following condition and requirements shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C;
b. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 6.2.1.2.;
c. At the beginning of the test, all internal and external protection devices which would affect the function of the Tested-Device and which are relevant to the outcome of the test shall be operational;
d. Vehicle body structure, electrical protection barriers, enclosures, or other mechanical protection functional devices against contact force regardless outside or inside of the REESS may be attached to the Tested-Device if so requested by the manufacturer. The manufacturer shall define the relevant parts used for the mechanical protection of the REESS. The test may be conducted with the REESS mounted to this vehicle structure in a way which is representative of its mounting in the vehicle.

6.2.11.3.2. Crush test.

6.2.11.3.2.1. Crush force.

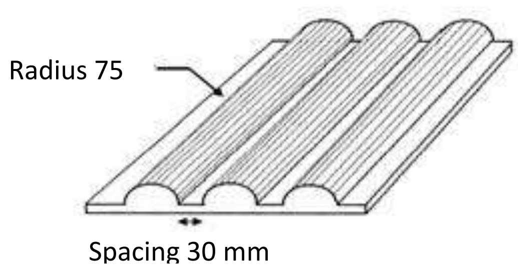
The Tested-Device shall be crushed between a resistance and a crush plate as described in Figure 15 with a force of at least 100 kN but not exceeding 105 kN unless otherwise specified in accordance with clause 5.7.2.1., with an onset time less than 3 minutes and a hold time of at least 100 ms but not exceeding 10 s.

A higher crush force, a longer onset time, a longer hold time, or a combination of these, may be applied at the request of the manufacturer.

The application of the force shall be decided by the manufacturer having consideration to the direction of travel of the REESS relative to its installation in the vehicle. The application force being applied horizontally and perpendicular to the direction of travel of the REESS.

The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

Figure 15 - Dimension of the crush plate



Dimension of the crush plate:

600 mm x 600 mm or smaller

7. Heavy duty vehicles – Performance requirements

7.1. Requirements of a vehicle with regard to its electrical safety - in-use.

7.1.1. Protection against electric shock.

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

7.1.1.1. Protection against direct contact.

High voltage live parts shall comply with clause s 7.1.1.1.1. and 7.1.1.1.2. for protection against direct contact. Conductive connection devices not energized except during charging of the REESS are exempted from this requirement if located on the roof of the vehicle out of reach for a person standing outside of the vehicle. For Category 1-2 vehicles, the minimum wrap around distance from the instep of the vehicle to the roof mounted charging devices is 3.00 m. In case of multiple steps due to elevated floor inside the vehicle, the wrap around distance is measured from the bottom most step at entry, as illustrated in Figure 16.

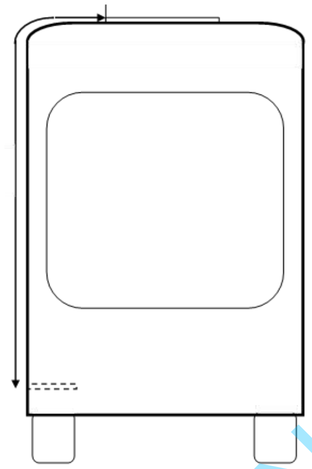
Electrical protection barriers, enclosures, solid insulators and connectors shall not be opened, disassembled or removed e.g. without the use of tools, an operator controlled activation/deactivation device, or equivalent.

However, connectors (including the vehicle inlet) are allowed to be separated without the use of tools, if they meet one or more of the following requirements:

a. They comply with clause s 7.1.1.1.1. and 7.1.1.1.2. when separated; or
b. They are provided with a locking mechanism (at least two distinct actions are needed to separate the connector from its mating component). Additionally, other components, not being part of the connector, shall be removable only with the use of tools, an operator controlled activation/deactivation device or equivalent, in order to be able to separate the connector; or

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

Figure 16 - Schematics of how to measure wrap-around distance



7.1.1.1.1. For high voltage live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.

7.1.1.1.2. For high voltage live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB shall be provided.

7.1.1.1.3. Service disconnect.

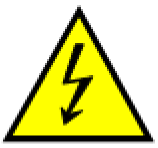
For a high voltage service disconnect which can be opened, disassembled or removed without the use of tools or an operator controlled activation/deactivation device, or equivalent, protection IPXXB degree shall be satisfied when it is opened, disassembled or removed as intended by the system design.

7.1.1.1.4. Marking.

7.1.1.1.4.1. The symbol shown in Figure 17 shall be present on or near the REESS having high voltage capability. The symbol background shall be yellow, the bordering and the arrow shall be black.

This requirement shall also apply to a REESS which is part of a galvanically connected electrical circuit where the specific voltage condition is not fulfilled, independent of the maximum voltage of the REESS.

Figure 17- Marking of high voltage equipment



7.1.1.1.4.2. The symbol shall be visible on enclosures and electrical protection barriers, which, when removed, expose live parts of high voltage circuits. This provision is optional to any connectors for high voltage buses. This provision shall not apply to the cases:

a. Where electrical protection barriers or enclosures cannot be physically accessed, opened, or removed; unless other vehicle components are removed with the use of tools, using an operator controlled activation/deactivation device, or equivalent, or

b. Where electrical protection barriers or enclosures are located underneath the vehicle floor.

7.1.1.1.4.3. Cables for high voltage buses which are not located within enclosures shall be identified by having an outer covering with the colour orange.

7.1.1.2. Protection against indirect contact.

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

7.1.1.2.2. The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 Ω when there is current flow of at least 0.2 A.

The resistance between any two simultaneously reachable exposed conductive parts of the electrical protection barriers that are less than 2.5 m from each other shall not exceed 0.2 Ω. This resistance may be calculated using the separately measured resistances of the relevant parts of electric path.

This requirement is satisfied if the connection has been established by welding. In case of doubts or the connection is established by other means than welding, a measurement shall be made by using one of the test procedures described in clause 8.1.4.

7.1.1.2.3. 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 conductive connection of the electrical chassis to the earth ground for the external electric power supply shall be provided.

The device shall 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, by visual inspection or drawings.

The above requirements are only applicable for vehicles when charging from a fixed, dedicated charging point, with a harness of a maximum length, through a vehicle connector containing a plug and an inlet.

7.1.1.2.4. Isolation resistance.

This clause shall not apply to electrical circuits that are galvanically connected to each other, where the DC part of these circuits is connected to the electrical chassis and the specific voltage condition is fulfilled.

7.1.1.2.4.1. Electric power train consisting of separate DC or AC buses.

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

The measurement shall be conducted according to clause 8.1.1.

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

If AC high voltage buses and DC high voltage buses are conductively connected, isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 Ω/V of the working voltage.

However, if all AC high voltage buses are protected by one of the two following measures, isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage:

a. At least two or more layers of solid insulators, electrical protection barriers or enclosures that meet the requirement in clause 7.1.1.1. independently, for example wiring harness, or
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 clause 8.1.1.

7.1.1.2.4.3. Fuel cell vehicles.

In fuel cell vehicles, DC high voltage buses shall have an on-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value of 100 Ω/V. The function of the on-board isolation resistance monitoring system shall be confirmed as described in clause 8.1.2.

The isolation resistance between the high voltage bus of the coupling system for charging the REESS, which is not energized in conditions other than that during the charging of the REESS, and the electrical chassis need not to be monitored.

7.1.1.2.4.4. Isolation resistance requirement for the coupling system for charging the REESS.

For the vehicle conductive connection device intended to be conductively connected to the external AC electric power supply and the electrical circuit that is conductively connected to the vehicle conductive connection device during charging of the REESS, the isolation resistance between the high voltage bus and the electrical chassis shall comply with the requirements of clause 7.1.1.2.4.1. when the vehicle connector is disconnected and the isolation resistance is measured at the high voltage live parts (contacts) of the vehicle conductive connection device. During the measurement, the REESS may be disconnected.

The measurement shall be conducted according to clause 8.1.1.

7.1.1.3. Protection against water effects.

The vehicles shall maintain isolation resistance after exposure to water (e.g. washing, driving through standing water). This clause shall not apply to electrical circuits that are galvanically connected to each other, where the DC part of these circuits is connected to the electrical chassis and the specific voltage condition is fulfilled.

7.1.1.3.1. The vehicle manufacturer can choose to comply with requirements specified in clause 7.1.1.3.2. or those specified in clause 7.1.1.3.3.

7.1.1.3.2. The vehicle manufacturers shall provide evidence and/or documentation to the regulatory or testing entity as applicable on how the electrical design or the components of the vehicle located outside the passenger compartment or externally attached, after water exposure remain safe and comply with the requirements described in Annex 2. If the evidence and/or documentation provided is not satisfactory the regulatory or testing entity as applicable shall require the manufacturer to perform a physical component test based on the same specifications as those described in Annex 2.

7.1.1.3.3. If the test procedures specified in clause 8.1.5. are performed, just after each exposure, and with the vehicle still wet, the vehicle shall then comply with isolation resistance test given in clause 8.1.1., and the isolation resistance requirements given in clause 7.1.1.2.4. shall be met. In addition, after a 24 hour pause, the isolation resistance test specified in clause 8.1.1. shall again be performed, and the isolation resistance requirements given in clause 7.1.1.2.4. shall be met.

A representative vehicle shall be selected for testing and a compliant test result for this vehicle shall constitute evidence of compliance for all variations of vehicles, provided that the REESS and the REESS installation on the vehicles are the same.

7.1.1.3.4. Each Contracting Party may elect to adopt the following requirement as an alternative to the requirements in clause 7.1.1.3.1.

If an isolation resistance monitoring system is provided, and the isolation resistance less than the requirements given in clause 7.1.1.2.4. is detected, a warning shall be indicated to the driver. The function of the on-board isolation resistance monitoring system shall be confirmed as described in clause 8.1.2.

7.1.2. Functional safety.

7.1.2.1. At least a momentary indication shall be given to the driver each time when the vehicle is first placed in "active driving possible mode" after manual activation of the propulsions system.

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

7.1.2.2. 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.

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

7.1.2.4. If the REESS can be externally charged, 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 conductive connection device.

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

The above requirement are only applicable for vehicles when charging from a fixed, dedicated charging point, with a harness of a maximum length, through a vehicle connector containing a plug and inlet.

7.2. Requirements with regard to installation and functionality of REESS in a vehicle

7.2.1. Installation of REESS on a vehicle.

For installation of REESS on a vehicle, the requirement of either clause 7.2.1.1. or clause 7.2.1.2. shall be satisfied.

7.2.1.1. The REESS shall comply with the respective requirements of clause 7.3., taking account of the installed conditions on a specific type of vehicle.

7.2.1.2. For a REESS which satisfies the requirements of clause 7.3. independently from the type of vehicles, the REESS shall be installed on the vehicle in accordance with the instructions provided by the manufacturer of the REESS.

7.2.2. Warning in the event of operational failure of vehicle controls that manage REESS safe operation.

The vehicle shall provide a warning to the driver when the vehicle is in active driving possible mode in the event of operational failure of the vehicle controls that manage the safe operation of the REESS. Vehicle manufacturers shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle:

7.2.2.1. A system diagram that identifies all the vehicle controls that manage REESS operations. The diagram must identify what components are used to generate a warning due to operational failure of vehicle controls to conduct one or more basic operations.

7.2.2.2. A written explanation describing the basic operation of the vehicle controls that manage REESS operation. The explanation must identify the components of the vehicle control system, provide description of their functions and capability to manage the REESS, and provide a logic diagram and description of conditions that would lead to triggering of the warning.

In case of optical warning, the tell-tale shall, when illuminated, be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions.

This tell-tale shall be activated as a check of lamp function either when the propulsion system is turned to the "On" position, or when the propulsion system is in a position between "On" and "Start" that is designated by the manufacturer as a check position. This requirement does not apply to the tell-tale or text shown in a common space.

7.2.3. Warning in the case of a thermal event within the REESS.

The vehicle shall provide a warning to the driver in the case of a thermal event in the REESS (as specified by the manufacturer) when the vehicle is in active driving possible mode. Vehicle manufacturers shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle:

7.2.3.1. The parameters and associated threshold levels that are used to indicate a thermal event (e.g. temperature, temperature rise rate, SOC level, voltage drop, electrical current, etc.) to trigger the warning.

7.2.3.2. A system diagram and written explanation describing the sensors and operation of the vehicle controls to manage the REESS in the event of a thermal event.

In case of optical warning, the tell-tale shall, when illuminated, be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions.

This warning tell-tale shall be activated as a check of lamp function either when the propulsion system is turned to the "On" position, or when the propulsion system is in a position between "On" and "Start" that is designated by the manufacturer as a check position. This requirement does not apply to the optical signal or text shown in a common space.

7.2.4. Warning in the event of low energy content of REESS.

For BEVs (vehicles in which propulsion system are powered only by a REESS), a warning to the driver in the event of low REESS state of charge shall be provided. Based on engineering judgment, the manufacturer shall determine the necessary level of REESS energy remaining, when the driver warning is first provided.

In case of optical warning, the tell-tale shall, when illuminated, be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions.

7.3. Requirements with regard to the safety of REESS - in-use.

7.3.1. General principle.

The requirements of clause s 7.3.2. to 7.3.12. shall be checked in accordance with the methods set out in clause 8.2.

7.3.2. Vibration.

The test shall be conducted in accordance with clause 8.2.2.

During the test, there shall be no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 8.1.1. shall not be less than 100 Ω/V.

7.3.3. Thermal shock and cycling.

The test shall be conducted in accordance with clause 8.2.3.

During the test, there shall be no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 8.1.1. shall not be less than 100 Ω/V.

7.3.4. Fire resistance.

The test shall be conducted in accordance with clause 8.2.4.

This test is required for REESS containing flammable electrolyte.

This test is not required when the REESS as installed in the vehicle, is mounted such that the lowest surface of the casing of the REESS is more than 1.5 m above the ground. At the choice of the manufacturer, this test may be performed where the lower surface of the REESS's is higher than 1.5 m above the ground. The test shall be carried out on one test sample.

During the test, the Tested-Device shall exhibit no evidence of explosion.

7.3.5. External short circuit protection.

The test shall be conducted in accordance with clause 8.2.5.

During the test there shall be no evidence of; electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

The REESS´s short circuit protection control shall terminate the short circuit current, or the temperature measured on the casing of the tested-device or the REESS shall be stabilized, such that the temperature gradient varies by less than 4 °C through 2 h after introducing the short circuit.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 8.1.1. shall not be less than 100 Ω/V.

7.3.6. Overcharge protection.

The test shall be conducted in accordance with clause 8.2.6.

During the test there shall be no evidence of electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 8.1.1. shall not be less than 100 Ω/V.

7.3.7. Over-discharge protection.

The test shall be conducted in accordance with clause 8.2.7.

During the test there shall be no evidence of; electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 8.1.1. shall not be less than 100 Ω/V.

7.3.8. Over-temperature protection.

The test shall be conducted in accordance with clause 8.2.8.

During the test there shall be no evidence of; electrolyte leakage, rupture (applicable to high voltage REESS only), venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with clause 8.1.1. shall not be less than 100 Ω/V.

7.3.9. Reserved.

7.3.10. Low-temperature protection.

Vehicle manufacturers must make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentations explaining safety performance of the system level or sub-system level of the vehicle to demonstrate that the vehicle monitors and appropriately controls REESS operations at low temperatures at the safety boundary limits of the REESS:

a. A system diagram;
b. Written explanation on the lower boundary temperature for safe operation of REESS;
c. Method of detecting REESS temperature;

d. Action taken when the REESS temperature is at or lower than the lower boundary for safe operation of the REESS.

7.3.11. Management of gases emitted from REESS.

7.3.11.1. Under vehicle operation including the operation with a failure, the vehicle occupants shall not be exposed to any hazardous environment caused by emissions from REESS.

7.3.11.2. For the open-type traction battery, requirement of clause 7.3.11.1. shall be verified by following test procedure.

7.3.11.2.1. The test shall be conducted following the method described in Annex 1 of this 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.

7.3.11.2.2. During a normal charge procedure in the conditions given in Annex 1, hydrogen emissions shall be below 125 g during 5 hours, or below 25 x t2 g during t2 (in h) where t2 is the time of overcharging at constant current.

7.3.11.2.3. During a charge carried out by a charger presenting a failure (conditions given in Annex 1), hydrogen emissions shall be below 42 g. Furthermore, the charger shall limit this possible failure to 30 minutes.

7.3.11.3. For REESS other than open-type traction battery, the requirement of clause 7.3.11.1. is deemed to be satisfied, if all requirements of the following tests are met: para. 8.2.2. (vibration), para. 8.2.3. (thermal shock and cycling), 8.2.5. (external short circuit protection), para. 8.2.6. (overcharge protection), para. 8.2.7. (over-discharge protection),para. 8.2.8. (over-temperature protection) and para. 8.2.9. (overcurrent protection).

7.3.12. Thermal propagation.

For the vehicles equipped with a REESS containing flammable electrolyte, the vehicle occupants shall not be exposed to any hazardous environment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway. To ensure this, the requirements of clause s 7.3.12.1. and 7.3.12.2. shall be satisfied.2

7.3.12.1. The vehicle shall provide an advance warning indication to allow egress or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway such as fire, explosion or smoke. This requirement is deemed to be satisfied if the thermal propagation does not lead to a hazardous situation for the vehicle occupants. This warning shall have characteristics in accordance with clause 7.2.3.2. The vehicle manufacturer shall make available, at the request of the regulatory or testing

2 In regions applying type-approval testing the manufacturer will be accountable for the verity and integrity of documentation submitted, assuming full responsibility for the safety of occupants against adverse effects arising from thermal propagation caused by internal short circuit. In regions applying self-certification responsibility is automatically borne by the manufacturer.

entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle:

7.3.12.1.1. The parameters (for example, temperature, voltage or electrical current) which trigger the warning indication.

7.3.12.1.2. Description of the warning system.

7.3.12.2. The vehicle shall have functions or characteristics in the cell, REESS or vehicle intended to protect vehicle occupants (as described in clause 7.3.12.) in conditions caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway. Vehicle manufacturers shall make available, at the request of the regulatory or testing entity as applicable with its necessity, the following documentation explaining safety performance of the system level or sub-system level of the vehicle (see also clause 196 in Part 1, section E):

7.3.12.2.1. A risk reduction analysis using appropriate industry standard methodology (for example, IEC 61508, ISO 26262, or similar), which documents the risk to vehicle occupants caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway and documents the reduction of risk resulting from implementation of the identified risk mitigation functions or characteristics.

7.3.12.2.2. A system diagram of all relevant physical systems and components. Relevant systems and components are those which contribute to protection of vehicle occupants from hazardous effects caused by thermal propagation triggered by a single cell thermal runaway.

7.3.12.2.3. A diagram showing the functional operation of the relevant systems and components, identifying all risk mitigation functions or characteristics.

7.3.12.2.4. For each identified risk mitigation function or characteristic:

7.3.12.2.4.1. A description of its operation strategy;

7.3.12.2.4.2. Identification of the physical system or component which implements the function;

7.3.12.2.4.3. One or more of the following engineering documents relevant to the manufacturers design which demonstrates the effectiveness of the risk mitigation function:

a. Tests performed including procedure used and conditions and resulting data;
b. Analysis or validated simulation methodology and resulting data.

7.4. Requirements with regard to the safety of REESS simulating inertial load.

7.4.1. Mechanical shock.

The test shall be conducted in accordance with clause 8.2.10.

During the test there shall be no evidence of electrolyte leakage, fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test.

An appropriate coating, if necessary, may be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

After the test, the Tested-Device shall be retained by its mounting and its components shall remain inside its boundaries.

For a high voltage REESS, the isolation resistance of the Tested-Device shall ensure at least 100 Ω/Volt for the whole REESS measured after the test in accordance with clause 7.2.1., or the protection IPXXB shall be fulfilled for the Tested-Device when assessed in accordance with clause 8.1.3.

8. Heavy duty vehicles – Test procedures

8.1. Test procedures for electrical safety.

8.1.1. Isolation resistance measurement method

8.1.1.1. General.

The isolation resistance for each high voltage bus of the vehicle is measured or shall be determined by calculating the measurement values of each part or component unit of a high voltage bus.

8.1.1.2. Measurement method.

The isolation resistance measurement is conducted by selecting an appropriate measurement method from among those listed in clause s 8.1.1.2.1. to 8.1.1.2.2., depending on the electrical charge of the live parts or the isolation resistance.

Megohmmeter or oscilloscope measurements are appropriate alternatives to the procedure described below for measuring isolation resistance. In this case, it may be necessary to deactivate the on-board isolation resistance monitoring system.

The range of the electrical circuit to be measured is clarified in advance, using electrical circuit diagrams. If the high voltage buses are conductively isolated from each other, isolation resistance shall be measured for each electrical circuit.

If the operating voltage of the Tested-Device (Vb, Figure 18) cannot be measured (e.g. due to disconnection of the electric circuit caused by main contactors or fuse operation), the test may be performed with a modified Tested-Device to allow measurement of the internal voltages (upstream the main contactors).

Moreover, modifications 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 and change in software.

In cases where the measured values are not stable due to the operation of the on-board isolation resistance monitoring system, necessary modifications for conducting the measurement may be carried out by stopping the operation of the device concerned or by removing it. Furthermore, when the device is removed, a set of drawings will be used to prove that the isolation resistance between the live parts and the electrical chassis remains unchanged.

These modifications shall not influence the test results.

Utmost care shall be exercised to avoid short circuit and electric shock since this confirmation might require direct operations of the high-voltage circuit.

8.1.1.2.1. Measurement method using DC voltage from external sources.

8.1.1.2.1.1. 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.

8.1.1.2.1.2. Measurement method.

An isolation resistance test instrument is connected between the live parts and the electrical chassis. The isolation resistance is subsequently 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 conductively 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 components disconnected.

8.1.1.2.2. Measurement method using the vehicle's own REESS as DC voltage source.

8.1.1.2.2.1. Test vehicle conditions.

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

8.1.1.2.2.2. Measurement instrument.

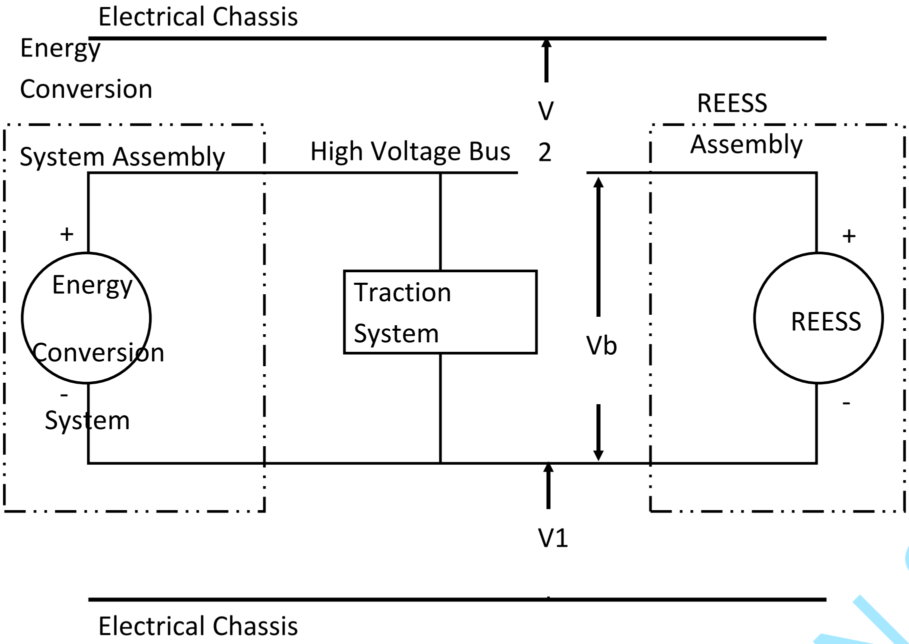
The voltmeter used in this test shall measure DC values and has an internal resistance of at least 10 MΩ.

8.1.1.2.2.3. Measurement method.

8.1.1.2.2.3.1. First step.

The voltage is measured as shown in Figure 18 and the high voltage bus voltage (Vb) is recorded. Vb shall be equal to or greater than the nominal operating voltage of the REESS and/or energy conversion system as specified by the vehicle manufacturer.

Figure 18 - Measurement of Vb, V1, V2



8.1.1.2.2.3.2. Second step.

The voltage (V1) between the negative side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 18).

8.1.1.2.2.3.3. Third step.

The voltage (V2) between the positive side of the high voltage bus and the electrical chassis is measured and recorded (see Figure 18).

8.1.1.2.2.3.4. Fourth step.

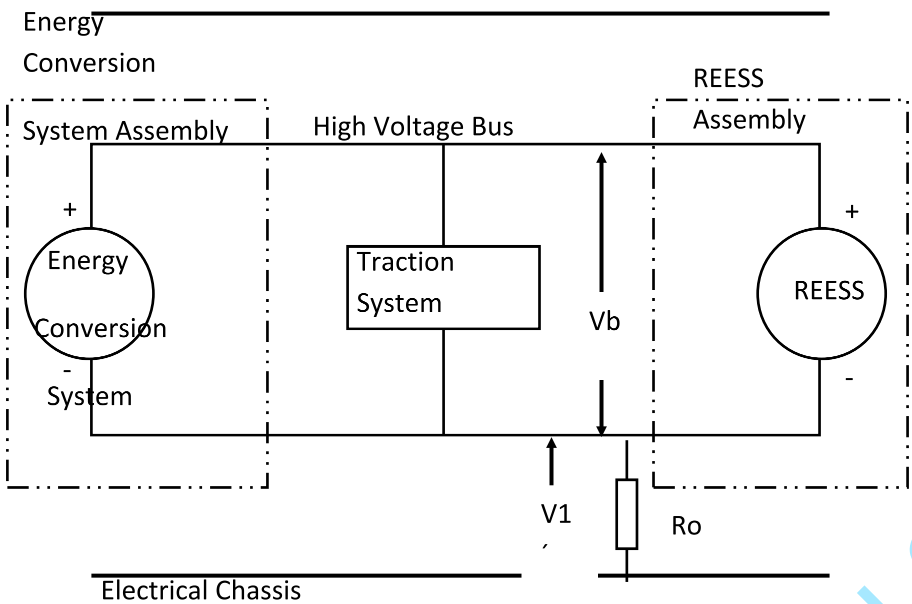
If V1 is greater than or equal to V2, a standard known resistance (Ro) is inserted between the negative side of the high voltage bus and the electrical chassis. With Ro installed, the voltage (V1') between the negative side of the high voltage bus and the electrical chassis is measured (see Figure 19).

The electrical isolation (Ri) is calculated according to the following formula:

$$Ri = Ro*(Vb/V1' – Vb/V1) \text{ or } Ri = Ro*Vb*(1/V1' – 1/V1)$$

Figure 19 - Measurement of V1'

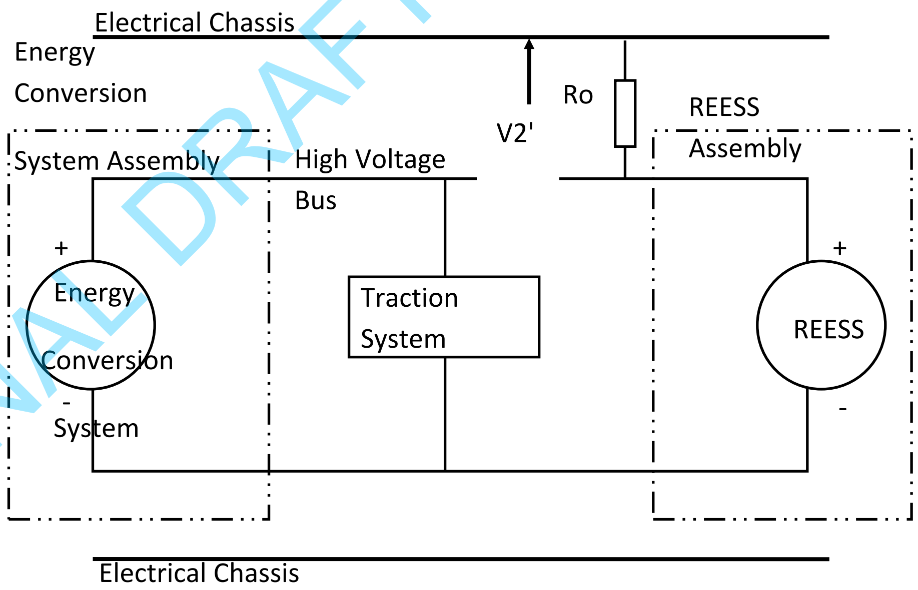
Electrical Chassis



If V2 is greater than V1, a standard known resistance (Ro) is inserted between the positive side of the high voltage bus and the electrical chassis. With Ro installed, the voltage (V2') between the positive side of the high voltage bus and the electrical chassis is measured. (See Figure 20). The electrical isolation (Ri) is calculated according to the formula shown below. This electrical isolation value (in Ω) is divided by the nominal operating voltage of the high voltage bus (in V). The electrical isolation (Ri) is calculated according to the following formula:

$$Ri = Ro*(Vb/V2' – Vb/V2) \text{ or } Ri = Ro*Vb*(1/V2' – 1/V2)$$

Figure 20 - Measurement of V2'



8.1.1.2.2.3.5. Fifth step.

The electrical isolation value Ri (in Ω) divided by the working voltage of the high voltage bus (in V) results in the isolation resistance (in Ω/V).

(Note 1: The standard known resistance Ro (in Ω) is the value of the minimum required isolation resistance (in Ω/V) multiplied by the working voltage of the vehicle plus/minus 20 per cent (in V). Ro is not required to be precisely this value since the equations are valid for any Ro; however, a Ro value in this range should provide good resolution for the voltage measurements.)

8.1.2. Confirmation method for functions of on-board isolation resistance monitoring system.

The on-board isolation resistance monitoring system specified in clause 7.1.1.2.4.3. for fuel cell vehicles and that specified in clause 7.1.1.3.4. for protection against water effects shall be tested using the following procedure:

a. Determine the isolation resistance, Ri, of the electric power train with the electrical isolation monitoring system using the procedure outlined clause 8.1.1.;
b. If the minimum isolation resistance value required in accordance with clause s 7.1.1.2.4.1. or 7.1.1.2.4.2. is 100 Ω/V, insert a resistor with resistance Ro between the positive terminal of the electric power train and the electrical chassis. The magnitude of the resistor, Ro, shall be such that:

   $1/(1/(95xV) – 1/Ri) \leq Ro < 1/(1/(100xV) – 1/Ri)$

   where V is the working voltage of the electric power train.

c. If the minimum isolation resistance value required in accordance with clause s 7.1.1.2.4.1. or 7.1.1.2.4.2. is 500 Ω/V, insert a resistor with resistance Ro between the positive terminal of the electric power train and the electrical chassis. The magnitude of the resistor, Ro, shall be such that:

   $1/(1/(475xV) – 1/Ri) \leq Ro < 1/(1/(500xV) – 1/Ri)$

   where V is the working voltage of the electric power train.

8.1.3. Protection against direct contact to live parts.

8.1.3.1. Access probes.

Access probes to verify the protection of persons against access to live parts are given in Table 5.

8.1.3.2. Test conditions.

The access probe is pushed against any openings of the enclosure with the force specified in Table 5. 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 electrical protection barriers are considered part of the enclosure.

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

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

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

8.1.3.3. 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 protection 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 are successively bent through an angle of up to 90 ° with respect to the axis of the adjoining section of the finger and are placed in every possible position.

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

Table 5

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

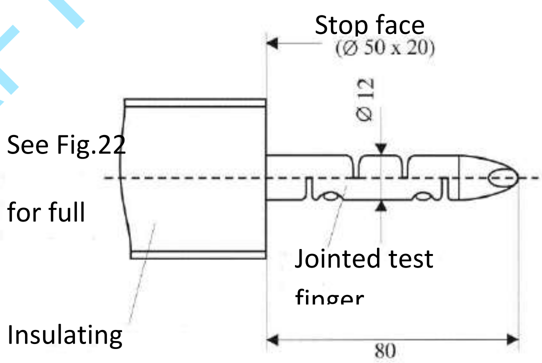
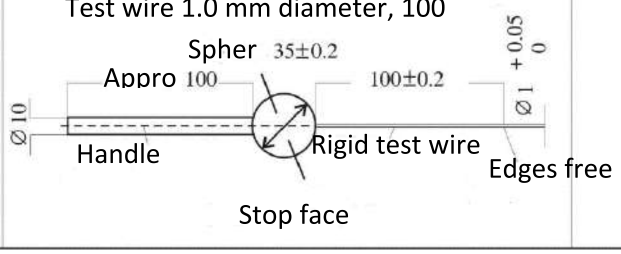
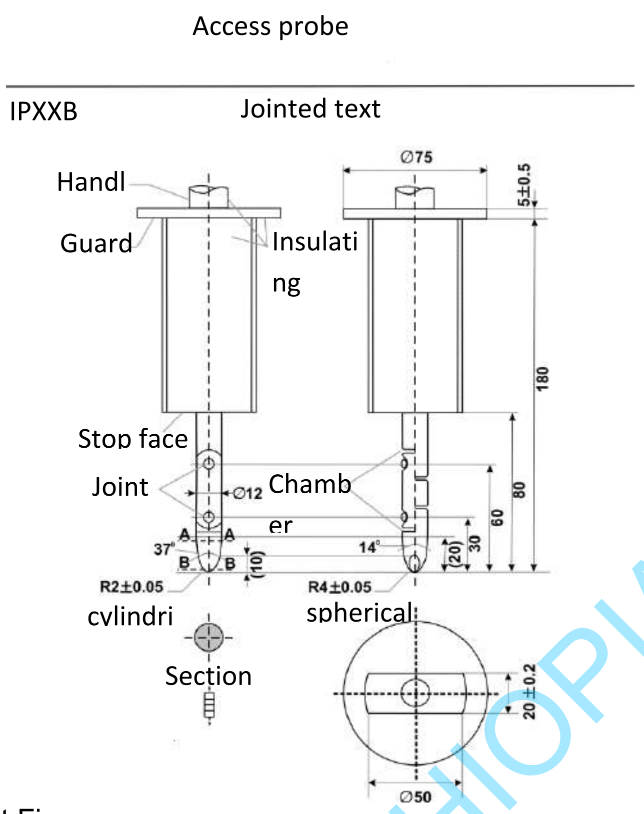
First	Addit.	Access probe	Test force
2	B	Jointed test finger 	10 N±10%
4, 5, 6	D	Test wire 1.0 mm diameter, 100 	1N±10%

Figure 22



Jointed Test Finger

Material: metal, except where otherwise specified.

Linear dimensions in mm.

Tolerances on dimensions without specific tolerance:

a. on angles: 0/10 seconds;
b. on linear dimensions:
   i. up to 25 mm: 0/-0.05;
   ii. over 25 mm: ±0.2.

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

8.1.4. Test method for measuring electric resistance:

a. Test method using a resistance tester.

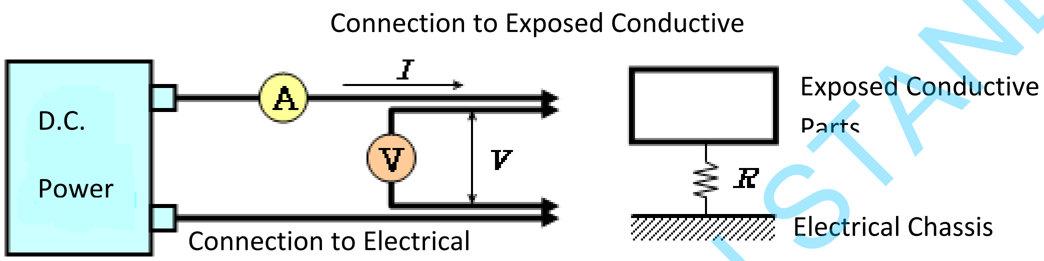
The resistance tester is connected to the measuring points (typically, electrical chassis and electro conductive enclosure/electrical protection barrier) and the resistance is measured using a resistance tester that meets the specification that follows:

i. Resistance tester: Measurement current at least 0.2 A;
ii. Resolution: 0.01 Ω or less;
iii. The resistance R shall be less than 0.1Ω.

b. Test method using DC power supply, voltmeter and ammeter.

Example of the test method using DC power supply, voltmeter and ammeter is shown below.

Figure 23 - Example of test method using DC power supply



8.1.4.1. Test Procedure.

The DC power supply, voltmeter and ammeter are connected to the measuring points (Typically, electrical chassis and electro conductive enclosure/electrical protection barrier).

The voltage of the DC power supply is adjusted so that the current flow becomes at least 0.2 A.

The current "I" and the voltage "V" are measured.

The resistance "R" is calculated according to the following formula:

R = V / I

The resistance R shall be less than 0.1 Ω.

Note:

If lead wires are used for voltage and current measurement, each lead wire shall be independently connected to the electrical protection barrier/enclosure/electrical chassis. Terminal can be common for voltage measurement and current measurement.

8.1.5. Test procedure for Protection against water effects.

8.1.5.1. Washing.

This test is intended to simulate the normal washing of vehicles, but not specific cleaning using high water pressure or underbody washing.

The areas of the vehicle regarding this test are border lines, i.e. a seal of two parts such as flaps, glass seals, outline of opening parts, outline of front grille and seals of lamps.

All border lines shall be exposed and followed in all directions with the water stream using a hose nozzle and conditions in accordance with IPX5 as specified in Annex 2.

8.1.5.2. Driving through standing water.

The vehicle shall be driven in a wade pool, with 10 cm water depth, over a distance of 500 m at a speed of 20 km/h, in a time of approximately 1.5 min. If the wade pool used is less than 500 m in length, then the vehicle shall be driven through it several times. The total time, including the periods outside the wade pool, shall be less than 10 min.

8.2. Test procedures for REESS.

8.2.1. General procedures.

8.2.1.1. Procedure for conducting a standard cycle.

Procedure for conducting a standard cycle for a complete REESS, REESS subsystem(s), or complete vehicle.

A standard cycle shall start with a standard discharge and is followed by a standard charge. The standard cycle shall be conducted at an ambient temperature of 20 ± 10 °C.

Standard discharge:

Discharge rate: The discharge procedure including termination criteria shall be defined by the manufacturer. If not specified, then it shall be a discharge with 1C current for a complete REESS and REESS subsystems.

Discharge limit (end voltage): Specified by the manufacturer.

For a complete vehicle, discharge procedure using a dynamometer shall be defined by the manufacturer. Discharge termination will be according to vehicle controls.

Rest period after discharge: minimum 15 min.

Standard charge:

The charge procedure shall be defined by the manufacturer. If not specified, then it shall be a charge with C/3 current. Charging is continued until normally terminated. Charge termination shall be according to clause 8.2.1.2.2 for REESS or REESS subsystem.

For a complete vehicle that can be charged by an external source, charge procedure using an external electric power supply shall be defined by the manufacturer. For a complete vehicle that can be charged by on-board energy sources, a charge procedure using a dynamometer shall be defined by the manufacturer. Charge termination will be according to vehicle controls.

8.2.1.2. Procedures for SOC adjustment.

8.2.1.2.1. The adjustment of SOC shall be conducted at an ambient temperature of 20 ± 10 °C for vehicle-based tests and 22 ± 5°C for component-based tests.

8.2.1.2.2. The SOC of the tested-device shall be adjusted according to one of the following procedures as applicable. Where different charging procedures are possible, the REESS shall be charged using the procedure which yields the highest SOC:

a. For a vehicle with a REESS designed to be externally charged, the REESS shall be charged to the highest SOC in accordance with the procedure specified by the manufacturer for normal operation until the charging process is normally terminated;

b. For a vehicle with a REESS designed to be charged only by an energy source on the vehicle, the REESS shall be charged to the highest SOC which is achievable with normal operation of the vehicle. The manufacturer shall advise on the vehicle operation mode to achieve this SOC;

c. In case that the REESS or REESS sub-system is used as the Tested-Device, the Tested-Device shall be charged to the highest SOC in accordance with the procedure specified by the manufacturer for normal use operation until the charging process is normally terminated. Procedures specified by the manufacturer for manufacturing, service or maintenance may be considered as appropriate if they achieve an equivalent SOC as for that under normal operating conditions. In case the Tested-Device does not control SOC by itself, the SOC shall be charged to not less than 95 per cent of the maximum normal operating SOC defined by the manufacturer for the specific configuration of the Tested-Device.

8.2.1.2.3. When the vehicle or REESS subsystem is tested, the SOC shall be no less than 95 per cent of the SOC according to clause s 8.2.1.2.1. and 8.2.1.2.2. for REESS designed to be externally charged and shall be no less than 90 per cent of SOC according to clause s 8.2.1.2.1. and 8.2.1.2.2. for REESS designed to be charged only by an energy source on the vehicle. The SOC will be confirmed by a method provided by the manufacturer.

8.2.2. Vibration test.

8.2.2.1. Purpose.

The purpose of this test is to verify the safety performance of the REESS under a vibration environment which the REESS will likely experience during the normal operation of the vehicle.

8.2.2.2. Installations.

8.2.2.2.1. This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management control unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

8.2.2.2.2. The Tested-Device shall be firmly secured to the platform of the vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the Tested Device.

As an alternative, the Test-Device should be mounted with its original mounting points and holders as mounted in the vehicle. The holders should be firmly secured to the platform of the vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the holders of the Tested-Device.

8.2.2.3. Procedures.

8.2.2.3.1. General test conditions.

The following conditions shall apply to the Tested-Device:

a. The test shall be conducted at an ambient temperature of 22 ± 5 °C;
b. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 8.2.1.2.;
c. At the beginning of the test, all protection devices which affect the function(s) of the Tested-Device that are relevant to the outcome of the test shall be operational.

8.2.2.3.2. Test procedures.

The Tested-Device shall be subjected to a vibration having a sinusoidal waveform with a logarithmic sweep between 7 Hz and 50 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours in the vertical direction of the mounting orientation of the REESS as specified by the manufacturer.

The correlation between frequency and acceleration shall be as shown in Table 6.

Table 6 - Frequency and acceleration

Frequency (Hz)	Acceleration (m/s2)
7-18	10
18 - 30	gradually reduced from 10 to 2
30 - 50	2

At the request of the manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

At the choice of the manufacturer, a vibration test profile determined by the vehicle-manufacturer verified for the vehicle application may be used as a substitute for the frequency - acceleration correlation of Table 6. The REESS certified according to this condition shall be limited to the installation for a specific vehicle type.

After the vibration profile, a standard cycle as described in clause 8.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

8.2.3. Thermal shock and cycling test.

8.2.3.1. Purpose.

The purpose of this test is to verify the resistance of the REESS to sudden changes in temperature. The REESS shall undergo a specified number of temperature cycles, which start at ambient temperature followed by high and low temperature cycling. It simulates a rapid environmental temperature change which a REESS would likely experience during its life.

8.2.3.2. Installations.

This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

8.2.3.3. Procedures.

8.2.3.3.1. General test conditions.

The following conditions shall apply to the Tested-Device at the start of the test:

a. The SOC shall be adjusted in accordance with the clause 8.2.1.2.;

b. All protection devices, which would affect the function of the Tested-Device and which are relevant to the outcome of the test shall be operational;

8.2.3.3.2. Test procedure.

The Tested-Device shall be stored for at least 6 hours at a test temperature equal to 60 ± 2 °C or higher if requested by the manufacturer, followed by storage for at least 6 hours at a test temperature equal to -40 ± 2°C or lower if requested by the manufacturer. The maximum time interval between test temperature extremes shall be 30 minutes. This procedure shall be repeated until a minimum of 5 total cycles are completed, after which the Tested-Device shall be stored for 24 hours at an ambient temperature of 22 ± 5 °C.

After the storage for 24 hours, a standard cycle as described in clause 8.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation 1 hour at the ambient temperature conditions of the test environment.

8.2.4. Fire resistance test.

8.2.4.1. Purpose.

The purpose of this test is to verify the resistance of the REESS, against exposure to fire from outside of the vehicle due to e.g. a fuel spill from a vehicle (either the vehicle itself or a nearby vehicle). This situation should leave the driver and passengers with enough time to evacuate.

8.2.4.2. Installations.

8.2.4.2.1. This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer. Where the relevant REESS subsystems are distributed throughout the vehicle, the test may be conducted on each relevant REESS subsystem.

8.2.4.3. Procedures.

8.2.4.3.1. General test conditions.

The following requirements and conditions shall apply to the test:

a. The test shall be conducted at a temperature of at least 0°C;
b. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 8.2.1.2.;
c. At the beginning of the test, all protection devices which affect the function of the Tested-Device and are relevant for the outcome of the test shall be operational.

8.2.4.3.2. Test procedure.

A vehicle based test or a component based test shall be performed at the discretion of the manufacturer.

8.2.4.3.2.1. Vehicle based test (according to test procedure described in clause 8.2.4.3.3.).

The Tested-Device shall be mounted in a testing fixture simulating actual mounting conditions as far as possible; no combustible material should be used for this with the exception of material that is part of the REESS. The method whereby the Tested-Device is fixed in the fixture shall correspond to the relevant specifications for its installation in a vehicle. In the case of a REESS designed for a specific vehicle use, vehicle parts which affect the course of the fire in any way shall be taken into consideration.

8.2.4.3.2.2. Component based test (according to test procedure described in clause 8.2.4.3.3. (Gasoline pool fire) or clause 8.2.4.3.4. (LPG burner))

In case of component based test, the manufacturer may choose either Gasoline pool fire test or LPG burner test.

8.2.4.3.3. Gasoline pool fire test set up for both vehicle-based and component-based test.

The Tested-Device shall be placed on a grating table positioned above the fire source, in an orientation according to the manufacturer's design intent.

The grating table shall be constructed by steel rods, diameter 6-10 mm, with 4-6 cm in between. If needed the steel rods could be supported by flat steel parts.

The flame to which the Tested-Device is exposed shall be obtained by burning commercial fuel for positive-ignition engines (hereafter called "fuel") in a pan. The quantity of fuel shall be sufficient to permit the flame, under free-burning conditions, to burn for the whole test procedure.

The fire shall cover the whole area of the pan during whole fire exposure. The pan dimensions shall be chosen so as to ensure that the sides of the Tested-Device are exposed to the flame. The pan shall therefore exceed the horizontal projection of the Tested-Device by at least 20 cm, but not more than 50 cm. The sidewalls of the pan shall not project more than 8 cm above the level of the fuel at the start of the test.

8.2.4.3.3.1. The pan filled with fuel shall be placed under the Tested-Device in such a way that the distance between the level of the fuel in the pan and the bottom of the Tested-Device corresponds to the design height of the Tested-Device above the road surface at the unladed mass if clause 8.2.4.3.2.1. is applied or approximately 50 cm if clause 8.2.4.3.2.2. is applied. Either the pan, or the testing fixture, or both, shall be freely movable.

8.2.4.3.3.2. During phase C of the test, the pan shall be covered by a screen. The screen shall be placed 3 cm +/- 1 cm above the fuel level measured prior to the ignition of the fuel. The screen shall be made of a refractory material, as prescribed in Figure 28. There shall be no gap between the bricks and they shall be supported over the fuel pan in such a manner that the holes in the bricks are not obstructed. The length and width of the frame shall be 2 cm to 4 cm smaller than the interior dimensions of the pan so that a gap of 1 cm to 2 cm exists between the frame and the wall of the pan to allow ventilation. Before the test, the screen shall be at least at the ambient temperature. The firebricks may be wetted in order to guarantee repeatable test conditions.

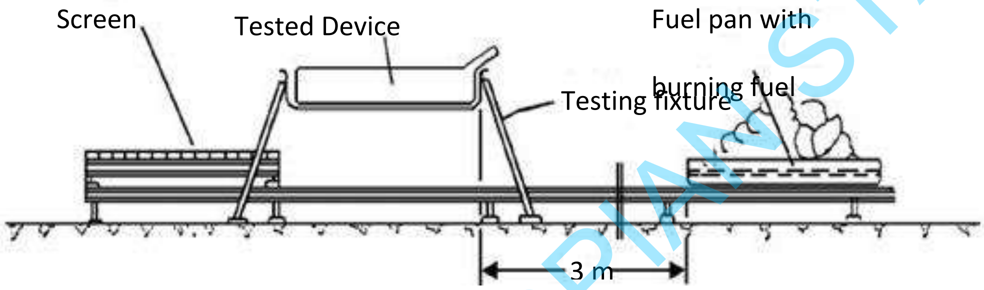
8.2.4.3.3.3. If the tests are carried out in the open air, sufficient wind protection shall be provided and the wind velocity at pan level shall not exceed 2.5 km/h.

8.2.4.3.3.4. The test shall comprise of three phases B-D, if the fuel is at a temperature of at least 20 °C. Otherwise, the test shall comprise four phases A-D.

8.2.4.3.3.4.1. Phase A: Pre-heating (Figure 24).

The fuel in the pan shall be ignited at a distance of at least 3 m from the Tested-Device. After 60 seconds pre-heating, the pan shall be placed under the Tested-Device. If the size of the pan is too large to be moved without risking liquid spills etc. then the Tested-Device and test rig can be moved over the pan instead.

Figure 24 - Phase A: Pre-heating



8.2.4.3.3.4.2. Phase B: Direct exposure to flame (Figure 25).

The Tested-Device shall be exposed to the flame from the freely burning fuel for 70 seconds.

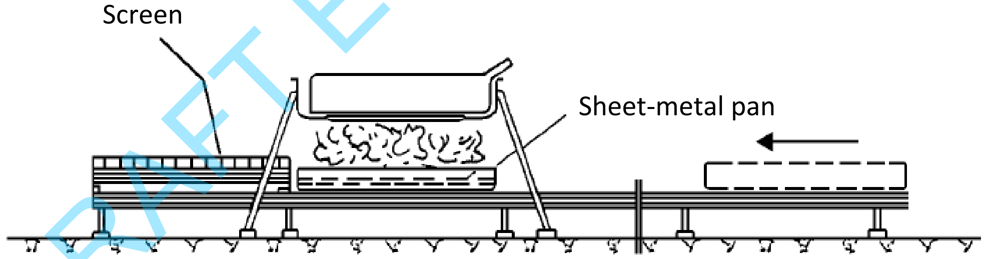


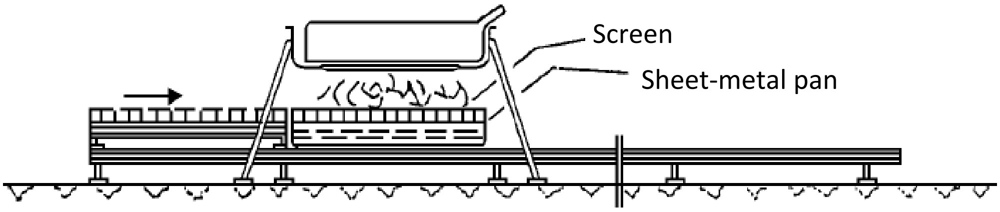
Figure 25 - Phase B: Direct exposure to flame

8.2.4.3.3.4.3. Phase C: Indirect exposure to flame (Figure 26).

As soon as phase B has been completed, the screen shall be placed between the burning pan and the Tested-Device. The Tested-Device shall be exposed to this reduced flame for a further 60 seconds.

As a compliance alternative to conducting Phase C of the test, Phase B may, at the choice of the manufacturer, be continued for an additional 60 seconds.

Figure 26 - Phase C: Indirect exposure to flame



8.2.4.3.3.4.4. Phase D: End of test (Figure 27).

The burning pan covered with the screen shall be moved back to the position described in phase A. No extinguishing of the Tested-Device shall be done. After removal of the pan the Tested-Device shall be observed until such time as the surface temperature of the Tested-Device has decreased to ambient temperature or has been decreasing for a minimum of 3 hours.

Figure 27 - Phase D: End of test

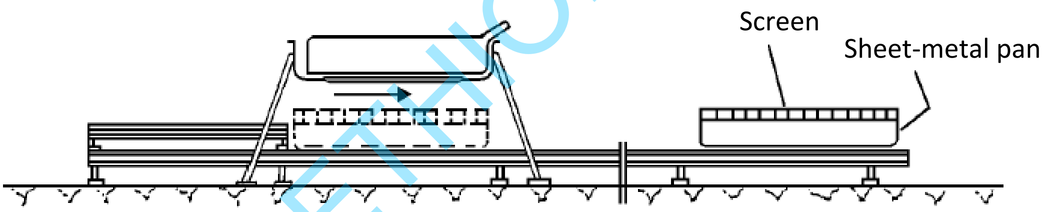
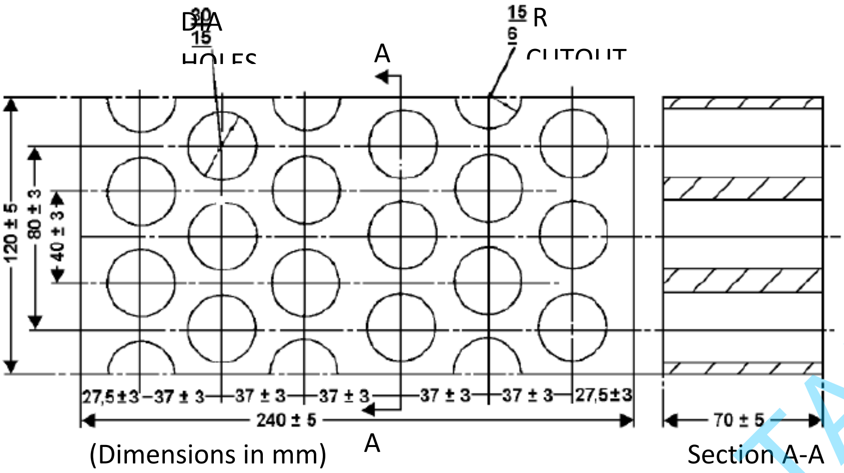


Figure 28 - Dimension of Firebricks



(Dimensions in mm) Section A-A

Fire resistance	(Seger-Kegel) SK 30
Al2O3 content	30 - 33 per cent
Open porosity (Po)	20 - 22 per cent vol.
Density	1,900 - 2,000 kg/m3
Effective holed area	44.18 per cent

8.2.4.3.4. LPG burner fire test set up for component based test.

8.2.4.3.4.1. The Tested-Device shall be placed on a test equipment, in the position that the manufacturer's design intends.

8.2.4.3.4.2. LPG burner shall be used to produce flame to which the tested-device is exposed. The height of the flame shall be about 60 cm or more, without the Tested-Device.

8.2.4.3.4.3. The flame temperature shall be measured continuously by temperature sensors. An average temperature shall be calculated, at least every second for the duration of the whole fire exposure, as the arithmetic average of temperatures measured by all temperature sensors fulfilling the location requirements described in clause 8.2.4.3.4.4.

8.2.4.3.4.4. All temperature sensors shall be installed at a height of 5 ± 1 cm below the lowest point of the Tested-Device's external surface when oriented as described in clause 8.2.4.3.4.1. At least one temperature sensor shall be located at the centre of Tested-Device, and at least four temperature sensors shall be located within 10 cm from the edge of the Tested-Device towards its centre with nearly equal distance between the sensors.

8.2.4.3.4.5. The bottom of Tested-Device shall be exposed to the even flame directly and entirely by fuel combustion. LPG burner flame shall exceed the horizontal projection of the tested-device by at least 20 cm.

8.2.4.3.4.6. The Tested-Device shall be exposed to flame for 2 minutes after the averaged temperature reaches 800 °C within 30 seconds. The averaged temperature shall be maintained 800-1,100 °C for 2 minutes.

8.2.4.3.4.7. After direct exposure to flame the Tested-Device shall be observed until such time as the surface temperature of the Tested-Device has decreased to ambient temperature or has been decreasing for a minimum of 3 hours.

8.2.5. External short circuit protection.

8.2.5.1. Purpose.

The purpose of this test is to verify the performance of the short circuit protection to prevent the REESS from any further related severe events caused by short circuit current.

8.2.5.2. Installations.

This test shall be conducted either with a complete vehicle or with the complete REESS or with the REESS subsystem(s). If the REESS consists of multiple REESS subsystems, either connected in series or in parallel, the test can be performed on a single REESS subsystem which includes an electronic management unit and (if it exists) a REESS protection device intended to be operational. If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device at the request of the manufacturer.

For a test with a complete vehicle, the manufacturer may provide information to connect a breakout harness to a location just outside the REESS that would permit applying a short circuit to the REESS.

8.2.5.3. Procedures.

8.2.5.3.1. General test conditions.

The following condition shall apply to the test:

a. The test shall be conducted at a ambient temperature of 20 ± 10 °C or at higher temperature if requested by the manufacturer;
b. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 8.2.1.2.;
c. For testing with a complete REESS or REESS subsystem(s), at the beginning of the test, all protection devices which would affect the function of the Tested-Device and which are relevant to the outcome of the test shall be operational;
d. For testing with a complete vehicle, a breakout harness is connected to the manufacturer specified location and vehicle protections systems relevant to the outcome of the test shall be operational.

8.2.5.3.2. Short circuit

At the start of the test all, relevant main contactors for charging and discharging shall be closed to represent the active driving possible mode as well as the mode to enable external charging. If this cannot be completed in a single test, then two or more tests shall be conducted.

For testing with a complete REESS or REESS subsystem(s), the positive and negative terminals of the Tested-Device shall be connected to each other to produce a short circuit. The connection used for creating the short circuit (including the cabling) shall have a resistance not exceeding 5 mΩ.

For testing with a complete vehicle, the short circuit is applied through the breakout harness. The connection used for creating the short circuit (including the cabling) shall have a resistance not exceeding 5 mΩ.

The short circuit condition shall be continued until the protection function operation of the REESS terminates the short circuit current, or for at least 1 h after the temperature measured on the casing of the Tested-Device or the REESS has stabilized, such that the temperature gradient varies by less than 4°C through 2 hours.

8.2.5.3.3. Standard Cycle and observation period

Directly after the termination of the short circuit a standard cycle as described in clause 8.2.1.1 shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

8.2.6. Overcharge protection test.

8.2.6.1. Purpose.

The purpose of this test is to verify the performance of the overcharge protection to prevent the REESS from any further related severe events caused by a too high SOC.

8.2.6.2. Installations.

This test shall be conducted, under standard operating conditions, either with a complete vehicle or with the complete REESS. Ancillary systems that do not influence to the test results may be omitted from the Tested-Device.

The test may be performed with a modified Tested-Device provided these modifications shall not influence the test results.

8.2.6.3. Procedures.

8.2.6.3.1. General test conditions.

The following requirements and conditions shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C or at a higher temperature if requested by the manufacturer;
b. The SOC of REESS shall be adjusted around the middle of normal operating range by normal operation recommended by the manufacturer such as driving

the vehicle or using an external charger. The accurate adjustment is not required as long as the normal operation of the REESS is enabled;

c. For vehicle-based test of vehicles with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), fill the fuel to allow the operation of such energy conversion systems;

d. At the beginning of the test, all protection devices which would affect the function of the Tested-Device and which are relevant to the outcome of the test shall be operational. All relevant main contactors for charging shall be closed.

8.2.6.3.2. Charging.

The procedure for charging the REESS for vehicle-based test shall be in accordance with clause s 8.2.6.3.2.1. and 8.2.6.3.2.2. and shall be selected as appropriate for the relevant mode of vehicle operation and the functionality of the protection system. Alternatively, the procedure for charging the REESS for vehicle-based test shall be in accordance with clause 8.2.6.3.2.3. For component-based test, the charging procedure shall be in accordance with clause 8.2.6.3.2.4.

8.2.6.3.2.1. Charge by vehicle operation.

This procedure is applicable to the vehicle-based tests in active driving possible mode:

a. For vehicles that can be charged by on-board energy sources (e.g. energy recuperation, on-board energy conversion systems), the vehicle shall be driven on a chassis dynamometer. The vehicle operation on a chassis dynamometer (e.g. simulation of continuous down-hill driving) that will deliver as high charging current as reasonably achievable shall be determined, if necessary, through consultation with the manufacturer;

b. The REESS shall be charged by the vehicle operation on a chassis dynamometer in accordance with clause 8.2.6.3.2.1.(a). The vehicle operation on the chassis dynamometer shall be terminated when the vehicle's overcharge protection controls terminates the REESS charge current or the temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 2 °C through 1 hour. Where an automatic interrupt function vehicle's overcharge protection control fails to operate, or if there is no such control function, the charging shall be continued until the REESS temperature reaches 10 °C above its maximum operating temperature specified by the manufacturer;

c. Immediately after the termination of charging, one standard cycle as described in clause 8.2.1.1. shall be conducted, if it is not prohibited by the vehicle, with vehicle operation on a chassis dynamometer.

8.2.6.3.2.2. Charge by external electricity supply (vehicle-based test).

This procedure is applicable to vehicle-based test for externally chargeable vehicles:

a. The vehicle inlet for normal use, if it exists, shall be used for connecting the external electricity supply equipment. The charge control communication of the external electricity supply equipment shall be altered or disabled to allow the charging specified in clause 8.2.6.3.2.2.(b) below;
b. The REESS shall be charged by the external electricity supply equipment with the maximum charge current specified by the manufacturer. The charging shall be terminated when the vehicle's overcharge protection control terminates the REESS charge current. Where vehicle's overcharge protection control fails to operate, or if there is no such control, the charging shall be continued until the REESS temperature reaches 10 °C above its maximum operating temperature specified by the manufacturer. In the case where charge current is not terminated and where the REESS temperature remains less than 10 °C above the maximum operating temperature, vehicle operation shall be terminated 12 hours after the start of charging by external electricity supply equipment;
c. Immediately after the termination of charging, one standard cycle as described in clause 8.2.1.1. shall be conducted, if it is not prohibited by the vehicle, with vehicle operation on a chassis dynamometer for discharging and with external electricity supply equipment for charging.

8.2.6.3.2.3. Charge by connecting breakout harness (vehicle-based test).

This procedure is applicable to vehicle-based tests for both externally chargeable vehicles and vehicles that can be charged only by on-board energy sources and for which the manufacturer provides information to connect a breakout harness to a location just outside the REESS that permits charging of the REESS:

a. The breakout harness is connected to the vehicle as specified by the manufacturer. The trip current/voltage setting of the external charge-discharge equipment shall be at least 10 per cent higher than the current/voltage limit of the Tested-Device. The external electricity supply equipment is connected to the breakout harness. The REESS shall be charged by the external electricity power supply with the maximum charge current specified by the manufacturer;
b. The charging shall be terminated when the vehicle's overcharge protection control terminates the REESS charge current. Where vehicle's overcharge protection control fails to operate, or if there is no such control, the charging shall be continued until the REESS temperature is 10 °C above its maximum operating temperature specified by the manufacturer. In the case where charge current is not terminated and where the REESS temperature remains less than 10 °C above the maximum operating temperature, vehicle operation shall be terminated 12 hours after the start of charging by external electricity supply equipment;
c. Immediately after the termination of charging, one standard cycle as described in clause 8.2.1.1. (for a complete vehicle) shall be conducted, if it is not prohibited by the vehicle.

8.2.6.3.2.4. **Charge by external electricity supply (component-based test).**

This procedure is applicable to component-based test:

a. The external charge/discharge equipment shall be connected to the main terminals of the REESS. The charge control limits of the test equipment shall be disabled;
b. The REESS shall be charged by the external charge/discharge equipment with the maximum charge current specified by the manufacturer. The charging shall be terminated when the REESS overcharge protection control terminates the REESS charge current. Where overcharge protection control of the REESS fails to operate, or if there is no such control, the charging shall be continued until the REESS temperature reaches 10 °C above its maximum operating temperature specified by the manufacturer. In the case where charge current is not terminated and where the REESS temperature remains less than 10 °C above the maximum operating temperature, vehicle operation shall be terminated 12 hours after the start of charging by external electricity supply equipment;
c. Immediately after the termination of charging, one standard cycle as described in clause 8.2.1.1. shall be conducted, if it is not prohibited by the REESS, with external charge-discharge equipment.

8.2.6.4. The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

8.2.7. Over-discharge protection test.

8.2.7.1. Purpose.

The purpose of this test is to verify the performance of the over-discharge protection to prevent the REESS from any severe events caused by a too low SOC.

8.2.7.2. Installations.

This test shall be conducted, under standard operating conditions, either with a complete vehicle or with the complete REESS. Ancillary systems that do not influence the test results may be omitted from the tested-device.

The test may be performed with a modified Tested-Device provided these modifications shall not influence the test results.

8.2.7.3. Procedures.

8.2.7.3.1. General test conditions.

The following requirements and condition shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C, or at higher temperature if requested by the manufacturer;
b. The SOC of REESS shall be adjusted at the low level, but within normal operating range, by normal operation recommended by the manufacturer, such as driving the vehicle or using an external charger. The accurate

adjustment is not required as long as the normal operation of the REESS is enabled;

c. For vehicle-based test of vehicles with on-board energy conversion systems (e.g. internal combustion engine, fuel cell, etc.), adjust the fuel level to nearly empty but enough so that the vehicle can enter into active driving possible mode;

d. At the beginning of the test, all protection devices which would affect the function of the Tested-Device and which are relevant for the outcome of the test shall be operational.

8.2.7.3.2. Discharging.

The procedure for discharging the REESS for vehicle-based test shall be in accordance with clause s 8.2.7.3.2.1. and 8.2.7.3.2.2. Alternatively, the procedure for discharging the REESS for vehicle-based test shall be in accordance with clause 8.2.7.3.2.3. For component-based test, the discharging procedure shall be in accordance with clause 8.2.7.3.2.4.

8.2.7.3.2.1. Discharge by vehicle driving operation.

This procedure is applicable to the vehicle-based tests in active driving possible mode:

a. The vehicle shall be driven on a chassis dynamometer. The vehicle operation on a chassis dynamometer (e.g. simulation of continuous driving at steady speed) that will deliver as constant discharging power as reasonably achievable shall be determined, if necessary, through consultation with the manufacturer;

b. The REESS shall be discharged by the vehicle operation on a chassis dynamometer in accordance with clause 8.2.7.3.2.1.(a). The vehicle operation on the chassis dynamometer shall be terminated when the vehicle's over-discharge protection control terminates REESS discharge current or the temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours. Where an over-discharge protection control fails to operate, or if there is no such control, then the discharging shall be continued until the REESS is discharged to 25 per cent of its nominal voltage level;

c. Immediately after the termination of discharging, one standard charge followed by a standard discharge as described in clause 8.2.1.1. shall be conducted if it is not prohibited by the vehicle.

8.2.7.3.2.2. Discharge by auxiliary electrical equipment (vehicle-based test).

This procedure is applicable to the vehicle-based tests in stationary condition:

a. The vehicle shall be switched in to a stationary operation mode that allow consumption of electrical energy from REESS by auxiliary electrical equipment. Such an operation mode shall be determined, if necessary, through consultation with the manufacturer. Equipments (e.g. wheel chocks) that prevent the vehicle movement may be used as appropriate to ensure the safety during the test;

b. The REESS shall be discharged by the operation of electrical equipment, air-conditioning, heating, lighting, audio-visual equipment, etc., that can be switched on under the conditions given in clause 8.2.7.3.2.2.(a). The operation shall be terminated when the vehicle's over-discharge protection control terminates REESS discharge current or the temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours. Where an over-discharge protection control fails to operate, or if there is no such control, then the discharging shall be continued until the REESS is discharged to 25 per cent of its nominal voltage level;

c. Immediately after the termination of discharging, one standard charge followed by a standard discharge as described in clause 8.2.1.1. shall be conducted if it is not prohibited by the vehicle.

8.2.7.3.2.3. Discharge of REESS using discharge resistor (vehicle-based test).

This procedure is applicable to vehicles for which the manufacturer provides information to connect a breakout harness to a location just outside the REESS that permits discharging the REESS:

a. Connect the breakout harness to the vehicle as specified by the manufacturer. Place the vehicle in active driving possible mode;

b. A discharge resistor is connected to the breakout harness and the REESS shall be discharged at a discharge rate under normal operating conditions in accordance with manufacturer provided information. A resistor with discharge power of 1 kW may be used;

c. The test shall be terminated when the vehicle's over-discharge protection control terminates REESS discharge current or the temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours. Where an automatic discharge interrupt function fails to operate, or if there is no such function, then the discharging shall be continued until the REESS is discharged to 25 per cent of its nominal voltage level;

d. Immediately after the termination of discharging, one standard charge followed by a standard discharge as described in clause 8.2.1.1. shall be conducted if it is not prohibited by the vehicle.

8.2.7.3.2.4. Discharge by external equipment (component-based test).

This procedure is applicable to component-based test:

a. All relevant main contactors shall be closed. The external charge-discharge shall be connected to the main terminals of the tested-device;

b. A discharge shall be performed with a stable current within the normal operating range as specified by the manufacturer;

c. The discharging shall be continued until the Tested-Device (automatically) terminates REESS discharge current or the temperature of the Tested-Device is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours. Where an automatic interrupt function fails to operate, or if there is no such function, then the discharging shall be continued until the Tested-Device is discharged to 25 per cent of its nominal voltage level;

d. Immediately after the termination of the discharging, one standard charge followed by a standard discharge as described in clause 8.2.1.1. shall be conducted if not inhibited by the Tested-Device.

8.2.7.4. The test shall end with an observation period of 1 h at the ambient temperature conditions of the test environment.

8.2.8. Over-temperature protection test.

8.2.8.1. Purpose.

The purpose of this test is to verify the performance of the protection measures of the REESS against internal overheating during operation. In the case that no specific protection measures are necessary to prevent the REESS from reaching an unsafe state due to internal over-temperature, this safe operation must be demonstrated.

8.2.8.2. The test may be conducted with a complete REESS according to clause s 8.2.8.3. and 8.2.8.4. or with a complete vehicle according to clause s 8.2.8.5 and 8.2.8.6.

8.2.8.3. Installation for test conducted using a complete REESS.

8.2.8.3.1. Ancillary systems that do not influence to the test results may be omitted from the tested-device. The test may be performed with a modified Tested-Device provided these modifications shall not influence the test results.

8.2.8.3.2. Where a REESS is fitted with a cooling function and where the REESS will remain functional in delivering its normal power without a cooling function system being operational, the cooling system shall be deactivated for the test.

8.2.8.3.3. The temperature of the Tested-Device shall be continuously measured inside the casing in the proximity of the cells during the test in order to monitor the changes of the temperature. The on-board sensors, if existing, may be used with compatible tools to read the signal.

8.2.8.3.4. The REESS shall be placed in a convective oven or climatic chamber. If necessary, for conduction the test, the REESS shall be connected to the rest of vehicle control system with extended cables. An external charge/discharge equipment may be connected under supervision by the vehicle manufacturer.

8.2.8.4. Test procedures for test conducted using a complete REESS.

8.2.8.4.1. At the beginning of the test, all protection devices which affect the function of the Tested-Device and are relevant to the outcome of the test shall be operational, except for any system deactivation implemented in accordance with clause 8.2.8.3.2.

8.2.8.4.2. The Tested-Device shall be continuously charged and discharged by the external charge/discharge equipment with a current that will increase the temperature of cells as rapidly as possible within the range of normal operation as defined by the manufacturer until the end of the test. Alternatively, the charge and discharge may be conducted by vehicle driving operations on chassis dynamometer where the driving operation shall be determined through consultation with the manufacturer to achieve the conditions above.

8.2.8.4.3. The temperature of the chamber or oven shall be gradually increased, from 20 ± 10 °C or at higher temperature if requested by the manufacturer, until it reaches the temperature determined in accordance with clause 8.2.8.4.3.1 or clause 8.2.8.4.3.2 below as applicable, and then maintained at a temperature that is equal to or higher than this, until the end of the test.

8.2.8.4.3.1. Where the REESS is equipped with protective measures against internal overheating, the temperature shall be increased to the temperature defined by the manufacturer as being the operational temperature threshold for such protective measures, to insure that the temperature of the Tested-Device will increase as specified in clause 8.2.8.4.2.

8.2.8.4.3.2. Where the REESS is not equipped with any specific measures against internal over-heating the temperature shall be increased to the maximum operational temperature specified by the manufacturer.

8.2.8.4.4. The test will end when one of the followings is observed:

a. The Tested-Device inhibits and/or limits the charge and/or discharge to prevent the temperature increase;
b. The temperature of the Tested-Device is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours;
c. Any failure of the acceptance criteria prescribed in clause 7.3.8.

8.2.8.4.5. Installation for test conducted using a complete vehicle.

8.2.8.4.5.1. Based on information from the manufacturer, for an REESS fitted with a cooling function the cooling system shall be disabled or in a state of significantly reduced operation (for an REESS that will not operate if the cooling system is disabled) for the test.

8.2.8.4.5.2. The temperature of the REESS shall be continuously measured inside the casing in the proximity of the cells during the test in order to monitor the changes of the temperature using on-board sensors and compatible tools according to manufacturer provided information to read the signals.

8.2.8.4.5.3. For vehicles with on-board energy conversion systems, adjust the fuel level to nearly empty but so that the vehicle can enter into active driving possible mode.

8.2.8.4.5.4. The vehicle shall be placed in in a climate control chamber set to a temperature between 40 °C to 45 °C for at least 6 hours.

8.2.8.6. **Test procedures for test conducted using a complete vehicle.**

8.2.8.6.1. **The vehicle shall be continuously charged and discharged in a manner that will** increases the temperature of REESS cells as rapidly as possible within the range of normal operation as defined by the manufacturer until the end of the test.

The charge and discharge will be conducted by vehicle driving operations on chassis dynamometer where the driving operation shall be determined through consultation with the manufacturer to achieve the conditions above.

For a vehicle that can be charged by an external power supply, the charging may be conducted using an external power supply if more rapid temperature increase is expected.

8.2.8.6.2. **The test will end when one of the followings is observed:**

a. The vehicle terminates the charge and/or discharge;
b. The temperature of the REESS is stabilised such that the temperature varies by a gradient of less than 4 °C through 2 hours;
c. Any failure of the acceptance criteria prescribed in clause 7.3.8.;
d. 3 hours elapse from the time of starting the charge/discharge cycles in clause 8.2.8.6.1.

8.2.9. **Reserved**.

8.2.10. Mechanical shock test.

8.2.10.1 **Purpose**.

The purpose of this test is to verify the safety performance of the REESS under inertial loads which may occur during a vehicle crash.

8.2.10.2 **Installations**.

8.2.10.2.1 This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested-Device if so requested by the manufacturer.

8.2.10.2.2 The Tested-Device shall be connected to the test fixture only by the intended mountings provided for the purpose of attaching the REESS or REESS subsystem to the vehicle.

8.2.10.3 **Procedures**.

8.2.10.3.1 General test conditions and requirements.

The following condition shall apply to the test:

a. The test shall be conducted at an ambient temperature of 20 ± 10 °C;

b. At the beginning of the test, the SOC shall be adjusted in accordance with the clause 8.2.1.2.;

c. At the beginning of the test, all protection devices which affect the function of the Tested-Device and which are relevant to the outcome of the test, shall be operational.

8.2.10.3.2 Test procedure.

The Tested-Device shall be decelerated or accelerated in compliance with the acceleration corridors which are specified in Figure 29 and Tables 7 or 8. The manufacturer shall decide whether the tests shall be conducted in either the positive or negative direction or both.

For each of the test pulses specified, a separate Tested-Device may be used.

The test pulse shall be within the minimum and maximum value as specified in Tables 7 or 8. A higher shock level and /or longer duration as described in the maximum value in Tables 7 or 8 can be applied to the Tested-Device if recommended by the manufacturer.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

Figure 29 - Generic description of test pulses

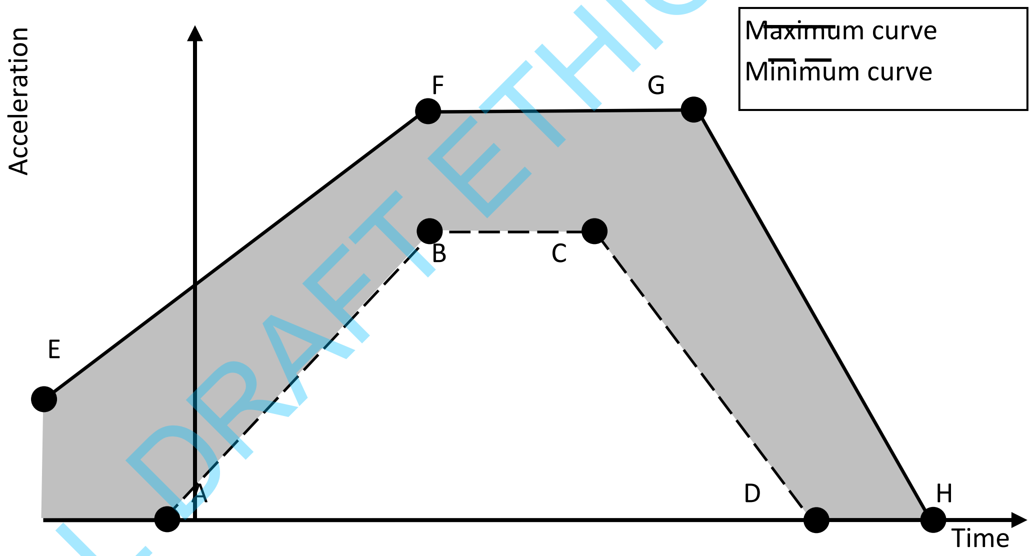


Table 7

Values for vehicles with GVM between 3,500 kg and 12,000 kg

		Acceleration (g)	
Point	Time (ms)	Longitudinal	Transverse
A	20	0	0
B	50	10	5
C	65	10	5
D	100	0	0
E	0	5	2.5
F	50	17	10
G	80	17	10
H	120	0	0

Table 8

Values for vehicles with GVM exceeding 12,000 kg

		Acceleration (g)	
Point	Time (ms)	Longitudinal	Transverse
A	20	0	0
B	50	6.6	5
C	65	6.6	5
D	100	0	0
E	0	4	2.5
F	50	12	10
G	80	12	10
H	120	0	0

Annex 1

(Normative)

Determination of hydrogen emissions during the charge procedures of the REESS

1. **Introduction**

This annex describes the procedure for the determination of hydrogen emissions during the charge procedures of the REESS with open-type traction battery, according to clause 5.4.11.2. of this UN GTR.

2. Description of test

The hydrogen emission test (Figure 1 of this annex) is conducted in order to determine hydrogen emissions during the charge procedures of the REESS with the charger. The test consists in the following steps:

(a) Vehicle/REESS preparation;

(b) Discharge of the REESS;

(c) Determination of hydrogen emissions during a normal charge;

(d) Determination of hydrogen emissions during a charge carried out with the charger failure.

3. Tests

3.1. Vehicle based test.

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

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

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

3.2. Component based test.

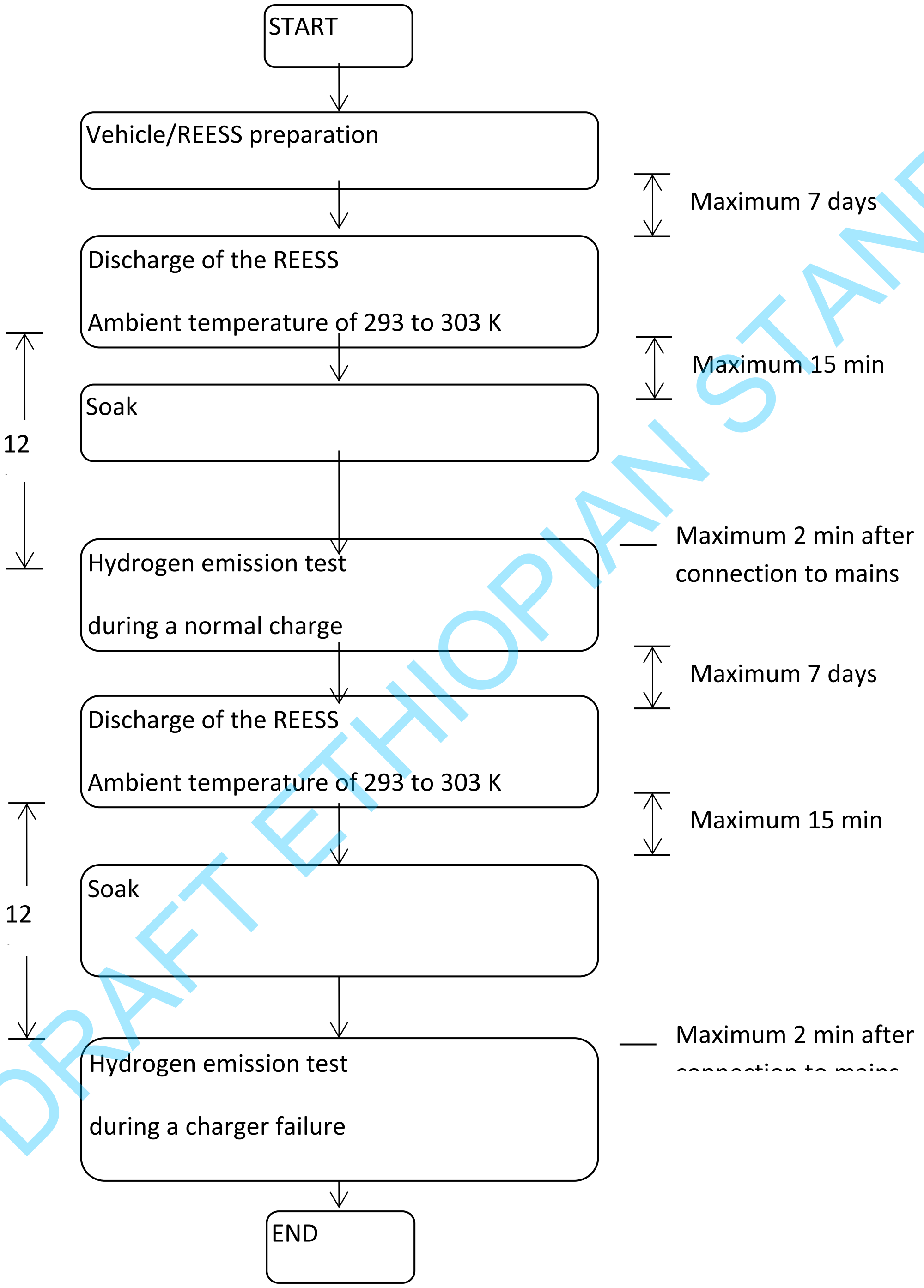
3.2.1. The REESS shall be in good mechanical condition and have been subject to minimum of 5 standard cycles (as specified in clause 6.2.1.1. or clause 8.2.1.1, as applicable, of this regulation).

3.2.2. If the REESS is used at a temperature above the ambient temperature, the operator shall follow the manufacturer's procedure in order to keep the REESS temperature in its normal functioning range.

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

Figure 1

Determination of hydrogen emissions during the charge procedures of the REESS



4. Test equipment for hydrogen emission test

4.1. Hydrogen emission measurement enclosure.

The hydrogen emission measurement enclosure shall be a gas-tight measuring chamber able to contain the vehicle/REESS under test. The vehicle/REESS 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 1, Appendix 1, clause 2.1.1.), taking into account hydrogen emissions during testing.

4.2. Analytical systems.

4.2.1. Hydrogen analyser.

4.2.1.1. 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.

4.2.1.2. The hydrogen analyser shall have a response time to 90 per cent of final reading of less than 10 s. Its stability shall be better than 2 per cent of full scale at zero and at 80 ± 20 per cent of full scale, over a 15-minutes period for all operational ranges.

4.2.1.3. 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 ± 20 per cent of full scale on all ranges used.

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

4.2.2. 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.

4.3. Temperature recording.

4.3.1. 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.

4.3.2. The temperatures in the proximity of the cells are recorded by means of the sensors.

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

4.3.4. 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.

4.3.5. The recording or data processing system shall be capable of resolving time to ± 15 s.

4.4. Pressure recording.

4.4.1. 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.

4.4.2. 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.

4.4.3. The recording or data processing system shall be capable of resolving time to ± 15 s.

4.5. Voltage and current intensity recording.

4.5.1. The charger voltage and current intensity (battery) shall, throughout the hydrogen emission measurements, be recorded at a frequency of at least once per minute.

4.5.2. 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.

4.5.3. 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.

4.5.4. The recording or data processing system shall be capable of resolving time to ± 15 s.

4.6. 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.

4.7. Gases.

4.7.1. 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.

4.7.2. 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/REESS preparation;

(b) discharge of the REESS;

(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 charger failure.

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

5.1. Vehicle based test.

5.1.1. Vehicle preparation.

The ageing of REESS 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.

5.1.1.1. Discharges and initial charges of the REESS.

The procedure starts with the discharge of the REESS of the vehicle while driving on the test track or on a chassis dynamometer at a steady speed of 70± 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.

5.1.1.2. Initial charge of the REESS.

The charge is carried out:

(a) With the charger;

(b) In an ambient temperature between 293 K and 303 K.

The procedure excludes all types of external chargers.

The end of REESS charge criteria corresponds to an automatic stop given by the 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.

5.1.1.3. Procedure from clause s 5.1.1.1. and 5.1.1.2. shall be repeated 2 times.

5.1.2. Discharge of the REESS.

The REESS is discharged while driving on the test track or on a chassis dynamometer at a steady speed of 70 ± 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.

5.1.3. Soak.

Within fifteen minutes of completing the battery discharge operation specified in clause 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 ± 2 K.

5.1.4. Hydrogen emission test during a normal charge.

5.1.4.1. 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.

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

5.1.4.3. 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.

5.1.4.4. The vehicle shall be connected to the mains. The REESS is charged according to normal charge procedure as specified in clause 5.1.4.7. below.

5.1.4.5. The enclosure doors are closed and sealed gas-tight within 2 minutes from electrical interlock of the normal charge step.

5.1.4.6. 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 CH2i, Ti and Pi for the normal charge test.

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

5.1.4.7. Procedure of normal charge.

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

(a) Charging at constant power during t1;

(b) Over-charging at constant current during t2. Over-charging intensity is specified by manufacturer and corresponds to the one used during equalisation charging.

The end of REESS charge criteria corresponds to an automatic stop given by the charger to a charging time of t1 + t2. This charging time will be limited to t1 + 5 h, even if a clear indication is given to the driver by the standard instrumentation that the battery is not yet fully charged.

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

5.1.4.9. The end of the emission sampling period occurs t1 + t2 or t1 + 5 h after the beginning of the initial sampling, as specified in clause 5.1.4.6. of this annex. The different times elapsed are recorded. The hydrogen concentration, temperature and barometric pressure are measured to give the final readings CH2f, Tf and Pf for the normal charge test, used for the calculation in clause 6. of this annex.

5.1.5. Hydrogen emission test with the charger failure.

5.1.5.1. Within seven days maximum after having completed the prior test, the procedure starts with the discharge of the REESS of the vehicle according to clause 5.1.2. of this annex.

5.1.5.2. The steps of the procedure in clause 5.1.3. of this annex shall be repeated.

5.1.5.3. 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.

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

5.1.5.5. 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.

5.1.5.6. The vehicle shall be connected to the mains. The REESS is charged according to failure charge procedure as specified in clause 5.1.5.9. below.

5.1.5.7. The enclosure doors are closed and sealed gas-tight within 2 minutes from electrical interlock of the failure charge step.

5.1.5.8. 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_{H2i}, T_i and P_i for the failure charge test.

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

5.1.5.9. Procedure of charging failure.

The charging failure is carried out with the suitable charger and consists of the following steps:

(a) Charging at constant power during t'1;

(b) Charging at maximum current as recommended by the manufacturer during 30 minutes. During this phase, the charger shall supply maximum current as recommended by the manufacturer.

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

5.1.5.11. The end of test period occurs t'1 + 30 minutes after the beginning of the initial sampling, as specified in clause 5.1.5.8. above. The times elapsed are recorded. The hydrogen concentration, temperature and barometric pressure are measured to give the final readings C_{H2f}, T_f and P_f for the charging failure test, used for the calculation in clause 6. of this annex.

5.2. Component based test.

5.2.1. REESS preparation.

The ageing of REESS shall be checked, to confirm that the REESS has performed at least 5 standard cycles (as specified in clause 6.2.1.).

5.2.2. Discharge of the REESS.

The REESS is discharged at 70 ± 5 per cent of the nominal power of the system.

Stopping the discharge occurs when minimum SOC as specified by the manufacturer is reached.

5.2.3. Soak.

Within 15 minutes of the end of the REESS discharge operation specified in clause 5.2.2. above, and before the start of the hydrogen emission test, the REESS shall be soaked at 293 ± 2 K for a minimum period of 12 hours and a maximum of period of 36 h.

5.2.4. Hydrogen emission test during a normal charge

5.2.4.1. Before the completion of the REESS's 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.

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

5.2.4.3. At the end of the soak period, the REESS shall be moved into the measuring chamber.

5.2.4.4. The REESS shall be charged in accordance with the normal charge procedure as specified in clause 5.2.4.7. below.

5.2.4.5. The chamber shall be closed and sealed gas-tight within two minutes of the electrical interlock of the normal charge step.

5.2.4.6. The start of a normal charge for hydrogen emission test period shall begin when the chamber is sealed. The hydrogen concentration, temperature and barometric pressure are measured to give the initial readings C_{H2i}, T_i and P_i for the normal charge test.

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

5.2.4.7. Procedure of normal charge

The normal charge is carried out with a suitable 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 corresponding to that used during equalisation charging.

The end of REESS charge criteria corresponds to an automatic stop given by the 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 by a suitable instrumentation that the REESS is not yet fully charged.

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

5.2.4.9. 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 clause 5.2.4.6. above. The different times elapsed are recorded. The hydrogen concentration, temperature and barometric pressure are measured to give the final readings C_{H2f}, T_f and P_f for the normal charge test, used for the calculation in clause 6. of this annex.

5.2.5. Hydrogen emission test with the charger failure.

5.2.5.1. The test procedure shall start within a maximum of seven days after having completed the test in clause 5.2.4. above, the procedure shall start with the discharge of the REESS of the vehicle in accordance with clause 5.2.2. above.

5.2.5.2. The steps of the procedure in clause 5.2.3. above shall be repeated.

5.2.5.3. 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.

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

5.2.5.5. At the end of the soak the REESS shall be moved into the measuring chamber.

5.2.5.6. The REESS shall be charged according to the failure charge procedure as specified in clause 5.2.5.9. below.

5.2.5.7. The chamber shall be closed and sealed gas-tight within 2 minutes from electrical interlock of the failure charge step.

5.2.5.8. 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 CH2i, Ti and Pi for the failure charge test.

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

5.2.5.9. Procedure of charging failure.

The charging failure is carried out with a suitable charger and consists of the following steps:

(a) Charging at constant power during t'1;

(b) Charging at maximum current as recommended by the manufacturer during 30 minutes. During this phase, the charger shall supply maximum current as recommended by the manufacturer.

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

5.2.5.11. The end of test period occurs t'1 + 30 minutes after the beginning of the initial sampling, as specified in clause 5.2.5.8. above. The times elapsed are recorded. The hydrogen concentration, temperature and barometric pressure are measured to give the final readings CH2f, Tf and Pf for the charging failure test, used for the calculation in clause 6. below.

6. Calculation

The hydrogen emission tests described in clause 5. above 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:

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

Where:

MH2 = hydrogen mass, in grams;

CH2 = measured hydrogen concentration in the enclosure, in ppm volume;

V = net enclosure volume in cubic metres (m3) 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 m3 is subtracted;

Vout = compensation volume in m3, 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 REESS are:

MN = hydrogen mass emission for normal charge test, in g;

MD = hydrogen mass emission for charging failure test, in g.

Annex 1 - 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 m3 from the internal volume of the chamber. Alternatively the volume of the test vehicle with the luggage compartment and windows open or REESS may be used instead of the 1.42 m3.

2.1.3. The chamber shall be checked as in clause 2.3. of this annex. 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 clause 2.1.1. above. Ambient temperature shall be maintained at 293 ± 2 K, throughout the 4-hours period mentioned below.

2.2.2. The enclosure may be sealed and the mixing fan operated for a period of up to 12 h before the 4-hours 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 CH2i, Ti and Pi 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 4 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 CH2f, Tf and Pf.

2.2.8. The change in mass of hydrogen in the enclosure shall be calculated over the time of the test in accordance with clause 2.4. of this annex 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 (clause 2.1. above) 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 6 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 K ± 2 K, the enclosure is sealed and the background concentration, temperature and barometric pressure measured. These are the initial readings CH2i, Ti and Pi 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 CH2f, Tf and Pf for the calibration of the enclosure as well as the initial readings CH2i, Ti and Pi for the retention check.

2.3.8. On the basis of the readings taken in clause s 2.3.4 and 2.3.7 above and the formula in clause 2.4. below, the mass of hydrogen in the enclosure is calculated. This shall be within ± 2 per cent of the mass of hydrogen measured in clause 2.3.6. above.

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 CH2f, Tf and Pf for the hydrogen retention check.

2.3.10. Using the formula in clause 2.4. below, the hydrogen mass is then calculated from the readings taken in clause s 2.3.7 and 2.3.9. above. This mass may not differ by more than 5 per cent from the hydrogen mass given by clause 2.3.8. above.

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

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

the mass change.

Where:

MH2 = hydrogen mass, in grams

CH2 = measured hydrogen concentration into the enclosure, in ppm volume

V = enclosure volume in cubic metres (m3) as measured in clause 2.1.1. above.

Vout = compensation volume in m³, 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 analyser

The analyser should be calibrated using hydrogen in air and purified synthetic air. See clause 4.8.2. of Annex 1.

Each of the normally used operating ranges is 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 clause 3.2. above, a table of analyser 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 analyser 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) real and indicated value of each calibration gas used together with the percentage differences;

(f) calibration pressure of analyser.

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 2

(Normative)

Verification method for testing authorities confirming document based isolation resistance compliance of electrical design of the vehicle after water exposure

This annex describes the applicable requirements when certifying the manufacturers' high voltage equipment or system components against adverse water effects rather than a physical test. As a general rule, the electrical design or components of the vehicles shall comply with the requirements as specified in clause s "5.1.1.1. or 7.1.1.1. Protection against direct contact, 5.1.1.2. or 7.1.1.2. Protection against indirect contact", and 5.1.1.2.4. or 7.1.1.2.4. respectively. Isolation resistance and this will be separately verified by the testing authority. Vehicle manufacturers shall provide information to testing authorities to identify, as a point of reference, the mounting location for each high-voltage component in/on the vehicle.

1. Documentation shall contain the following information:

(a) on how the manufacturer tested isolation resistance compliance of electrical design of the vehicle by using fresh water;

(b) on how, after the test had been carried out, the high-voltage component or system was inspected for ingress of water and how, depending on its mounting location, each high voltage component/system met the appropriate degree of protection against water.

2. The testing authority will verify and confirm the authencity of documented conditions that have been observed, and should have been complied with, during the process of certification by manufacturer:

2.1. It is permitted that, during the test, the moisture contained inside the enclosure is partly condensed. The dew which may be deposited is not considered as ingress of water. For the purpose of the tests, the surface area of the tested high-voltage component or system is calculated with an accuracy of 10 per cent. If possible, the tested high-voltage component or system is run energized. If the tested high-voltage component or system is energized, adequate safety precautions are taken.

2.2. For electrical components, externally attached (e.g. in engine compartment), open underneath, both exposed or protected locations, the testing authority shall verify, with a view to confirming the compliance, whether the test is conducted by spraying the high-voltage component or system from all practicable directions with a stream of water from a standard test nozzle as shown in Figure 1. The following parameters are observed during the test in particular:

(a) Nozzle internal diameter: 6.3 mm;

(b) Delivery rate: 11.9 – 13.2 l/min;

(c) Water pressure at the nozzle: approximately 30 kPa (0.3 bar);

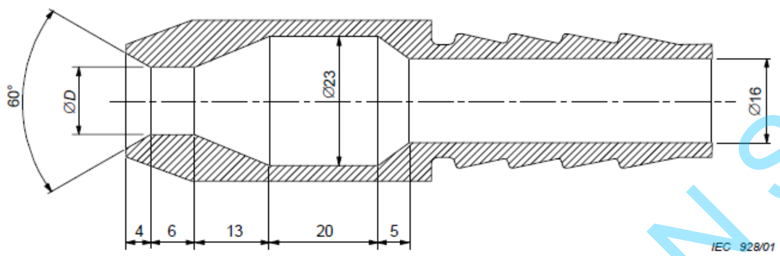
(d) Test duration per m2 of surface area of the tested high-voltage component or system: 1 min;

(e) Minimum test duration: 3 min;

(f) Distance from nozzle to tested high-voltage component or system surface: approximately 3 m (this distance may be reduced, if necessary to ensure proper wetting when spraying upwards).

Figure 1

Standard nozzle for the test



Dimensions in millimetres
D is 6.3 mm as specified in (a) above.

2.3. For electrical components, externally attached (e.g. in engine compartment), covered from underneath, the testing authority shall verify, with a view to confirming the compliance, whether:

(a) The cover protects the component against direct spray water from underneath and is not visible;

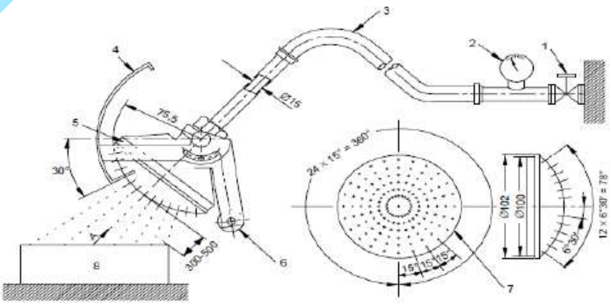
(b) The test is conducted by using splashing test nozzle as shown in Figure 2;

(c) The moving shield is removed from the spray nozzle and the machine is sprayed from all practicable directions;

(d) The water pressure is adjusted to give a delivery rate of (10 ± 0.5) l/min (pressure approximately 80 kPa to 100 kPa (0.8 bar to 1.0 bar));

(e) The test duration is 1 min/m2 of calculated surface area of the machine (excluding any mounting surface and cooling fin) with a minimum duration of 5 min.

Figure 2



Viewed according to arrow A (with shield removed)

Splashing test nozzle

Note:

1. Cock	7. Spray nozzle – brass with 121 holes ∅ 0,5:
2. Pressure gauge	1 hole in centre
3. Hose	2 inner circles of 12 holes at 30° pitch
4. Moving shield – aluminium	4 outer circles of 24 holes at 15° pitch
5. Spray nozzle	8. Machine under test
6. Counter weight	

3. The entire high voltage system or each component is checked to comply with the isolation resistance requirement in clause 5.1.1.2.4. or clause 7.1.1.2.4. with the following conditions:

(a) The electric chassis shall be simulated by an electric conductor, e.g. a metal plate, and the components are attached with their standard mounting devices to it;

(b) Cables, where provided, shall be connected to the component.

4. The parts designed not to be wet during operation are not allowed to be wet and no accumulation of water which could have reached them is tolerated inside the high-voltage component or system.

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Organization and Objectives

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- Develop Ethiopian standards and establish a system that enable to check whether goods and service are in compliance with the required standards,
- Facilitate the country's technology transfer through the use of standards,
- Develop national standards for local products and services so as to make them competitive in the international market.
- Conduct standards related research and provide training and technical support.

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For More Information?
Contact us at the following address.
The Head Office of IES is at Addis Ababa.
☎011-6460685, 011-6460565
011-6460880
✉2310AddisAbaba, Ethiopia
E-mail:info@ethiostandards.org
Website:www.ethiostandards.org

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