ELSA 7th Meeting, September 11, 2010

ELECTRICAL SAFETY PROVISIONS FOR VEHICLES Post Crash

1. General

This module shall apply to the electric power train of electric vehicles, hybrid vehicles and fuel cell vehicles, and the high voltage components and systems which are galvanically connected to the high voltage bus of the electric power train following vehicle crash test(s). The crash test(s) to be used for purposes of evaluating compliance to these requirements are those specified within existing regulations of the contracting parties.

2. Definitions

For the purposes of this regulation the following definitions apply.

2-1 Electric power train
the electrical circuit which may include the RESS, the energy conversion system, the electronic converters, the traction motors, the associated wiring harness and connectors, and the coupling system for charging the RESS

2-2 "RESS"
Rechargeable energy storage system that provides the electric energy for propulsion

2-3 Energy conversion system
system that generates and provides electric energy for propulsion.

2-4 Electronic converter
a device capable of controlling or converting electric power.

2-5 Coupling system for charging the RESS
the electrical circuit used for charging the RESS from an external electric power supply (AC or DC electric power supply outside of the vehicle) including the vehicle inlet

2–7 Passenger compartment
the space for occupant accommodation, bounded by the roof, floor, side walls, doors, window glass, front bulkhead and rear bulkhead, or rear gate, as well as by the barriers and enclosures provided for protecting the power train from direct contact with live parts.

2–8 Luggage compartment
the space in the vehicle for luggage accommodation, bounded by the roof, hood, floor, side walls, as well as by the barrier and enclosure provided for protecting the power train from direct contact with live parts, being separated from the passenger compartment by the front bulkhead or the rear bulk head.

2–9 Direct contact
the contact of persons with live parts.

2–10 Live parts
conductive part(s) intended to be electrically energized in normal use.

2–11 Indirect contact
the contact of persons with exposed conductive parts.

2–12 Protection degree
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 Attached Sheet 1

2-13 Exposed conductive part
the conductive part which can be touched under the provisions of the protection degree IPXXB, and which ~~only~~ becomes electrically energized under isolation failure conditions.

2–14 Electrical circuit
an assembly of connected live parts which is designed to be electrically energized in normal operation.

2–15 Working voltage
the highest value of an electrical circuit voltage, specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions.

2–16 Electrical chassis
a set made of conductive parts electrically linked together, whose potential is taken as reference.

2–17 Solid insulator
insulating coating of wiring harnesses provided in order to cover and protect the live parts against direct contact from any direction of access; covers for insulating the live parts of connectors; and varnish or paint for the purpose of insulation.

2–18 Barrier
the part providing protection against direct contact to the live parts from any direction of access.

2–19 Enclosure
the part enclosing the internal units and providing protection against direct contact from any ~~**usual**~~ direction of access.

2-22 High Voltage
classification of an electric component or circuit, if its maximum working voltage is > 60 V and ≤ 1500 V d.c. or > 30 V and ≤ 1000 V a.c.

2-23 High Voltage Bus
electrical circuit, including the coupling system for charging the RESS, that operates on high voltage

3. Requirements

During and after the specified crash test(s), vehicles shall meet the performance requirements specified in paragraphs 3.1 through 3.3.

3-1 [Electrolyte spillage from RESS

Not more than 5.0 liters of electrolyte from propulsion batteries shall spill outside the passenger compartment, and no visible trace of electrolyte shall spill into the passenger compartment, within 30 minutes after a barrier impact test. Compliance may be demonstrated by test or analysis.]

3-2 [Traction battery retention

Battery modules located inside the passenger compartment must remain in the location in which they are installed. No part of any battery system component that is located outside the passenger compartment shall enter the passenger compartment during the test procedures, as determined by visual inspection.]

3-3 [Electrical Safety

After each crash test, at least one of the following criteria specified in paragraph 3-3-1 thorough paragraph 3-3-4 shall be met. If the vehicle has an automatic disconnect function, the criteria shall be applied to each divided portion individually.

3-3-1 Isolation Resistance

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

3-3-1-1 For AC high voltage buses, isolation resistance between the high voltage bus and the electrical chassis shall have minimum value of 500 ohms/volt of working voltage.
If the protection degree IPXXB is satisfied for AC portion of the high voltage buses after crash, isolation resistance between the high voltage bus and the electrical chassis shall have minimum value of 100 ohms/volt of working voltage.

3-3-1-2 For DC high voltage buses, isolation resistance between any high voltage bus and the electrical chassis shall have minimum value of 100 ohms/volt of working voltage.

3-3-2 Voltage

3-3-2-1 For AC high voltage buses, voltage of the bus shall be equal to or less than 30 VAC.
3-3-2-2 For DC high voltage buses, voltage of the bus shall be equal to or less than 60 VDC.

3-3-3 Energy

Energy on the high voltage bus shall be less than 0.2 Joules.

3-3-4 Physical Protection

3-3-4-1 For protection of live parts, the protection degree IPXXB shall be provided.

3-3-4-2 For protection against indirect contact with live parts, all exposed conductive parts shall be securely connected to the electrical chassis such that no dangerous potentials are produced. The resistance between the electrical chassis and all conductive parts shall be less than 0.1 ohm, which is measured when there is a current flow of at least 0.2 amps.

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

4. Test Conditions

The test conditions specified in paragraphs 4-1 and 4-2 shall be used. Where a range is specified, the vehicle must be capable of meeting the requirements at all points within the range.

4-1 Vehicle conditions

4-1-1 The high voltage system shall be energized.

4-1-2 The vehicle conditions other than specified in 4-1-1 shall be in the crash test protocols of the contracting parties.

4-2 RESS state of charge

The RESS is at the level specified in the following paragraph (a), (b), or (c), as appropriate:

a) At the maximum state of charge recommended by the manufacturer, as stated in the vehicle operator's manual or on a label that is permanently affixed to the vehicle;
b) If the manufacturer has made no recommendation, at a state of charge of not less than 95 percent of the maximum capacity of the RESS; or
c) If the RESS are rechargeable only by an energy source on the vehicle, at any state of charge within the normal operating voltage, as defined by the vehicle manufacturer.

4-3 Energy conversion system

Proposal from OICA together with JAISIC

5. Test Procedures

This section describes test procedures demonstrate compliance to the electrical safety requirements of paragraph 3-3. [Alternative test and analysis methods may also be used.] For example, megohmmeter measurements are an appropriate alternative to the procedure described below for measuring isolation resistance. [Well-established calculation methods also exist to determine electrical energy on high voltage buses.]

The following procedures should be performed after each of the specified crash tests.

5-1 Test setup and equipment

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

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

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

5-2 Bus voltage

The following instructions may be used if voltage is measured.
[Prior to the vehicle crash test measure and record the high voltage bus voltage (Vb) (see Figure 1). If Vb is high voltage, conduct the specified vehicle crash test]. After the crash test, determine the high voltage bus voltages (Vb, V1, V2) (see Figure 1). [If the RESS has exposed conductive parts, measure the voltage V3 between any exposed conductive parts of it and the electrical chassis.]
The measurement shall be made after [5 seconds of] the vehicle coming to rest after each crash test.

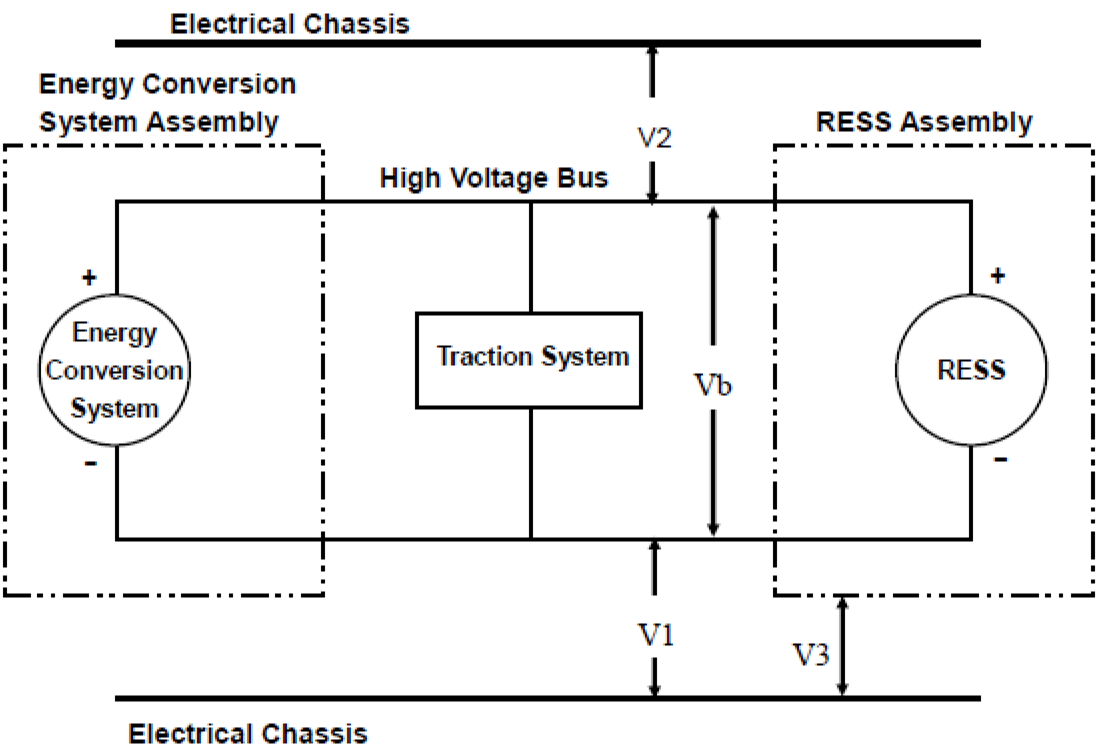


Figure 1: Measurement of Vb, V1, V2, V3

5-3 Resistance isolation

5-3-1 First step

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

5-3-2 Second step

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

5-3-3 Third step

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

5-3-4 Fourth step

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

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

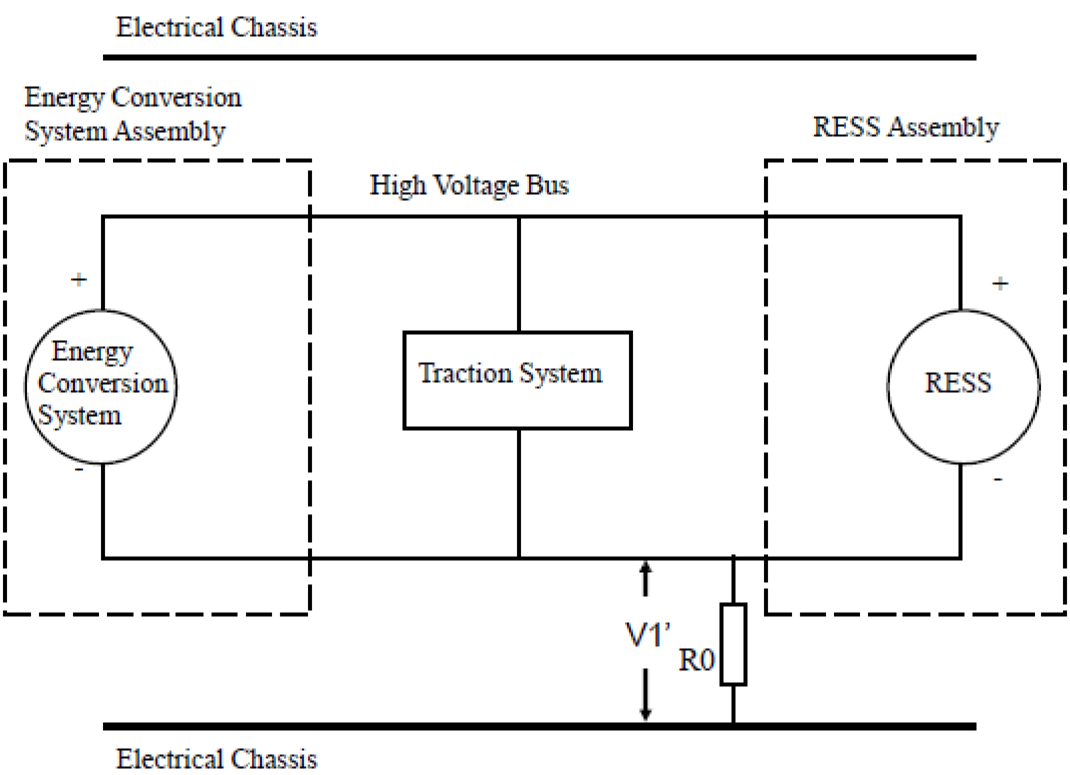


Figure 2: Measurement of V1'

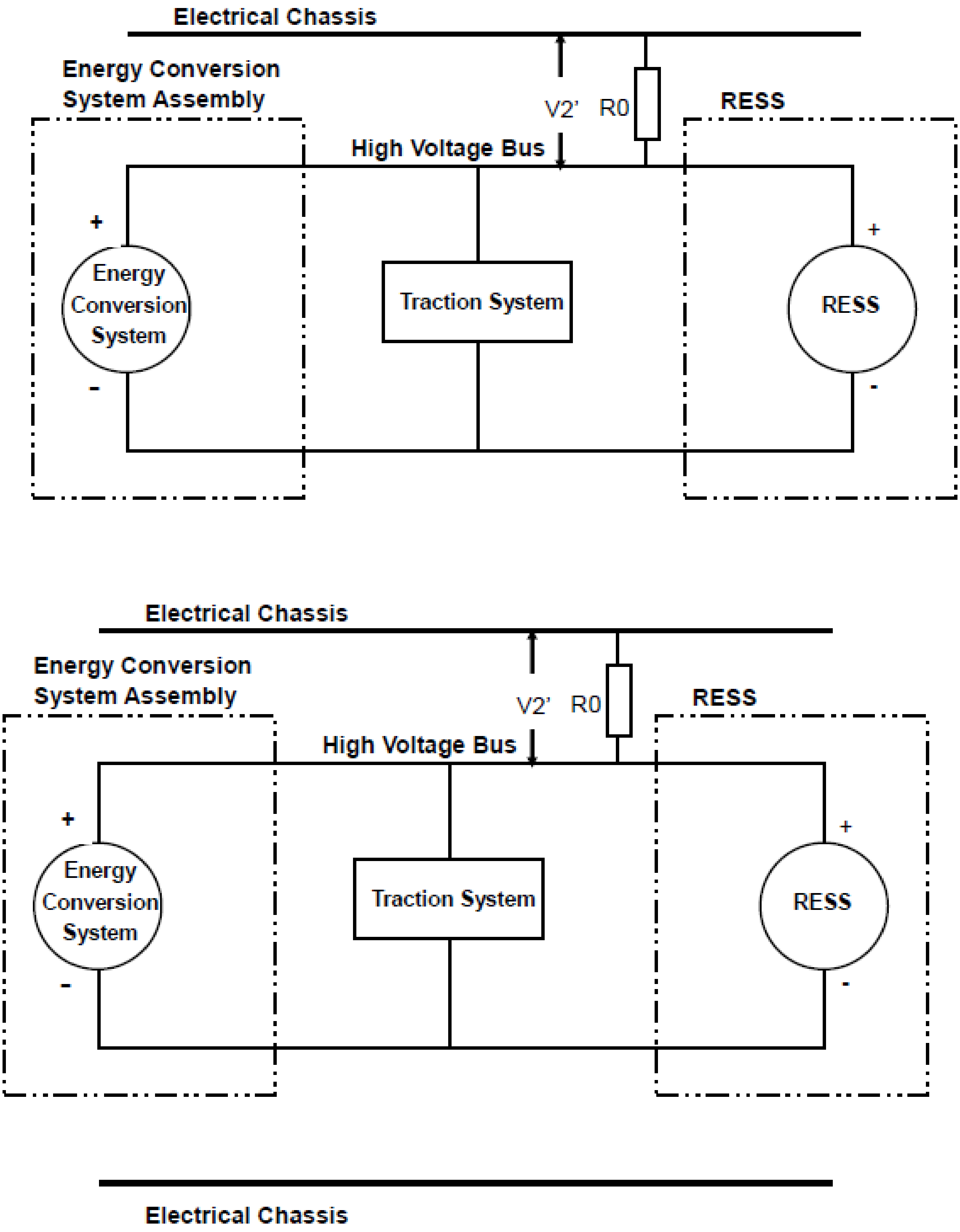


Figure 3: Measurement of V2'

5-3-5 Fifth step

The electrical isolation value Ri (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 Ro (in ohms) should be the value of the minimum required isolation resistance (in ohms/V) multiplied by the working voltage of the vehicle plus/minus 20% (in volts). 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.)

5-4 Electrical Energy

The following procedure may be used if energy is measured.

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

$$\int_{t_0}^{t_1} V_b \times I_e dt$$

t_0 = ???

t_1= ???

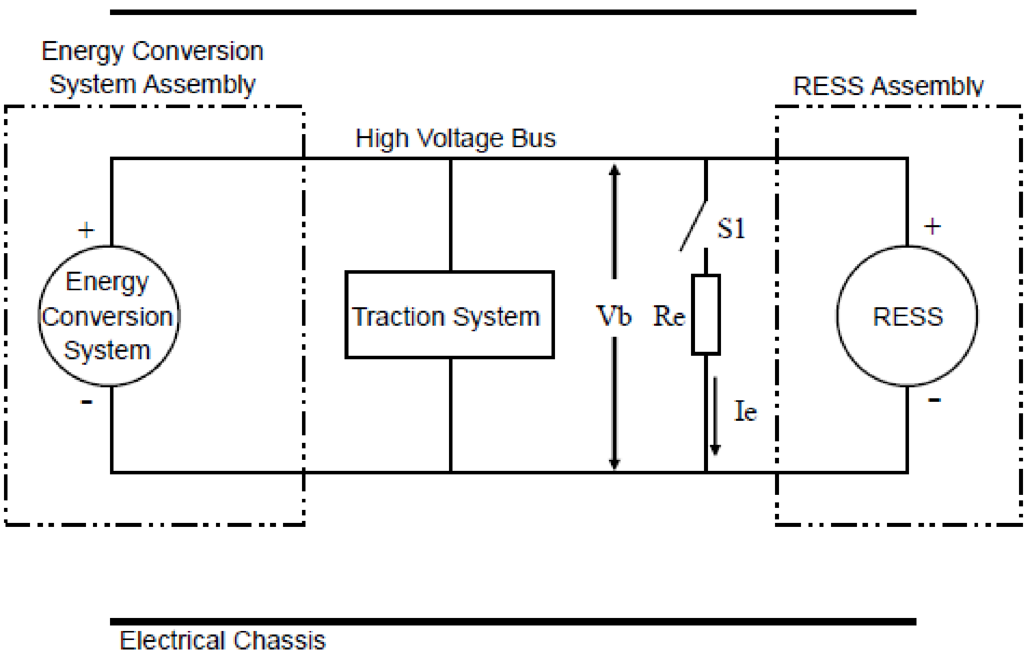


Figure 4: Measurement of high voltage bus energy

5-5 Physical Barrier

5-5-1 Test conditions

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

Any surrounding parts of the high voltage components that can be opened, disassembled or removed without the use of tools after crash test shall be opened, disassembled or removed. Surrounding parts that cannot be opened, disassembled or removed without the use of tools are considered as a part of the physical barrier.

The access probe is pushed against any openings of the physical barrier with the force specified in table 1. If it partly or fully penetrates into the original physical protection, it is placed in every possible position.

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

5-5-2 Acceptance conditions

[The access probe shall not touch live parts.]

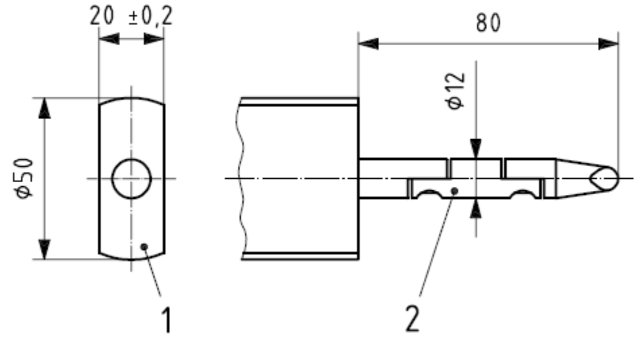
A mirror or a fiberscope may be used in order to inspect whether the access probe touches the high voltage buses, if necessary.

Attached Sheet 1

PROTECTION DEGREES

1 IPXXB

Jointed test finger diameter 12; 80 length Dimensions in millimetres



Key

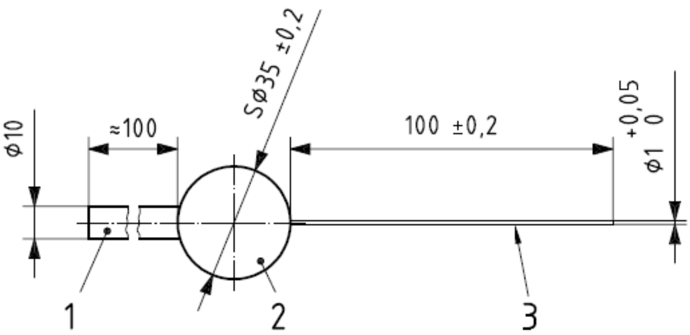
1 stop face (diameter 50 × 20) (insulating material)

2 jointed test finger (metal)

The jointed test finger may penetrate over its full length of 80 mm but shall not contact the hazardous parts, even when its joints are bent at any optional angle (up to 90° from its axis) and are brought i nto any possible position. The stop face (Ø50 mm · 20 mm) shall not pass through the opening.
The test force shall be 10 N ± 10 %.

2 IPXXD

Test wire diameter 1,0; 100 long Dimensions in millimetres



Key

1 handle (insulating material)

2 stop face (insulating material)

3 sphere

4 rigid test wire (metal) (edges free from burrs)

The rigid test wire (diameter 1,0 mm, 100 mm long) may penetrate over its full length of 100 mm, but shall be sufficiently distant from hazardous parts in any possible angular position. The stop face (sphere Ø35 mm) shall not pass through the opening.
The test force shall be 1 N ± 10 %.