

## 64-1 Electric safety requirements for battery electric vehicles: Effective date from 2019/1/1

Refer to: R100 02-S3

### 64-1.1 Effective Date and Scope:

64-1.1.1 Effective date from 2019/1/1, the new type of vehicles and from 2021/1/1, all types of vehicles as below, shall comply with this regulation. The existing vehicle variants of category symbols M and N electric vehicles which were confirmed to “64. Electric safety requirements for battery electric vehicles”, regard as conform to this regulation.

64-1.1.1.1 Equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid, as well as their high voltage components and systems which are galvanically connected to the high voltage bus of the electric power train of category symbols M and N electric vehicles.

64-1.1.2 This Regulation does not apply to the vehicle with a maximum design speed not exceeding 25 km/h, and the REESS(s) whose primary use is to supply power for starting the engine and/or lighting and/or other vehicle auxiliaries systems.

64-1.1.3 The same applicant applying for low volume safety approval and the amounts of vehicle not exceed 3 at same year and vehicle of same variant and specification, could exempt from paragraph 64-1.4.1.3 Isolation resistance and / or paragraph 64-1.7. Confirmation method for functions of on-board isolation resistance monitoring system and the paragraph 64-1.8. of this Regulation; Notwithstanding the paragraph above, category symbols M2 or M3 electric vehicles shall still comply with the paragraph 64-1.8. of this Regulation.

64-1.1.4 The same applicant applying for vehicle-by-vehicle low volume safety approval and the amounts of vehicle not exceed 20 at same year and vehicle of same variant and specification, could exempt from paragraph 64-1.4.1.3 Isolation resistance and / or paragraph 64-1.7. Confirmation method for functions of on-board isolation resistance monitoring system and the paragraph 64-1.8. of this Regulation; Notwithstanding the paragraph above, category symbols M2 or M3 electric vehicles shall still comply with the paragraph 64-1.8. of this Regulation.

64-1.1.5 The applicant applying for low volume or vehicle-by-vehicle low volume safety approval could exempt from the table 2 and table 3.

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64-1.1.6 Technical Service can carry out test according to UN Regulations that this direction harmonized with: R100 02 Series of amendments and following amendments of above-mentioned regulations.

## 64-1.2 Definitions

64-1.2.1 "Active driving possible mode" means the vehicle mode when application of pressure to the accelerator pedal (or activation of an equivalent control) or release of the brake system will cause the electric power train to move the vehicle.

64-1.2.2 "Barrier" means the part providing protection against direct contact to the live parts from any direction of access.

64-1.2.3 "Cell" means a single encased electrochemical unit containing one positive and one negative electrode which exhibits a voltage differential across its two terminals.

64-1.2.4 "Conductive connection" means the connection using connectors to an external power supply when the REESS is charged.

64-1.2.5 "Coupling system for charging the rechargeable energy storage system (REESS)" means the electrical circuit used for charging the REESS from an external electric power supply including the vehicle inlet.

64-1.2.6 "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 of the state of charge and 100 per cent of the state of charge.

64-1.2.7 "Direct contact" means the contact of persons with live parts.

64-1.2.8 "Electrical chassis" means a set made of conductive parts electrically linked together, whose potential is taken as reference.

64-1.2.9 "Electrical circuit" means an assembly of connected live parts which is designed be electrically energized in normal operation.

64-1.2.10 "Electric energy conversion system" means a system that generates and provides electric energy for electric propulsion.

64-1.2.11 "Electric power train" means the electrical circuit which includes the traction motor(s), and may 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.

64-1.2.12 "Electronic converter" means a device capable of controlling and/or converting electric power for electric propulsion.

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64-1.2.13 "Enclosure" means the part enclosing the internal units and providing protection against direct contact from any direction of access.

64-1.2.14 "Exposed conductive part" means the conductive part which can be touched under the provisions of the protection degree IPXXB, and which becomes electrically energized under isolation failure conditions. This includes parts under a cover that can be removed without using tools.

64-1.2.15 "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.

64-1.2.16 "External electric power supply" means an alternating current (AC) or direct current (DC) electric power supply outside of the vehicle.

64-1.2.17 "High Voltage" means the classification of an electric component or circuit, if its working voltage is  $> 60 \text{ V}$  and  $\leq 1500 \text{ V DC}$  or  $> 30 \text{ V}$  and  $\leq 1000 \text{ V AC}$  root mean square (rms).

64-1.2.18 "Fire" means the emission of flames from a tested-device. Sparks and arcing shall not be considered as flames.

64-1.2.19 "Flammable electrolyte" means an electrolyte that contains flammable substances.

64-1.2.20 "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, are galvanically connected to the electrical chassis and the maximum voltage between any live part and the electrical chassis or any exposed conductive part is  $\leq 30 \text{ V AC}$  and  $\leq 60 \text{ V DC}$ , only the components or parts of the electric circuit that operate on high voltage are classified as a high voltage bus.

64-1.2.21 "Indirect contact" means the contact of persons or livestock with exposed conductive parts.

64-1.2.22 "Live parts" means the conductive part(s) intended to be electrically energized in normal use.

64-1.2.23 "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 live parts, being separated from the passenger compartment by the front bulkhead or the rear bulk head.

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64-1.2.24 "On-board isolation resistance monitoring system" means the device which monitors the isolation resistance between the high voltage buses and the electrical chassis.

64-1.2.25 "Open type traction battery" means a liquid type battery requiring refilling with water and generating hydrogen gas released to the atmosphere.

64-1.2.26 "Passenger compartment" means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, window glass, front bulkhead and rear bulkhead, or rear gate, as well as by the barriers and enclosures provided for protecting the occupants from direct contact with live parts.

64-1.2.27 "Protection degree" means the protection provided by a barrier/enclosure related to the contact with live parts by a test probe, such as a test finger (IPXXB) or a test wire (IPXXD), as defined in paragraph 64-1.5.

64-1.2.28 "Rechargeable energy storage system (REESS)" means the rechargeable energy storage system that provides electric energy for electrical propulsion. The REESS may include subsystem(s) together with the necessary ancillary systems for physical support, thermal management, electronic control and enclosures.

64-1.2.29 "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 table 1 and figure 2).

64-1.2.30 "Service disconnect" means the device for deactivation of the electrical circuit when conducting checks and services of the REESS, fuel cell stack, etc.

64-1.2.31 "State of Charge (SOC)" means the available electrical charge in a tested-device expressed as a percentage of its rated capacity.

64-1.2.32 "Solid insulator" means the insulating coating of wiring harnesses provided in order to cover and protect the live parts against direct contact from any direction of access; covers for insulating the live parts of connectors, and varnish or paint for the purpose of insulation.

64-1.2.33 "Subsystem" means any functional assembly of REESS components.

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64-1.2.34 "Tested-device" means either the complete REESS or the subsystem of a REESS that is subjected to the tests prescribed by this Regulation.

64-1.2.35 "Working voltage" means the highest value of an electrical circuit voltage root mean- square (rms), specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions. If the electrical circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.

64-1.2.36 "Type of REESS" means systems which do not differ significantly in such essential aspects as:

64-1.2.36.1 The manufacturer's trade name or mark,

64-1.2.36.2 The chemistry, capacity and physical dimensions of its cells,

64-1.2.36.3 The number of cells, the mode of connection of the cells and the physical support of the cells,

64-1.2.36.4 The construction, materials and physical dimensions of the casing,

64-1.2.36.5 The necessary ancillary devices for physical support, thermal management and electronic control and

64-1.2.36.6 The category of vehicles on which the REESS can be installed.

64-1.2.37 "Chassis connected to the electric circuit" means AC and DC electric circuits galvanically connected to the electrical chassis.

64-1.3 The applicable type and scope principles for battery electric vehicles are as below :

64-1.3.1 If use completed vehicle for testing, which shall according to suitable variants and range of principle are as below : :

64-1.3.1.1 The same vehicle category.

64-1.3.1.2 The same type of large passenger vehicle body.

64-1.3.1.3 The same brand and vehicle type.

64-1.3.1.4 The same type of vehicle propulsion source (internal combustion engine or pure electric motor or hybrid).

64-1.3.1.5 The same installation of the electric power train and the galvanically connected high voltage bus.

64-1.3.1.6 The same nature and type of electric power train and the galvanically connected high voltage components.

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64-1.3.1.7 The same characteristic of REESS.

64-1.3.2 If use chassis vehicle instead of completed vehicle for testing, which shall according to suitable variants and range of principle are as below :

64-1.3.2.1 The same vehicle category.

64-1.3.2.2 The same chassis brand.

64-1.3.2.3 Chassis manufacturers announced that the same chassis vehicle type .

64-1.3.2.4 The same type of vehicle propulsion source (internal combustion engine or pure electric motor or hybrid).

64-1.3.2.5 The same installation of the electric power train and the galvanically connected high voltage bus.

64-1.3.2.6 The same nature and type of electric power train and the galvanically connected high voltage components.

64-1.3.2.7 The same characteristic of REESS.

#### 64-1.4 Tests and requirements:

The applicant required to apply for certification testing shall provide at least one representative vehicle and submit the documents of the essential characteristics of road vehicles (at least contain table 2), or the Essential characteristics of REESS in comply with the paragraph 64-1.8. (at least contain table 3), and incorporate into the documents for installation of the vehicle.

Table 2 - Essential characteristics of road vehicles

1.	General
1.1	Make (trade name of manufacturer)
1.2	Type
1.3	Vehicle category
1.4	Commercial name(s) if available

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1.5	Manufacturer's name and address
1.6	(---)
1.7	Drawing and/or photograph of the vehicle
1.8	Approval report of the REESS (if any)
2.	Electric motor (traction motor)
2.1	Type (winding, excitation)
2.2	Maximum net power and / or maximum 30 minutes power (kW)
3.	REESS
3.1	Trade name and mark of the REESS
3.2	Indication of all types of cells
3.2.1	The cell chemistry
3.2.2	Physical dimensions
3.2.3	Capacity of the cell (Ah)
3.3	Description and / or drawing(s) and / or picture(s) of the REESS explaining
3.3.1	Structure
3.3.2	Configuration (number of cells, mode of connection, etc.)
3.3.3	Dimensions
3.3.4	Casing (construction, materials and physical dimensions)
3.4	Electrical specification
3.4.1	Nominal voltage (V)

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3.4.2	Working voltage (V)
3.4.3	Capacity (Ah)
3.4.4	Maximum current (A)
3.5	Gas combination rate (in per cent)
3.6	Description and / or drawing(s) and / or picture(s) of the installation of the REESS in the vehicle
3.6.1	Physical support
3.7	Type of thermal management
3.8	Electronic control
4.	Fuel Cell (if any)
4.1	Trade name and mark of the fuel cell
4.2	Types of fuel cell
4.3	Nominal voltage (V)
4.4	Number of cells
4.5	Type of cooling system (if any)
5.	Fuse and/or circuit breaker
5.1	Type
5.2	Diagram showing the functional range
6.	Power wiring harness
6.1	Type
7.	Protection against Electric Shock

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7.1	Description of the protection concept
8.	Additional data
8.1	Brief description of the power circuit components installation or drawings/pictures showing the location of the power circuit components installation
8.2	Schematic diagram of all electrical functions included in power circuit
8.3	Working voltage (V)

Table 3 - Essential characteristics of REESS

1.1	Trade name and mark of the REESS
1.2	Indication of all types of cells
1.2.1	The cell chemistry
1.2.2	Physical dimensions
1.2.3	Capacity of the cell (Ah)
1.3	Description or drawing(s) or picture(s) of the REESS explaining
1.3.1	Structure
1.3.2	Configuration (number of cells, mode of connection, etc.)
1.3.3	Dimensions
1.3.4	Casing (construction, materials and physical dimensions)
1.4	Electrical specification
1.4.1	Nominal voltage (V)

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1.4.2	Working voltage (V)
1.4.3	Capacity (Ah)
1.4.4	Maximum current (A)
1.5	Gas combination rate (in percentage)
1.6	Description and / or drawing(s) and / or picture(s) of the installation of the REESS in the vehicle
1.6.1	Physical support
1.7	Type of thermal management
1.8	Electronic control
1.9	Category of vehicles on which the REESS can be installed

#### 64-1.4.1 Protection against Electrical Shock

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

##### 64-1.4.1.1 Protection against direct contact

Protection against direct contact with live parts is also required for vehicles equipped with any REESS type approved under the paragraph 64-1.8. of this Regulation.

Live parts shall be protected against direct contact and shall comply with paragraphs 64-1.4.1.1.1. and 64-1.4.1.1.2. Barriers, enclosures, solid insulators and connectors shall not be able to be opened, separated, 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:

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- (a) They comply with paragraphs 64-1.4.1.1.1. and 64-1.4.1.1.2. when separated, or
- (b) They are located underneath the floor and are provided with a locking mechanism, or
- (c) They are provided with a locking mechanism. 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
- (d) The voltage of the live parts becomes equal or below 60 V DC or equal or below 30 V AC (rms) within 1 s after the connector is separated.

64-1.4.1.1.1 For protection of live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.

64-1.4.1.1.2 For protection of live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB shall be satisfied.

64-1.4.1.1.3 Service disconnect

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

64-1.4.1.1.4 Vehicle Markings

64-1.4.1.1.4.1 In the case of a REESS having high voltage capability the symbol shown in Figure 1 shall appear on or near the REESS.

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



Figure 1 — Marking of high voltage equipment

64-1.4.1.1.4.2 The symbol shall also be visible on enclosures and barriers, which, when removed expose live parts of high voltage circuits. This provision is optional to any connector for high voltage buses. This provision shall not apply to any of the following cases :

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

64-1.4.1.1.4.3 Cables for high voltage buses which are not located within enclosures shall be identified by having an outer covering with the colour orange.

#### 64-1.4.1.2 Protection against indirect contact

Protection against indirect contact is also required for vehicles equipped with any REESS type approved under the paragraph 64-1.8. of this Regulation.

64-1.4.1.2.1 For protection against electrical shock which could arise from indirect contact, the exposed conductive parts, such as the conductive barrier and enclosure, shall be galvanically connected securely to the electrical chassis by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc. so that no dangerous potentials are produced.

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64-1.4.1.2.2 The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2 amperes. This requirement is satisfied if the galvanic connection has been established by welding.

64-1.4.1.2.3 In the case of motor vehicles which are intended to be connected to the grounded external electric power supply through the conductive connection, a device to enable the galvanical connection of the electrical chassis to the earth ground shall be provided.

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

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

#### 64-1.4.1.3 Isolation resistance

64-1.4.1.3.1 Electric power train consisting of separate direct current- or alternating current buses

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

The measurement shall be conducted according to paragraph 64-1.6 "isolation resistance measurement method for vehicle based tests".

64-1.4.1.3.2 Electric power train consisting of combined DC- and AC-buses

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

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

(a) Double or more layers of solid insulators, barriers or enclosures that meet the requirement in paragraph 64-1.4.1.1.

independently, for example wiring harness

(b) Mechanically robust protections that have sufficient durability over vehicle service life such as motor housings, electronic converter cases or connectors.

The isolation resistance between the high voltage bus and the electrical chassis may be demonstrated by calculation, measurement or a combination of both.

The measurement shall be conducted according to paragraph 64-1.6 "Isolation Resistance Measurement Method for vehicle based tests ".

#### 64-1.4.1.3.3 Fuel cell vehicles

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

(a) Double or more layers of solid insulators, barriers or enclosures that meet the requirement in paragraph 64-1.4.1.1 independently.

(b) On-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value. The isolation resistance between the high voltage bus of the coupling system for charging the REESS, which is not energized besides during charging the REESS, and the electrical chassis need not to be monitored. The function of the on-board isolation resistance monitoring system shall be confirmed as described in paragraph 64-1.7.

#### 64-1.4.1.3.4 Isolation resistance requirement for the coupling system for charging the REESS

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

64-1.4.1.3.5 This paragraph shall not apply to chassis connected electrical circuits where the maximum voltage between any live part and the electrical chassis or any exposed conductive part does not exceed 30V AC (rms) or 60 V DC.

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#### 64-1.4.2 Rechargeable Electrical Energy Storage System (REESS)

64-1.4.2.1 For a vehicle with a REESS, the requirement below shall be satisfied.

64-1.4.2.1.1 The REESS shall be installed in accordance with the instructions provided by the manufacturer of the REESS (at least contain the documents of table 3) which specified manner and the vehicle type which REESS can be installed.

64-1.4.2.1.2 The REESS shall comply with the respective requirements of paragraph 64-1.8. of this Regulation.

#### 64-1.4.2.2 Accumulation of gas

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

#### 64-1.4.3 Functional safety requirements

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

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

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

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

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

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

#### 64-1.5 Protection against direct contacts of parts under voltage

##### 64-1.5.1 Access probes

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

##### 64-1.5.2 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,

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it is placed in every possible position, but in no case shall the stop face fully penetrate through the opening.

Internal barriers are considered part of the enclosure.

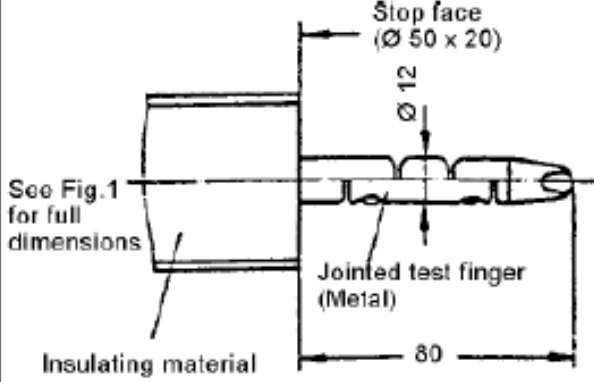
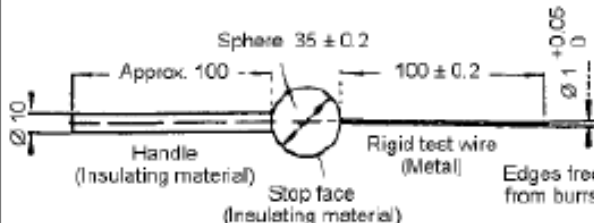
A low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected, if necessary, between the probe and live parts inside the barrier or enclosure.

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

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



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

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

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#### 64-1.5.3 Acceptance conditions

The access probe shall not touch live parts.

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

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

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

#### 64-1.6 Isolation resistance measurement method for vehicle based tests

##### 64-1.6.1 General

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

##### 64-1.6.2 Measurement Method

The isolation resistance measurement shall be conducted by selecting an appropriate measurement method from among those listed in Paragraphs 64-1.6.2.1 through 64-1.6.2.2., depending on the electrical charge of the live parts or the isolation resistance, etc.

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

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

In cases where the measured values are not stable due to the operation of the on-board isolation resistance monitoring system, etc., necessary modification for conducting the measurement may be carried out, such as stopping of the operation of the device concerned or removing it. Furthermore, when the device is removed, it shall be proven, using drawings, etc., that it will not change the isolation resistance between the live parts and the electrical chassis. Utmost care shall be exercised as to short circuit, electric shock, etc., for this confirmation might require direct operations of the high-voltage circuit.

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#### 64-1.6.2.1 Measurement method using DC voltage from off-vehicle sources

##### 64-1.6.2.1.1 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.

##### 64-1.6.2.1.2 Measurement method

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

#### 64-1.6.2.2 Measurement method using the vehicle's own REESS as DC voltage source

##### 64-1.6.2.2.1 Test vehicle conditions

The high voltage-bus shall be 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.

##### 64-1.6.2.2.2 Measurement instrument

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

##### 64-1.6.2.2.3 Measurement method

###### 64-1.6.2.2.3.1 First step

The voltage is measured as shown in Figure 1 and the high voltage Bus voltage ( $V_b$ ) is recorded.  $V_b$  shall be equal to or

greater than the nominal operating voltage of the REESS and/or energy conversion system as specified by the vehicle manufacturer.

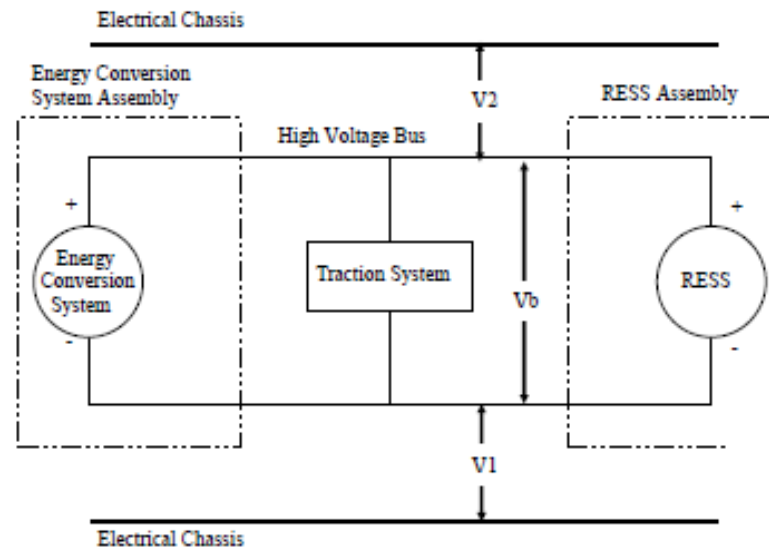


Figure 3: Measurement of  $V_b$ ,  $V_1$ ,  $V_2$

#### 64-1.6.2.2.3.2 Second step

Measure and record the voltage ( $V_1$ ) between the negative side of the high voltage bus and the electrical chassis (see Figure 3):

#### 64-1.6.2.2.3.3 Third step

Measure and record the voltage ( $V_2$ ) between the positive side of the high voltage bus and the electrical chassis (see Figure 3):

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#### 64-1.6.2.2.3.4 Fourth step

If  $V_1$  is greater than or equal to  $V_2$ , insert a standard known resistance ( $R_0$ ) between the negative side of the high voltage bus and the electrical chassis. With  $R_0$  installed, measure the voltage ( $V_1'$ ) between the negative side of the high voltage bus and the electrical chassis (see Figure 4).

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

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

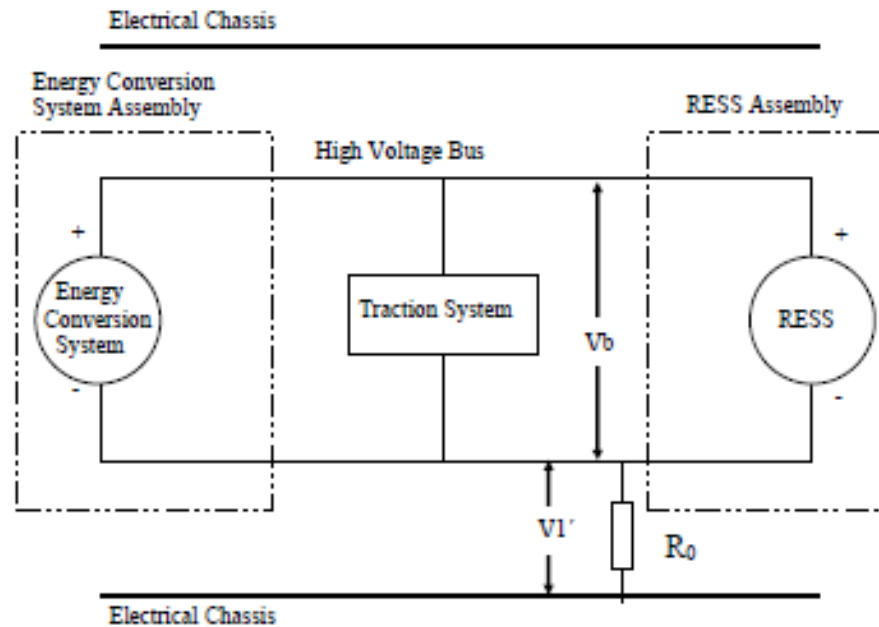


Figure 4: Measurement of  $V_1'$

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

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

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

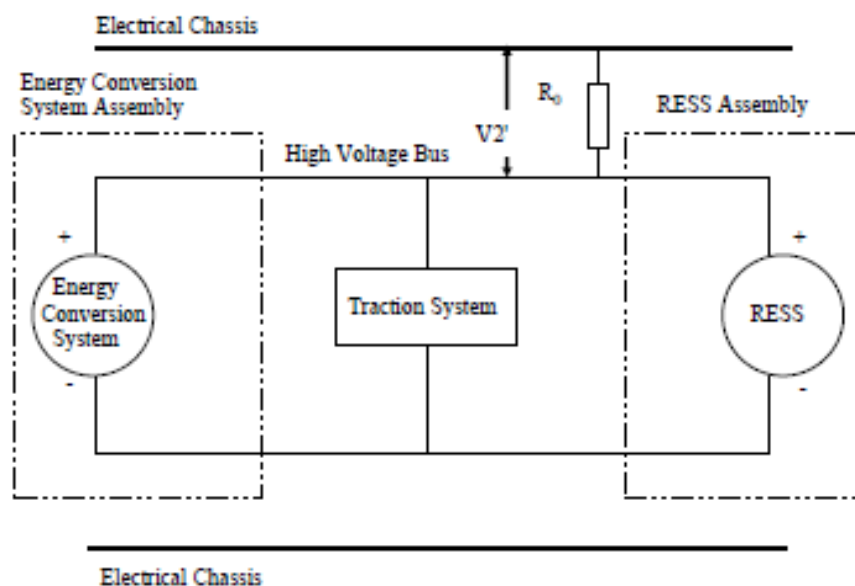


Figure 5: Measurement of  $V_2'$

#### 64-1.6.2.2.3.5 Fifth step

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

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

#### 64-1.7 Confirmation method for functions of on-board isolation resistance monitoring system

The function of the on-board isolation resistance monitoring system shall be confirmed by the following method.

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

64-1.8 Basic safety protection requirements for the installation of REESS, the applicant shall submit the test report that REESS has passed the test according to the following regulations as the compliance documents. In addition, it is also possible to submit the test report of REESS according to UN R100 02 or 03 series, issued by technical services with accreditation for this regulation by MOTC, technical services designated by the United Nations WP.29 1958 agreement or professional institution with on-site confirmation of testing capacity by certification institution, as the compliance documents.

#### 64-1.8.1 Requirements of a Rechargeable Energy Storage System (REESS) with regard to its safety

##### 64-1.8.1.1 General

The procedures prescribed in paragraph 64-1.8.2 of this Regulation shall be applied.

##### 64-1.8.1.2 Vibration

64-1.8.1.2.1 The test shall be conducted in accordance with the paragraph 64-1.8.2.1 to this Regulation.



64-1.8.1.2.2 Acceptance criteria

64-1.8.1.2.2.1 During the test, there shall be no evidence of:

- (a) Electrolyte leakage;
- (b) Rupture (applicable to high voltage REESS (s) only);
- (c) Fire;
- (d) Explosion.

Evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

64-1.8.1.2.2.2 For a high voltage REESS, the isolation resistance measured after the test in accordance with the paragraph 64-1.8.3 to this Regulation shall not be less than 100 ohms/Volt.

64-1.8.1.3 Thermal shock and cycling

64-1.8.1.3.1 The test shall be conducted in accordance with the paragraph 64-1.8.2.2 to this Regulation.

64-1.8.1.3.2 Acceptance criteria

64-1.8.1.3.2.1 During the test, there shall be no evidence of:

- (a) Electrolyte leakage;
- (b) Rupture (applicable to high voltage REESS(s) only);
- (c) Fire;
- (d) Explosion.

Evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

64-1.8.1.3.2.2 For a high voltage REESS, the isolation resistance measured after the test in accordance with the paragraph

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64-1.8.3 of this Regulation shall not be less than 100 ohms/Volt.

#### 64-1.8.1.4 Mechanical impact

##### 64-1.8.1.4.1 Mechanical Shock

At the manufacturer's choice the test may be performed as, either

- (a) Vehicle based tests in accordance with paragraph 64-1.8.1.4.1.1 of this Regulation, or
- (b) Component based tests in accordance with paragraph 64-1.8.1.4.1.2 of this Regulation, or
- (c) Any combination of (a) and (b) above, for different direction of vehicle travel.

##### 64-1.8.1.4.1.1 Vehicle based test

Compliance with the requirements of the acceptance criteria of paragraph 64-1.8.1.4.1.3. below may be demonstrated by REESS(s) installed in vehicles that have been subjected to vehicle crash tests in accordance to VSTD " Steering control system –The protection of the driver against the steering mechanism in the event of impact " for frontal- impact test against a barrier or VSTD " The protection of the occupants in the event of a frontal collision " for frontal impact, and VSTD " The protection of the occupants in the event of a lateral collision " for side impact. The ambient temperature and the SOC shall be in accordance with the said Regulations.

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

##### 64-1.8.1.4.1.2 Component based test

The test shall be conducted in accordance with the paragraph 64-1.8.2.3 to this Regulation.

##### 64-1.8.1.4.1.3 Acceptance criteria

During the test there shall be no evidence of:

- (a) Fire;
- (b) Explosion;

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(c1) Electrolyte leakage if tested according to paragraph 64-1.8.1.4.1.1.:

- (i) For a period from the impact until 30 minutes after the impact there shall be no electrolyte spillage from the REESS into the passenger compartment;
- (ii) No more than 7 per cent by volume of the REESS electrolyte capacity shall spill from the REESS to the outside of the passenger compartment (for open type traction batteries a limitation to a maximum of 5 litres also applies);

(c2) Electrolyte leakage if tested according to paragraph 64-1.8.1.4.1.2.

After the vehicle based test (paragraph 64-1.8.1.4.1.1.), a REESS which is located inside the passenger compartment shall remain in the installed location and the REESS components shall remain inside REESS boundaries. No part of any REESS that is located outside the passenger compartment shall enter the passenger compartment during or after the impact test procedures.

After the component based test (paragraph 64-1.8.1.4.1.2.) 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 ohms/Volt for the whole REESS measured after the test in accordance with paragraph 64-1.6. or paragraph 64-1.8.3 to this Regulation, or the protection degree IPXXB shall be fulfilled for the tested-device.

For a REESS tested in accordance with paragraph 64-1.8.1.4.1.2., the evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

To confirm compliance to (c1) of paragraph 64-1.8.1.4.1.3. an appropriate coating shall, if necessary, be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the impact test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all

liquid leakage shall be considered as the electrolyte.

#### 64-1.8.1.4.2 Mechanical integrity

This test applies only to a REESS intended for installation in vehicles of categories M1 and N1.

At the manufacturer's choice, the test may be performed as, either:

- (a) Vehicle based tests in accordance with paragraph 64-1.8.1.4.2.1. of this Regulation, or
- (b) Component based tests in accordance with paragraph 64-1.8.1.4.2.2. of this Regulation.

##### 64-1.8.1.4.2.1 Vehicle specific test

At the manufacturer's choice, the test may be performed as either:

- (a) A vehicle based dynamic tests in accordance with paragraph 64-1.8.1.4.2.1.1. of this Regulation, or
- (b) A vehicle specific component test in accordance with paragraph 64-1.8.1.4.2.1.2. of this Regulation, or
- (c) Any combination of (a) and (b) above, for different directions of vehicle travel.

When the REESS is mounted in a position which is between a line from the rear edge of the vehicle perpendicular to the centre line of the vehicle and 300 mm forward and parallel to this line, the manufacturer shall demonstrate the mechanical integrity performance of the REESS in the vehicle to the Technical Service.

The approval of a REESS tested under this paragraph shall be limited to specific vehicle type.

##### 64-1.8.1.4.2.1.1 Vehicle based dynamic test

Compliance with the requirements of the acceptance criteria of paragraph 64-1.8.1.4.2.3. below may be demonstrated by REESS(s) installed in vehicles that have been subjected to a vehicle crash test in accordance with VSTD " Steering control system –The protection of the driver against the steering mechanism in the event of impact " for frontal- impact test against a barrier or VSTD " The protection of the occupants in the event of a frontal collision " for frontal impact, and VSTD " The protection of the occupants in the event of a lateral

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collision ” for side impact. The ambient temperature and the SOC shall be in accordance with the said Regulations.

#### 64-1.8.1.4.2.1.2 Vehicle specific component test

The test shall be conducted in accordance with paragraph 64-1.8.2.4 of this Regulation.

The crush force replacing the prescribed force specified in paragraph 64-1.8.2.4.3.2.1 shall be determined by the vehicle manufacturer using the data obtained from either actual crash tests or its simulation as specified in VSTD ” Steering control system –The protection of the driver against the steering mechanism in the event of impact ” for frontal- impact test against a barrier or VSTD ” The protection of the occupants in the event of a frontal collision ” in the direction of travel and according to VSTD ” The protection of the occupants in the event of a lateral collision ” in the direction horizontally perpendicular to the direction of travel. These forces shall be agreed by the Technical Service.

The manufacturers may, in agreement with the Technical Services, use forces derived from the 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 Regulations specified above.

The manufacturer may define the relevant parts of the vehicle structure used for the mechanical protection of the REESS components. The test shall be conducted with the REESS mounted to this vehicle structure in a way which is representative of its mounting in the vehicle.

#### 64-1.8.1.4.2.2 Component based test

The test shall be conducted in accordance with paragraph 64-1.8.2.4 to this Regulation.

REESS approved according to this paragraph 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

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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 paragraph 64-1.8.2.4.3.2.1 may be replaced with the value declared by the manufacturer. In this case, such force shall be determined by the vehicle manufacturer using the data obtained from either actual crash test or its simulation as specified in VSTD "Steering control system –The protection of the driver against the steering mechanism in the event of impact" for frontal- impact test against a barrier or VSTD "The protection of the occupants in the event of a frontal collision" in the direction of travel and according to VSTD "The protection of the occupants in the event of a lateral collision" in the direction horizontally perpendicular to the direction of travel. These forces shall be agreed by the manufacturer together with the Technical Service.

The manufacturers may, in agreement with the Technical Services, use forces derived from the 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 regulations specified above.

#### 64-1.8.1.4.2.3 Acceptance criteria

During the test there shall be no evidence of:

- (a) Fire;
- (b) Explosion;
- (c1) Electrolyte leakage if tested according to paragraph 64-1.8.1.4.2.1.:
  - (i) For a period from the impact until 30 minutes after the impact there shall be no electrolyte spillage from the REESS into the passenger compartment.
  - (ii) No more than 7 per cent by volume of the REESS electrolyte capacity shall spill from the REESS to the outside of the passenger compartment (for open type traction batteries a limitation to a maximum of 5 litres also

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applies).

(c2) Electrolyte leakage if tested according to paragraph 64-1.8.1.4.2.2.

For a high voltage REESS, the isolation resistance of the tested-device shall ensure at least 100 ohms/Volt for the whole REESS measured in accordance with paragraph 64-1.6. or paragraph 64-1.8.3 of this Regulation or the protection degree IPXXB shall be fulfilled for the Tested-Device.

If tested according to paragraph 64-1.8.1.4.2.2., the evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

To confirm compliance to (c1) of paragraph 64-1.8.1.4.2.3. an appropriate coating shall, if necessary, be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the impact test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

#### 64-1.8.1.5 Fire resistance

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 1.5m above the ground. At the option of the manufacturer, this test may be performed where the of the REESS's lower surface is higher than 1.5 m above the ground. The test shall be carried out on one test sample.

At the manufacturer's choice the test may be performed as, either:

- (a) A vehicle based test in accordance with paragraph 64-1.8.1.5.1. of this Regulation, or
- (b) A component based test in accordance with paragraph 64-1.8.1.5.2. of this Regulation.

##### 64-1.8.1.5.1 Vehicle based test

The test shall be conducted in accordance with paragraph 64-1.8.2.5.3.2.1. of this Regulation.

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The approval of a REESS tested according to this paragraph shall be limited to approvals for a specific vehicle type.

64-1.8.1.5.2 Component based test

The test shall be conducted in accordance with paragraph 64-1.8.2.5.3.2.2. of this Regulation.

64-1.8.1.5.3 Acceptance criteria

64-1.8.1.5.3.1 During the test, the tested-device shall exhibit no evidence of explosion.

64-1.8.1.6 External short circuit protection

64-1.8.1.6.1 The test shall be conducted in accordance with paragraph 64-1.8.2.6 of this Regulation.

64-1.8.1.6.2 Acceptance criteria;

64-1.8.1.6.2.1 During the test there shall be no evidence of:

- (a) Electrolyte leakage;
- (b) Rupture (applicable to high voltage REESS(s) only);
- (c) Fire;
- (d) Explosion.

Evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

64-1.8.1.6.2.2 For a high voltage REESS, the isolation resistance measured after the test in accordance with paragraph 64-1.8.3 to this Regulation shall not be less than 100 ohms/Volt.

64-1.8.1.7 Overcharge protection

64-1.8.1.7.1 The test shall be conducted in accordance with paragraph 64-1.8.2.7 to this Regulation.

64-1.8.1.7.2 Acceptance criteria

64-1.8.1.7.2.1 During the test there shall be no evidence of:

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- (a) Electrolyte leakage;
- (b) Rupture (applicable to high voltage REESS(s) only);
- (c) Fire;
- (d) Explosion.

Evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

64-1.8.1.7.2.2 For a high voltage REESS, the isolation resistance measured after the test in accordance with paragraph 64-1.8.3 to this Regulation shall not be less than 100 ohms/Volt.

#### 64-1.8.1.8 Over-discharge protection

64-1.8.1.8.1 The test shall be conducted in accordance with paragraph 64-1.8.2.8 to this Regulation.

#### 64-1.8.1.8.2 Acceptance criteria

64-1.8.1.8.2.1 During the test there shall be no evidence of:

- (a) Electrolyte leakage;
- (b) Rupture (applicable to high voltage REESS(s) only);
- (c) Fire;
- (d) Explosion.

Evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

64-1.8.1.8.2.2 For a high voltage REESS the isolation resistance measured after the test in accordance with paragraph 64-1.8.3 to this Regulation shall not be less than 100 ohms/Volt.

#### 64-1.8.1.9 Over-temperature protection

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64-1.8.1.9.1 The test shall be conducted in accordance with paragraph 64-1.8.2.9 to this Regulation.

64-1.8.1.9.2 Acceptance criteria

64-1.8.1.9.2.1 During the test there shall be no evidence of:

- (a) Electrolyte leakage;
- (b) Rupture (applicable to high voltage REESS(s) only);
- (c) Fire;
- (d) Explosion.

Evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the tested-device.

64-1.8.1.9.2.2 For a high voltage REESS, the isolation resistance measured after the test in accordance with paragraph 64-1.8.3 to this Regulation shall not be less than 100 ohms/Volt.

64-1.8.2 REESS test procedures

A standard cycle will start with a standard discharge followed by a standard charge.

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.

Discharge limit (end voltage): specified by the manufacturer

Rest period after discharge: minimum 30 min

Standard charge: The charge procedure including termination criteria shall be defined by the manufacturer.

If not specified, then it shall be a charge with C/3 current.

64-1.8.2.1 Vibration test

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#### 64-1.8.2.1.1 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.

#### 64-1.8.2.1.2 Installations

64-1.8.2.1.2.1 This test shall be conducted either with the complete REESS or with a related REESS subsystem(s) including the cells and their electrical connections. If the manufacturer chooses to test with related 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.

64-1.8.2.1.2.2 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.

#### 64-1.8.2.1.3 Procedures

##### 64-1.8.2.1.3.1 General test conditions

The following conditions shall apply to the tested-device:

- (a) The test shall be conducted at an ambient temperature of 20 +/- 10 deg. C,
- (b) At the beginning of the test, the SOC shall be adjusted to a value in the upper 50 per cent of the normal operating SOC range of the tested-device,
- (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.

##### 64-1.8.2.1.3.2 Test Procedures

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The tested-devices 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 4:

Table 4: Frequency and acceleration

Frequency (Hz)	Acceleration (m/s <sup>2</sup> )
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 request of the manufacturer a vibration test profile determined by the vehicle-manufacturer, verified for the vehicle application and agreed with the Technical Service may be used as a substitute for the frequency - acceleration correlation of table 4. The approval of a REESS tested according to this condition shall be limited to approvals for a specific vehicle type.

After the vibration, a standard cycle as described in paragraph 64-1.8.2 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.

#### 64-1.8.2.2 Thermal shock and cycling test

##### 64-1.8.2.2.1 Purpose

The purpose of this test is to verify the resistance of the REESS to sudden changes in temperature. The REESS shall

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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.

#### 64-1.8.2.2.2 Installations

This test shall be conducted either with the complete REESS or with related REESS subsystem(s) of the REESS including the cells and their electrical connections. If the manufacturer chooses to test with related 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.

#### 64-1.8.2.2.3 Procedures

##### 64-1.8.2.2.3.1 General test conditions

The following conditions shall apply to the tested-device at the start of the test

- (a) The SOC shall be adjusted to a value in the upper 50 per cent of the normal operating SOC range,
- (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.

##### 64-1.8.2.2.3.2 Test Procedure

The tested-device shall be stored for at least six hours at a test temperature equal to 60 +/- 2 deg. C or higher if requested by the manufacturer, followed by storage for at least six hours at a test temperature equal to -40 +/- 2 deg. 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 20 +/- 10 deg. C.

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After the storage for 24 hours, a standard cycle as described in paragraph 64-1.8.2 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.

#### 64-1.8.2.3 Mechanical shock

##### 64-1.8.2.3.1 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.

##### 64-1.8.2.3.2 Installation

64-1.8.2.3.2.1 This test shall be conducted either with the complete REESS or with related REESS subsystem(s) including the cells and their electrical connections. If the manufacturer chooses to test with related 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

64-1.8.2.3.2.2 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.

##### 64-1.8.2.3.3 Procedures

###### 64-1.8.2.3.3.1 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 deg. C,
- (b) At the beginning of the test, the SOC shall be adjusted to a value in the upper 50 per cent of the normal operating

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SOC range,

- (c) At the beginning of the test, all protection devices which effect the function of the tested-device and which are relevant to the outcome of the test, shall be operational.

#### 64-1.8.2.3.3.2 Test Procedure

The tested-device shall be decelerated or, at the choice of the applicant, accelerated in compliance with the acceleration corridors which are specified in tables 5 - 7. The Technical Service in consultation with 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 5 to 7. A higher shock level and /or longer duration as described in the maximum value in tables 5 to 7 can be applied to the tested-device if recommended by the manufacturer.

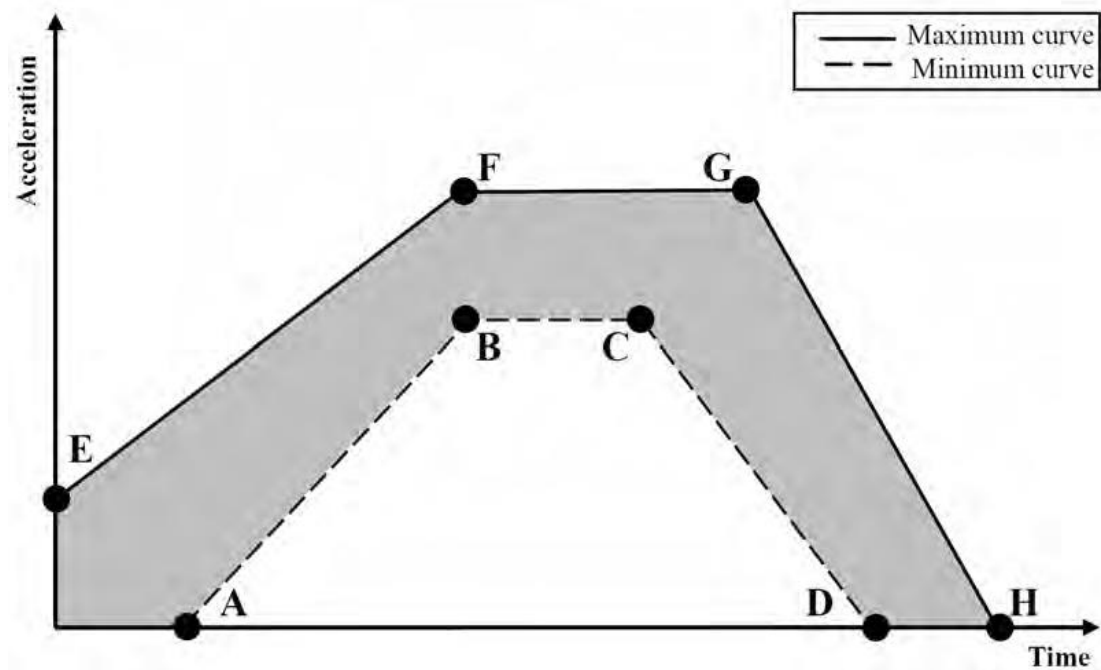


Figure 9: Generic description of test pulses

Table 5 for M1 and N1 vehicles:

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64-1. Electric safety requirements for battery electric vehicles



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 6 for M2 and N2 vehicles:

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

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64-1. Electric safety requirements for battery electric vehicles

Table 7 for M3 and N3 vehicles:

Point	Time (ms)	Acceleration (g)	
		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

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

#### 64-1.8.2.4 Mechanical integrity

##### 64-1.8.2.4.1 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.

##### 64-1.8.2.4.2 Installations

64-1.8.2.4.2.1 This test shall be conducted with either the complete REESS or with a related REESS subsystem(s) including the cells and their electrical connections. If the manufacturer chooses to test with related 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

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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.

64-1.8.2.4.2.2 The tested-device shall be connected to the test fixture as recommended by the manufacturer.

#### 64-1.8.2.4.3 Procedures

##### 64-1.8.2.4.3.1 General test conditions

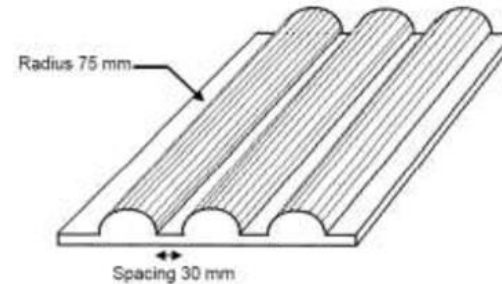
The following condition and requirements shall apply to the test:

- (a) The test shall be conducted at an ambient temperature of 20 +/- 10 deg. C,
- (b) At the beginning of the test, the SOC shall be adjusted to a value in the upper 50 per cent of the normal operating SOC range,
- (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.

##### 64-1.8.2.4.3.2 Crush test

###### 64-1.8.2.4.3.2.1 Crush force

The tested-device shall be crushed between a resistance and a crush plate as described in figure 7 with a force of at least 100 kN, but not exceeding 105 kN, unless otherwise specified in accordance with Paragraph 64-1.8.1.4.2 of this Regulation, with an onset time less than 3 minutes and a hold time of at least 100 ms but not exceeding 10s.



Dimension of the crush plate: 600 mm x 600 mm or smaller

Figure 7

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 together with the Technical Service 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.

#### 64-1.8.2.5 Fire resistance

##### 64-1.8.2.5.1 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.

##### 64-1.8.2.5.2 Installations

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64-1.8.2.5.2.1 This test shall be conducted either with the complete REESS or with related REESS subsystem(s) including the cells and their electrical connections. If the manufacturer chooses to test with related 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 of the REESS subsystem.

#### 64-1.8.2.5.3 Procedures

##### 64-1.8.2.5.3.1 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 deg. C,
- (b) At the beginning of the test, the SOC shall be adjusted to a value in the upper 50 per cent of the normal operating SOC range,
- (c) At the beginning of the test, all protection devices which effect the function of the tested-device and are relevant for the outcome of the test shall be operational.

##### 64-1.8.2.5.3.2 Test Procedure

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

###### 64-1.8.2.5.3.2.1 Vehicle based test

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

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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.

#### 64-1.8.2.5.3.2.2 Component based test

The tested-device shall be placed on a grating table positioned above the pan, 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.

64-1.8.2.5.3.3 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.

64-1.8.2.5.3.4 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 unladen mass if paragraph 64-1.8.2.5.3.2.1. is applied or approximately 50 cm if Paragraph 64-1.8.2.5.3.2.2. is applied. Either the pan, or the testing fixture, or both, shall be freely movable.

64-1.8.2.5.3.5 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 paragraph 64-1.8.2.5.4. There shall be no gap between the bricks and they shall be supported over the

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64-1. Electric safety requirements for battery electric vehicles

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.

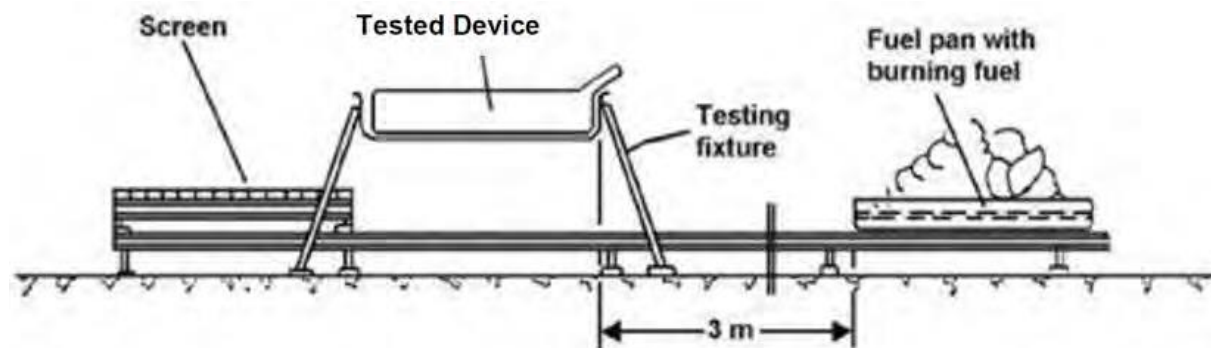
64-1.8.2.5.3.6 If the tests are carried out in the open air, sufficient wind protection shall be provided and the wind velocity at pan level shall not exceed 2.5 km/h.

64-1.8.2.5.3.7 The test shall comprise of three phases B-D, if the fuel is at least at temperature of 20 deg. C. Otherwise the test shall comprise four phases A-D.

64-1.8.2.5.3.7.1 Phase A: Pre-heating (Figure 8)

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.



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Figure 8: Phase A: Pre-heating

64-1.8.2.5.3.7.2 Phase B: Direct exposure to flame (Figure 9)

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

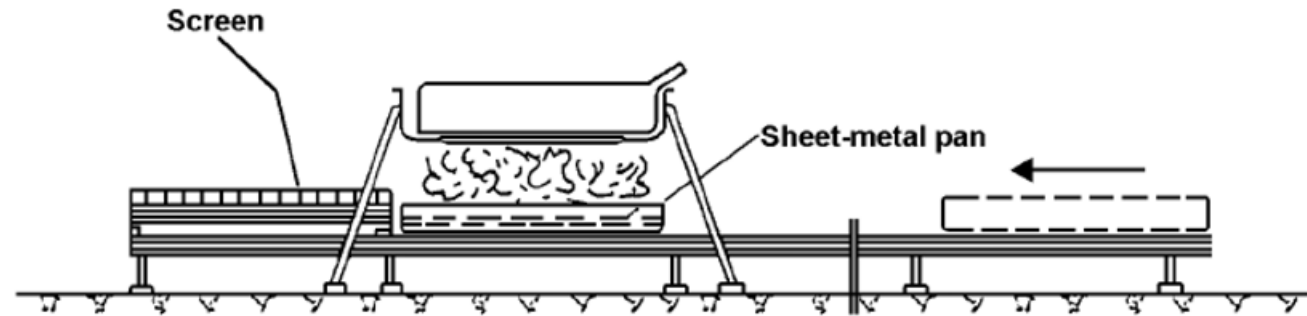


Figure 9: Phase B: Direct exposure to flame

64-1.8.2.5.3.7.3 Phase C: Indirect exposure to flame (Figure 10)

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.

Instead of conducting Phase C of the test, Phase B may at the manufacturer's discretion be continued for an additional 60 seconds.

However this shall only be permitted where it is demonstrable to the satisfaction of the Technical Service that it will not result in a reduction in the severity of the test.



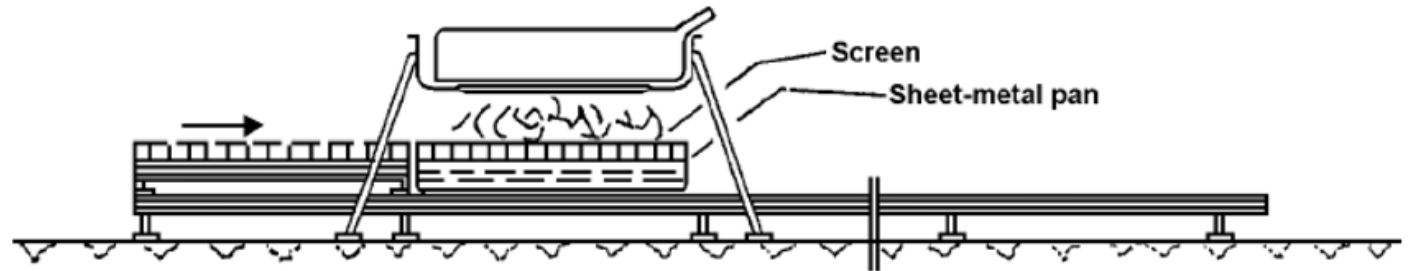


Figure 10: Phase C: Indirect exposure to flame

#### 64-1.8.2.5.3.7.4 Phase D: End of test (Figure 11)

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.

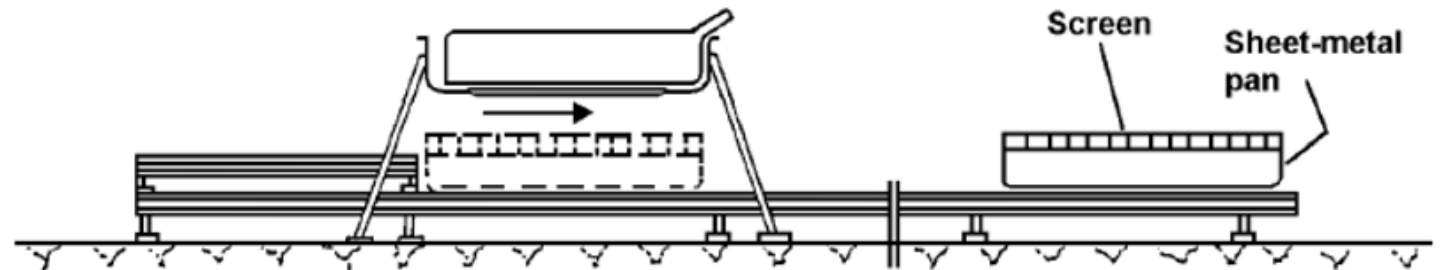
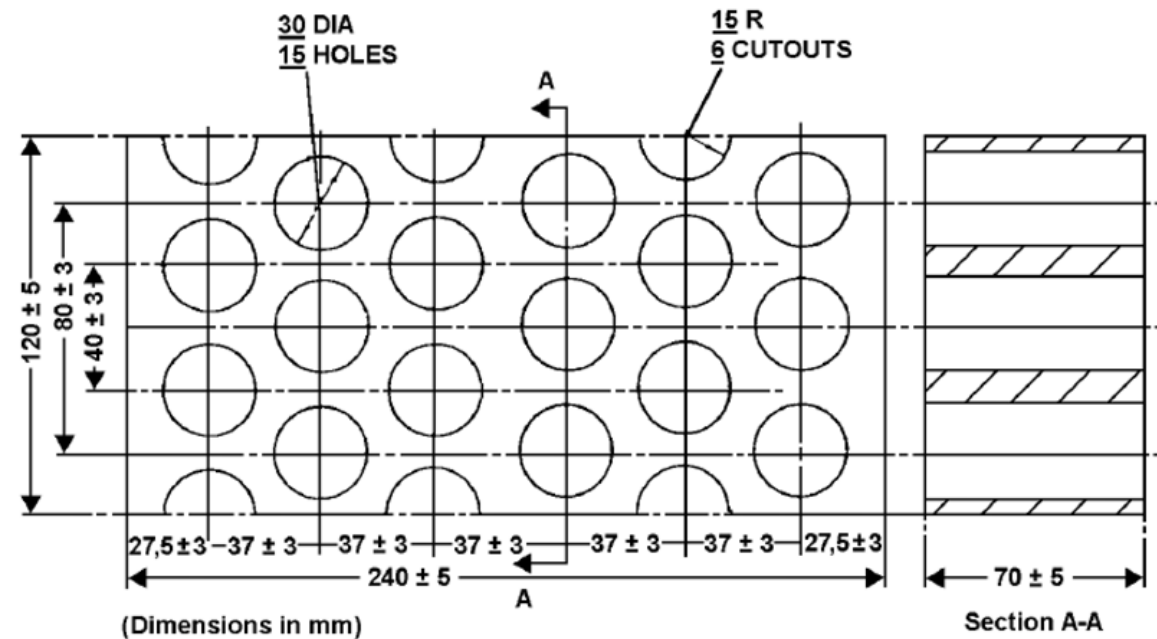


Figure 11: Phase D: End of test

#### 64-1.8.2.5.4 Dimension and Technical Data of Firebricks

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Fire resistance: (Segger-Kegel) SK 30

Al<sub>2</sub>O<sub>3</sub> content: 30 - 33 per cent

Open porosity (Po): 20 - 22 per cent vol.

Density: 1,900 - 2,000 kg/m<sup>3</sup>

Effective holed area: 44.18 per cent

#### 64-1.8.2.6 External short circuit protection

##### 64-1.8.2.6.1 Purpose

The purpose of this test is to verify the performance of the short circuit protection. This functionality, if implemented, shall

interrupt or limit the short circuit current to prevent the REESS from any further related severe events caused by short circuit

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current.

#### 64-1.8.2.6.2 Installations

This test shall be conducted either with the complete REESS or with related REESS subsystem(s), including the cells and their electrical connections. If the manufacturer chooses to test with related 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.

#### 64-1.8.2.6.3 Procedures

##### 64-1.8.2.6.3.1 General test conditions

The following condition shall apply to the test:

- (a) The test shall be conducted at a ambient temperature of 20 +/- 10 deg. C or at higher temperature if requested by the manufacturer,
- (b) At the beginning of the test, the SOC shall be adjusted to a value in the upper 50 per cent of the normal operating SOC range,
- (c) 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.

##### 64-1.8.2.6.3.2 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.

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The positive and negative terminals of the tested-device shall be connected to each other to produce a short circuit.

The connection used for this purpose shall have a resistance not exceeding 5 megohms.

The short circuit condition shall be continued until the operation of the REESS's protection function to interrupt or limit the short circuit current is confirmed, or for at least one hour after the temperature measured on the casing of the tested-device has stabilised, such that the temperature gradient varies by a less than 4 deg. C through 1 hour.

#### 64-1.8.2.6.3.3 Standard Cycle and observation period

Directly after the termination of the short circuit a standard cycle as described in paragraph 64-1.8.2 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.

### 64-1.8.2.7 Overcharge protection

#### 64-1.8.2.7.1 Purpose

The purpose of this test is to verify the performance of the overcharge protection.

#### 64-1.8.2.7.2 Installations

This test shall be conducted, under standard operating conditions, either with the complete REESS (this maybe a complete vehicle) or with related REESS subsystem(s), including the cells and their electrical connections. If the manufacturer chooses to test with related 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.

The test may be performed with a modified tested-device as agreed by the manufacturer and the Technical Service. These modifications shall not influence the test results.

#### 64-1.8.2.7.3 Procedures

##### 64-1.8.2.7.3.1 General test conditions

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The following requirements and conditions shall apply to the test:

- (a) The test shall be conducted at an ambient temperature of 20 +/- 10 deg. C or at higher temperature if requested by the manufacturer,
- (b) 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.

#### 64-1.8.2.7.3.2 Charging

At the beginning all relevant main contactors for charging shall be closed.

The charge control limits of the test equipment shall be disabled.

The tested-device shall be charged with a charge current of at least 1/3C rate but not exceeding the maximum current within the normal operating range as specified by the manufacturer.

The charging shall be continued until the tested-device (automatically) interrupts or limits the charging. Where an automatic interrupt function fails to operate, or if there is no such function the charging shall be continued until the tested-device is charged to twice of its rated charge capacity.

#### 64-1.8.2.7.3.3 Standard cycle and observation period

Directly after the termination of charging a standard cycle as described in paragraph 64-1.8.2 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.

#### 64-1.8.2.8 Over-discharge protection

##### 64-1.8.2.8.1 Purpose

The purpose of this test is to verify the performance of the over-discharge protection.

This functionality, if implemented, shall interrupt or limit the discharge current to prevent the REESS from any severe events

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caused by a too low SOC as specified by the manufacturer.

#### 64-1.8.2.8.2 Installations

This test shall be conducted, under standard operating conditions, either with the complete REESS (this maybe a complete vehicle) or with related REESS subsystem(s), including the cells and their electrical connections. If the manufacturer chooses to test with related 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.

The test may be performed with a modified tested-device as agreed by the manufacturer and the Technical Service. These modifications shall not influence the test results.

#### 64-1.8.2.8.3 Procedures

##### 64-1.8.2.8.3.1 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 deg. C or at higher temperature if requested by the manufacturer,
- (b) 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.

##### 64-1.8.2.8.3.2 Discharging

At the beginning of the test, all relevant main contactors shall be closed.

A discharge shall be performed with at least 1/3 C rate but shall not exceed the maximum current within the normal operating range as specified by the manufacturer.

The discharging shall be continued until the tested-device (automatically) interrupts or limits the discharging. Where an automatic interrupt function fails to operate, or if there is no such function then the discharging shall be continued

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until the tested-device is discharged to 25 per cent of its nominal voltage level.

#### 64-1.8.2.8.3.3 Standard charge and observation period

Directly after termination of the discharging the tested-device shall be charged with a standard charge as specified in paragraph 64-1.8.2 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.

#### 64-1.8.2.9 Over-temperature protection

##### 64-1.8.2.9.1 Purpose

The purpose of this test is to verify the performance of the protection measures of the REESS against internal overheating during the operation, even under the failure of the cooling function if applicable. 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.

##### 64-1.8.2.9.2 Installations

64-1.8.2.9.2.1 The following test may be conducted with the complete REESS (maybe as a complete vehicle) or with related REESS subsystem(s), including the cells and their electrical connections. If the manufacturer chooses to test with related 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. The test may be performed with a modified Tested-Device as agreed by the manufacturer and the Technical Service. These modifications shall not influence the test results.

64-1.8.2.9.2.2 Where a REESS is fitted with a cooling function and where the REESS will remain functional without a cooling function system being operational, the cooling system shall be deactivated for the test.

64-1.8.2.9.2.3 The temperature of the tested-device shall be continuously measured inside the casing in the proximity of the cells

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during the test in order to monitor the changes of the temperature. The onboard sensor if existing may be used. The manufacturer and Technical Service shall agree on the location of the temperature sensor(s) used.

#### 64-1.8.2.9.3 Procedures

64-1.8.2.9.3.1 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 Paragraph 64-1.8.2.9.2.2.

64-1.8.2.9.3.2 During the test, the tested-device shall be continuously charged and discharged with a steady current that will increase the temperature of cells as rapidly as possible within the range of normal operation as defined by the manufacturer.

64-1.8.2.9.3.3 The tested-device shall be placed in a convective oven or climatic chamber. The temperature of the chamber or oven shall be gradually increased until it reaches the temperature determined in accordance with Paragraph 64-1.8.2.9.3.3.1 or 64-1.8.2.9.3.3.2 below as applicable, and then maintained at a temperature that is equal to or higher than this, until the end of the test.

64-1.8.2.9.3.3.1 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 Paragraph 64-1.8.2.9.3.2.

64-1.8.2.9.3.3.2 Where the REESS is not equipped with any specific measures against internal overheating, the temperature shall be increased to the maximum operational temperature specified by the manufacturer.

64-1.8.2.9.3.4 The end of test: 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,

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- (b) The temperature of the tested-device is stabilised, which means that the temperature varies by a gradient of less than 4 deg. C through 2 hours,
- (c) Any failure of the acceptance criteria prescribed in paragraph 64-1.8.1.9.2.1.

### 64-1.8.3 Isolation Resistance Measurement Method for component based tests of a REESS

#### 64-1.8.3.1 Measurement method

The isolation resistance measurement shall be conducted by selecting an appropriate measurement method from among those listed in Paragraphs 64-1.8.3.1.1. through 64-1.8.3.1.2., depending on the electrical charge of the live parts or the isolation resistance, etc.

If the operating voltage of the tested-device ( $V_b$ , Figure 12) 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).

These modifications shall not influence the test results.

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

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

In cases where the measured values are not stable due to the operation of the isolation resistance monitoring system, etc., necessary modification for conducting the measurement may be carried out, such as stopping the operation of the device concerned or removing it. Furthermore, when the device is removed, it shall be proven, using drawings, etc., that it will not change the isolation resistance between the live parts and the ground connection designated by the manufacturer as a point to be connected to the electrical chassis when installed on the vehicle. Utmost care shall be exercised as to short circuit, electric shock,

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etc., for this confirmation might require direct operations of the high-voltage circuit.

#### 64-1.8.3.1.1 Measurement method using voltage from external sources

##### 64-1.8.3.1.1.1 Measurement instrument

An isolation resistance test instrument capable of applying a DC voltage higher than the nominal voltage of the tested-device shall be used.

##### 64-1.8.3.1.1.2 Measurement method

An insulation resistance test instrument shall be connected between the live parts and the ground connection. Then, the isolation resistance shall be measured.

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

#### 64-1.8.3.1.2 Measurement method using the tested-device as DC voltage source

##### 64-1.8.3.1.2.1 Test conditions

The voltage level of the tested-device throughout the test shall be at least the nominal operating voltage of the tested-device.

##### 64-1.8.3.1.2.2 Measurement instrument

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

##### 64-1.8.3.1.2.3 Measurement method

###### 64-1.8.3.1.2.3.1 First step

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The voltage is measured as shown in Figure 12 and the operating voltage of the tested device ( $V_b$ , Figure 12) is recorded.  $V_b$  shall be equal to or greater than the nominal operating voltage of the tested-device.

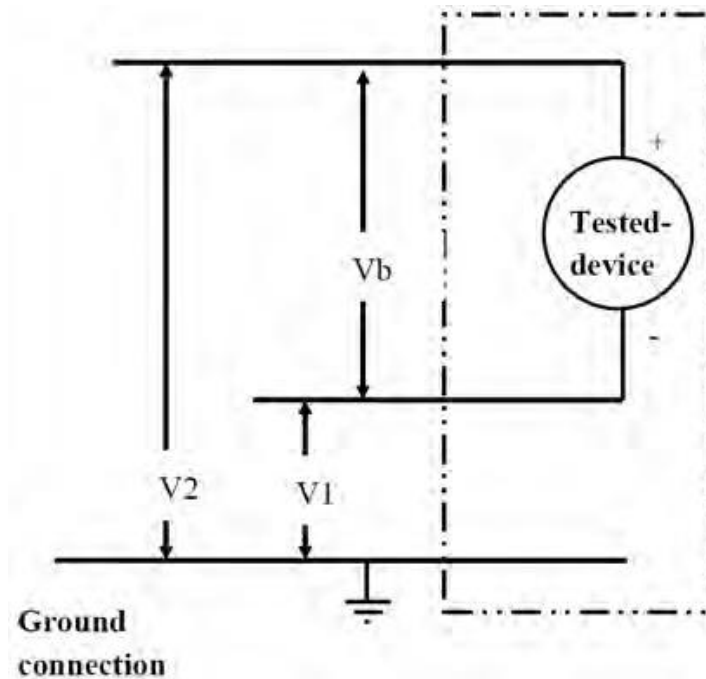


Figure 12

#### 64-1.8.3.1.2.3.2 Second step

Measure and record the voltage ( $V_1$ ) between the negative pole of the tested-device and the ground connection (Figure 12).

#### 64-1.8.3.1.2.3.3 Third step

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Measure and record the voltage ( $V_2$ ) between the positive pole of the tested-device and the ground connection (Figure 12).

#### 64-1.8.3.1.2.3.4 Fourth step

If  $V_1$  is greater than or equal to  $V_2$ , insert a standard known resistance ( $R_0$ ) between the negative pole of the tested-device and the ground connection. With  $R_0$  installed, measure the voltage ( $V_1'$ ) between the negative pole of the tested-device and the ground connection (see Figure 13).

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

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

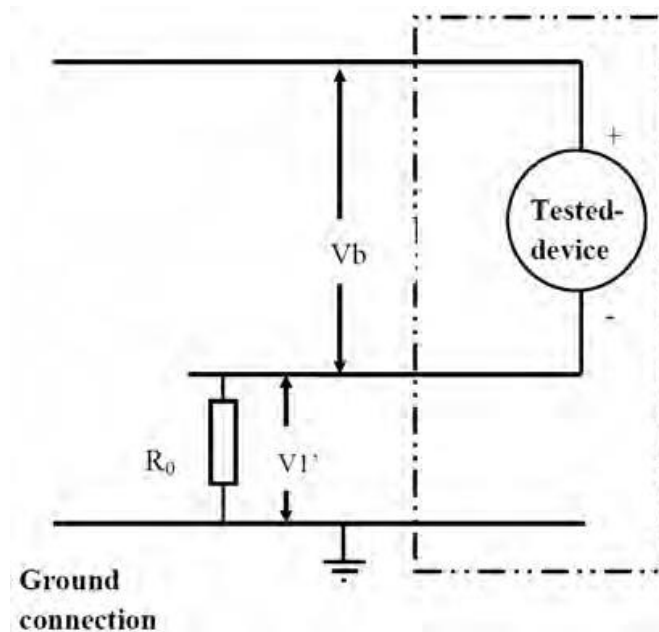


Figure 13

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If  $V_2$  is greater than  $V_1$ , insert a standard known resistance ( $R_0$ ) between the positive pole of the tested-device and the ground connection. With  $R_0$  installed, measure the voltage ( $V_2'$ ) between the positive pole of the tested-device and the ground connection (see Figure 14). Calculate the electrical isolation ( $R_i$ ) according to the following formula:

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

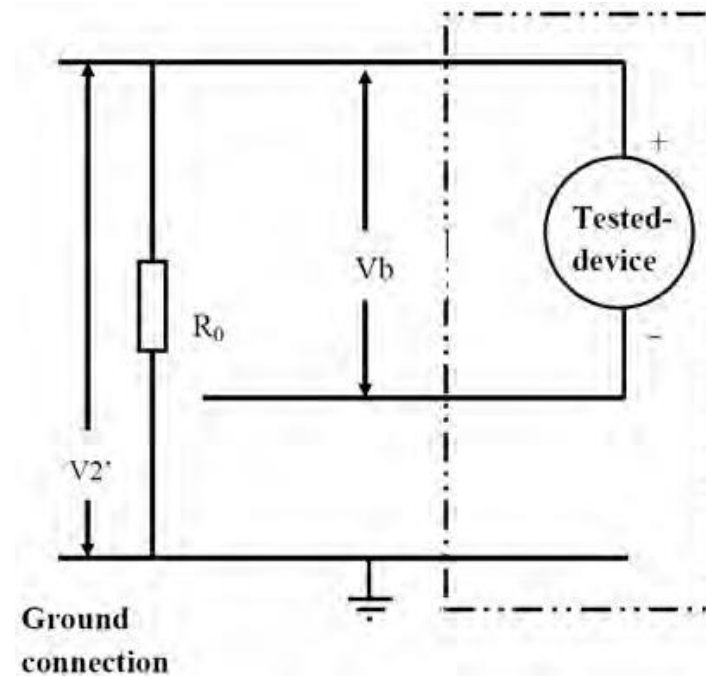


Figure 14

#### 64-1.8.3.1.2.3.5 Fifth step

The electrical isolation value  $R_i$  (in ohm) divided by the nominal voltage of the tested-device (in volts) results in the isolation resistance (in ohm/V).

The standard known resistance  $R_o$  (in ohm) should be the value of the minimum required isolation resistance (in ohm/V) multiplied by the nominal voltage of the tested-device plus/minus 20 per cent (in volts).  $R_o$  is not required to be precisely this value since the equations are valid for any  $R_o$ ; however, a  $R_o$  value in this range should provide good resolution for the voltage measurements.