

INTERNATIONAL STANDARD



GROUP SAFETY PUBLICATION

**Safety requirements for electrical equipment for measurement, control and laboratory use –
Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test**



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IEC 61010-031

Edition 2.0 2015-05
REDLINE VERSION

INTERNATIONAL STANDARD



**Safety requirements for electrical equipment for measurement, control and laboratory use –
Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.080

ISBN 978-2-8322-2723-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT
FOR MEASUREMENT, CONTROL AND LABORATORY USE –****Part 031: Safety requirements for hand-held
probe assemblies for electrical measurement and test**

FOREWORD

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International Standard IEC 61010-031 has been prepared by IEC technical committee 66: Safety of measuring, control and laboratory equipment.

It has the status of a group safety publication in accordance with IEC GUIDE 104.

IEC 61010-031 is a stand-alone standard. This second edition cancels and replaces the first edition published in 2002 and Amendment 1:2008. This edition constitutes a technical revision.

This edition includes the following significant changes from the first edition, as well as numerous other changes:

- a) Voltages above the levels of 30 V r.m.s., 42,4 V peak, or 60 V d.c. are deemed to be HAZARDOUS LIVE instead of 33 V r.m.s., 46,7 V peak, or 70 V d.c.
- b) Servicing is now included within the scope.
- c) Extended environmental conditions are included within the scope.
- d) New terms have been defined.
- e) Tests for REASONABLY FORESEEABLE MISUSE have been added, in particular for fuses.
- f) Additional instruction requirements for probe assembly operation have been specified.
- g) Limit values for ACCESSIBLE parts and for measurement of voltage and touch current have been modified.
- h) SPACINGS requirements for mating of CONNECTORS have been modified.
- i) PROBE TIPS and SPRING-LOADED CLIPS requirements have been modified. The PROTECTIVE FINGERGUARD replace the BARRIER with new requirements.
- j) Insulation requirements (6.5) and test procedures (6.6.5) have been rewritten and aligned when relevant with Part 1. Specific requirements have been added for solid insulation and thin-film insulation.
- k) The terminology for MEASUREMENT CATEGORY I has been replaced with the designation “not RATED for measurements within MEASUREMENT CATEGORIES II, III, or IV”.
- l) The flexing/pull test (6.7.4.3) has been partially rewritten.
- m) Surface temperature limits (Clause 10) have been modified to conform to the limits of IEC Guide 117.
- n) Requirements for resistance of PROBE WIRES to mechanical stresses have been added in Clause 12 and a new Annex D.
- o) Requirements have been added regarding the prevention of HAZARD from arc flash and short-circuits for SPRING-LOADED CLIPS.
- p) A new informative Annex E defines the dimension of the 4 mm banana CONNECTORS.

The text of this standard is based on the following documents:

FDIS	Report on voting
66/569/FDIS	66/571/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61010 series, under the general title, *Safety requirements for electrical equipment for measurement, control, and laboratory use*, may be found on the IEC website.

In this standard, the following print types are used:

- requirements and definitions: in roman type;
- NOTES and EXAMPLES: in smaller roman type;
- *conformity and tests: in italic type;*
- terms used throughout this standard which have been defined in Clause 3: SMALL ROMAN CAPITALS.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,
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SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL AND LABORATORY USE –

Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test

1 Scope and object

1.1 Scope

1.1.1 Probe assemblies included in scope

This part of IEC 61010 ~~applies to~~ specifies safety requirements for hand-held and hand-manipulated probe assemblies of the types described below, and ~~their~~ related accessories ~~which are intended for professional, industrial process, and educational use~~. These probe assemblies are for ~~use in the interface between an direct electrical phenomenon and connection between a part and electrical test or~~ and measurement equipment. They may be fixed to the equipment or be detachable accessories for the equipment.

- a) Type A: low-voltage and high-voltage, non-attenuating probe assemblies. Non-attenuating probe assemblies that are RATED for direct connection to voltages exceeding ~~33~~ 30 V r.m.s. ~~or 46,7, 42,4 V peak, or 70 60 V d.c.~~, but not exceeding 63 kV. They do not incorporate ~~active~~ components, ~~nor which are they~~ intended to provide a voltage divider function or a signal conditioning function, but they may contain ~~passive~~ non-attenuating components such as fuses (see Figure 1).
- b) Type B: high-voltage attenuating or divider probe assemblies. Attenuating or divider probe assemblies that are RATED for direct connection to secondary voltages exceeding 1 kV r.m.s. ~~or 1,5 kV d.c.~~ but not exceeding 63 kV r.m.s. ~~or d.c.~~ The divider function may be carried out wholly within the probe assembly, or partly within the test or measurement equipment to be used with the probe assembly (see Figure 2).
- c) Type C: low-voltage attenuating or divider probe assemblies. Attenuating ~~or divider or other signal conditioning~~ probe assemblies for direct connection to voltages ~~exceeding 33 V r.m.s. or 46,7 V peak or 70 V d.c., but~~ not exceeding 1 kV r.m.s. or 1,5 kV d.c. The signal conditioning function may be carried out wholly within the probe assembly, or partly within the test or measurement equipment intended to be used with the probe assembly (see Figure 3).
- d) Type D: low-voltage attenuating, non-attenuating or other signal conditioning probe assemblies, that are RATED for direct connection only to voltages not exceeding 30 V r.m.s., or 42,4 V peak, or 60 V d.c., and are suitable for currents exceeding 8 A (see Figure 4).

NOTE—PROBE ASSEMBLIES which

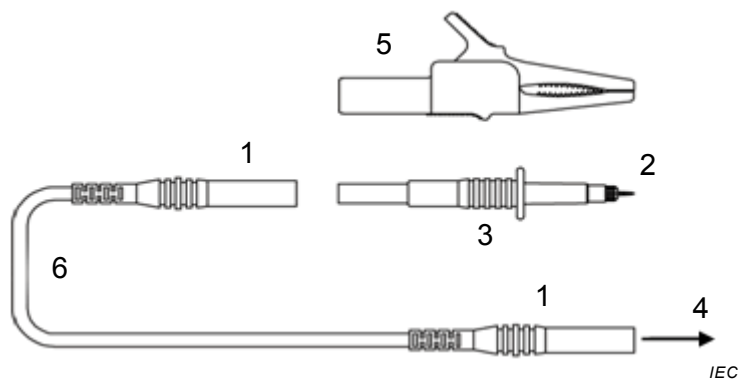
— are not within the definitions of types A, B or C, or,

— which are designed to be powered from a low-voltage mains supply, or

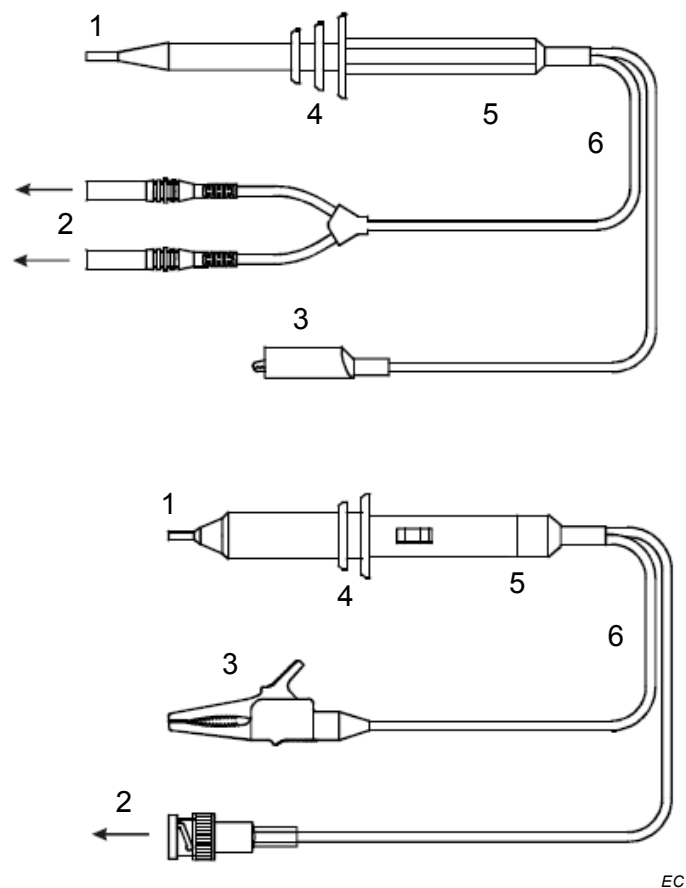
— include other features not specifically addressed in this standard

may also need to meet the relevant requirements of other parts of IEC 61010 [6]¹⁾.

¹⁾—Figures in square brackets refer to the bibliography.

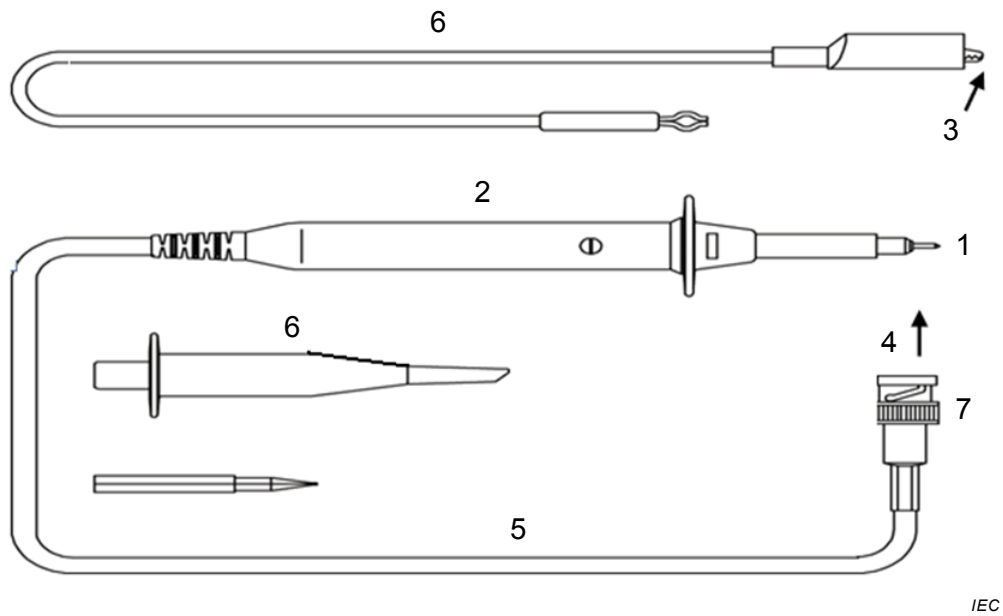
**Key**

- | | |
|----------------------|-------------------------------------|
| 1 typical connectors | 4 to equipment |
| 2 PROBE TIP | 5 Crocodile clip SPRING-LOADED CLIP |
| 3 probe body | 6 PROBE WIRE |

Figure 1 – Examples of type A probe assemblies**Key**

- | | |
|-----------------------|----------------------------------|
| 1 PROBE TIP | 4 BARRIER PROTECTIVE FINGERGUARD |
| 2 to equipment | 5 hand-held area of probe body |
| 3 reference CONNECTOR | 6 PROBE WIRE |

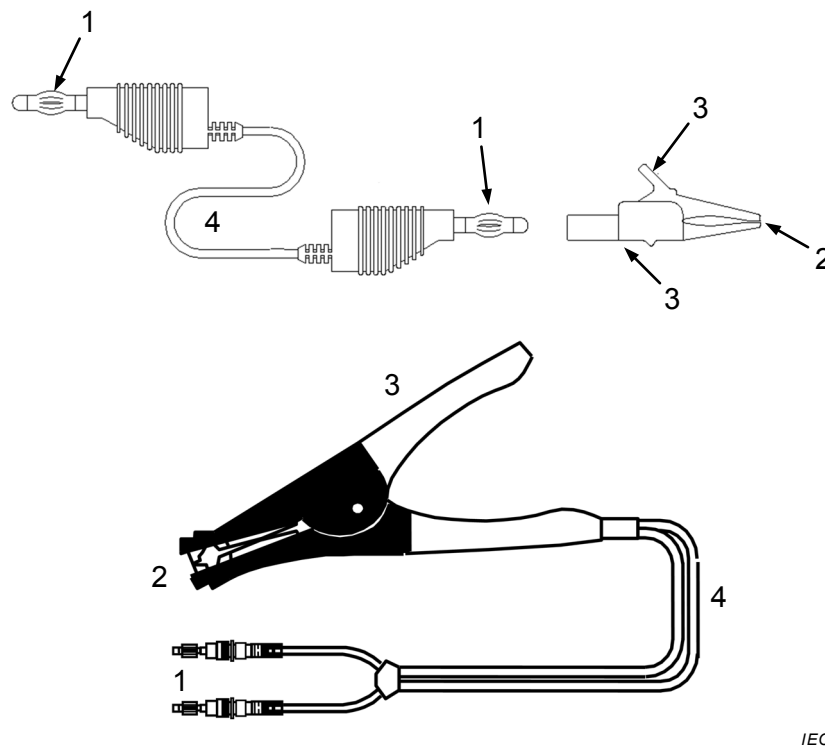
Figure 2 – Examples of type B probe assemblies



Key

- | | |
|-----------------------|---------------------------|
| 1 PROBE TIP | 5 PROBE WIRE |
| 2 probe body | 6 examples of accessories |
| 3 reference CONNECTOR | 7 BNC CONNECTOR |
| 4 to equipment | |

Figure 3 – Examples of type C probe assemblies



Key

- | | |
|-------------|---|
| 1 CONNECTOR | 3 hand-held area of SPRING-LOADED CLIP or clamp |
| 2 PROBE TIP | 4 PROBE WIRE |

Figure 4 – Examples of type D probe assemblies

1.1.2 Probe assemblies excluded from scope

This standard does not apply to current sensors within the scope of IEC 61010-2-032 (Hand-held and hand-manipulated current sensors), but may apply to their input measuring circuit leads and accessories.

1.2 Object

1.2.1 Aspects included in scope

The purpose of the requirements of this standard is to ensure that ~~the design and methods of construction used provide adequate protection for~~ HAZARDS to the OPERATOR and the surrounding area ~~against~~ are reduced to a tolerable level.

Requirements for protection against particular types of HAZARDS are given in Clauses 6 to 13, as follows:

- a) electric shock or burn (see Clauses 6, 10 and 11);
- b) mechanical HAZARDS (see Clauses 7, 8 and 11);
- c) excessive temperature (see Clause 9);
- d) spread of fire from the probe assembly (see Clause 9);
- e) arc flash (see Clause 13).

Additional requirements for probe assemblies which are designed to be powered from a low-voltage mains supply, or include other features not specifically addressed in this standard are in other parts of IEC 61010.

NOTE Attention is drawn to the possible existence of additional requirements ~~which may be specified by national authorities responsible for~~ regarding the health and safety of labour forces.

1.2.2 Aspects excluded from scope

This standard does not cover:

- a) reliable function, performance, or other properties of the probe assembly;
- b) effectiveness of transport packaging.
- ~~c) servicing (repair);~~
- ~~d) protection of servicing (repair) personnel.~~

~~NOTE Servicing personnel are expected to be reasonably careful in dealing with obvious HAZARDS, but the design should protect against mishap in an appropriate manner, and the service documentation should point out any residual HAZARDS.~~

1.3 Verification

This standard also specifies methods of verifying that the probe assembly meets the requirements of this standard, through inspection, TYPE TESTS, and ROUTINE TESTS.

1.4 Environmental conditions

1.4.1 Normal environmental conditions

This standard applies to probe assemblies designed to be safe at least under the following conditions:

- a) altitude up to 2 000 m, ~~or above 2 000 m if specified by the manufacturer;~~
- b) ambient temperature of 5 °C to 40 °C; ~~or below 5 °C or above 40 °C if specified by the manufacturer;~~

- c) maximum relative humidity of 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;
- d) applicable ~~RATED~~ POLLUTION DEGREE of the intended environment.

1.4.2 Extended environmental conditions

This standard applies to probe assemblies designed to be safe not only in the environmental conditions specified in 1.4.1, but also in any of the following conditions as RATED by the manufacturer of the probe assemblies:

- a) outdoor use;
- b) altitudes above 2 000 m;
- c) ambient temperatures below 5 °C or above 40 °C;
- d) relative humidities above the levels specified in 1.4.1;
- e) WET LOCATIONS.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60027 (all parts), *Letters symbols to be used in electrical technology*

~~IEC 60060 (all parts), *High-voltage test techniques*~~

~~IEC 60417 (all parts), *Graphical symbols for use on equipment*~~

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

~~IEC 60664-3, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coatings to achieve insulation coordination of printed board assemblies*~~

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61180-1:1992, *High-voltage test techniques for low voltage equipment – Part 1: Definitions, test and procedure requirements*

IEC 61180-2, *High-voltage test techniques for low-voltage equipment – Part 2: Test equipment*

IEC GUIDE 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC GUIDE 51, *Safety aspects – Guidelines for their inclusion in standards*

~~ISO 7000, *Graphical symbols for use on equipment – Index and synopsis*~~

3 Terms and definitions

For the purposes of this document, the following **terms and** definitions apply.

~~Unless otherwise specified, the terms "voltage" and "current" mean the r.m.s. values of an alternating, direct or composite voltage or current. Where the term "mains" is used, it refers to the low voltage electricity supply system (above the values of 6.3.2.1).~~

3.1 Parts and accessories

3.1.1

TERMINAL

component provided for the connection of a device (equipment) to external conductors

Note 1 to entry: TERMINALS can contain one or several contacts and the term includes sockets, pins, connectors, etc.

3.1.2

ENCLOSURE

part providing protection of ~~equipment~~ **a probe assembly** against certain external influences and, in any direction, protection against direct contact

3.1.3

BARRIER

~~part providing protection against direct contact from any usual direction of access~~

~~NOTE—ENCLOSURES and BARRIERS may provide protection against the spread of fire (see 9.1).~~

3.1.4

PROBE ASSEMBLY

~~device for making temporary contact between test or measurement equipment and a point on an electrical circuit being measured or tested. It includes the cable and the means for making a connection with the test or measurement equipment~~

~~NOTE—See figures 1 and 2 for examples of PROBE ASSEMBLIES and an explanation of the function of their parts.~~

3.1.3

PROTECTIVE FINGERGUARD

part of the ENCLOSURE that indicates the limit of safe access and that reduces the risk of the OPERATOR touching HAZARDOUS LIVE parts

3.1.4

PROBE TIP

part of a probe assembly **or accessory** which makes a connection to the point being measured or tested

Note 1 to entry: The term "PROBE TIP" includes the conductive parts of the jaws or hooks of SPRING-LOADED CLIPS.

3.1.6

REFERENCE CONNECTOR

~~device used to connect a reference point in the test or measurement equipment (usually the functional earth TERMINAL) to a reference point on the electrical circuit being measured or tested~~

3.1.5

CONNECTOR

component which is attached to the PROBE WIRE, to connect to a TERMINAL of the equipment or to a CONNECTOR of another probe assembly

3.1.6

TOOL

external device, including a key or coin, used to aid a person performing a mechanical function

3.1.7

PROBE WIRE

flexible wire or cable used as part of the probe assembly or its accessories, consisting of one or more conductors and associated insulation

3.1.8

SPRING-LOADED CLIP

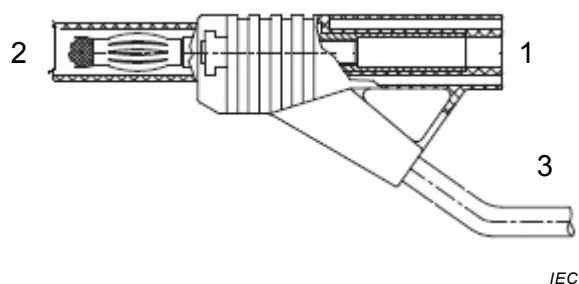
probe or probe accessory with one or more hooks or jaws forced by a spring to grip the part being measured or tested

3.1.9

STACKABLE CONNECTOR

CONNECTOR assembly which contains an additional TERMINAL

EXAMPLE: Figure 5 is an example of a STACKABLE CONNECTOR with a male CONNECTOR and a female TERMINAL.



Key

- 1 TERMINAL for additional CONNECTOR
- 2 CONNECTOR
- 3 PROBE WIRE

Figure 5 – Example of a STACKABLE CONNECTOR with a male CONNECTOR and a female TERMINAL

3.2 ~~Electrical~~ Quantities

3.2.1

RATED (condition or value)

condition or quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device, or ~~equipment~~ probe assembly

~~[IEV 151-04-03]~~

3.2.2

RATING

set of RATED values and operating conditions

~~[IEV 151-04-04]~~ SOURCE: IEC 60050-151:2001, 151-16-11]

3.2.3

WORKING VOLTAGE

highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can continuously appear during NORMAL USE

Note 1 to entry: ~~Both open-circuit conditions and normal operating conditions are taken into account. Transients and voltage fluctuations are not considered to be part of the WORKING VOLTAGE~~

3.3 Tests

3.3.1

TYPE TEST

test of one or more samples of ~~equipment~~ a probe assembly (or parts of ~~equipment~~ a probe assembly) made to a particular design, to show that the design and construction meet ~~one or more the~~ requirements of this standard

Note 1 to entry: This is an amplification of the ~~IEV 151-04-15~~ IEC 60050-151:2001, 151-16-16 definition to cover design as well as construction ~~requirements~~.

3.3.2

ROUTINE TEST

conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.4 Safety terms

3.4.1

ACCESSIBLE ~~(of a part)~~

able to be touched with a standard test finger or test pin, when used as specified in 6.2

3.4.2

HAZARDOUS LIVE

capable of rendering an electric shock or electric burn ~~in NORMAL CONDITION or SINGLE FAULT CONDITION (see 6.3.1 for values applicable to NORMAL CONDITION and 6.3.2 for the higher values deemed to be appropriate in SINGLE FAULT CONDITION)~~

3.4.3

HIGH INTEGRITY

~~not liable to become defective in such a manner as to cause a risk of HAZARD; a HIGH INTEGRITY part is considered as not subject to failure when tests under fault conditions are made~~

3.4.3

HAZARD

potential source of harm

3.4.4

PROTECTIVE IMPEDANCE

~~component, assembly of components or the combination of BASIC INSULATION and a current or voltage limiting device, the impedance, construction and reliability of which are such that when connected between parts which are HAZARDOUS LIVE and ACCESSIBLE conductive parts, it provides protection to the extent required by this standard in NORMAL CONDITION and SINGLE FAULT CONDITION~~

component or assembly of components whose impedance, construction and reliability are suitable to provide protection against electric shock

3.4.5

NORMAL USE

operation, including stand-by, according to the instructions for use or for the obvious intended purpose

NOTE ~~In most cases, NORMAL USE also implies NORMAL CONDITION, because the instructions for use will warn against using the equipment when it is not in NORMAL CONDITION.~~

3.4.6

NORMAL CONDITION

condition in which all means for protection against HAZARDS are intact

3.4.7

SINGLE FAULT CONDITION

condition in which one means for protection against a HAZARD is defective or one fault is present which could cause a HAZARD

~~NOTE If a SINGLE FAULT CONDITION results unavoidably in another SINGLE FAULT CONDITION, the two failures are considered as one SINGLE FAULT CONDITION.~~

3.4.8

OPERATOR

person operating ~~equipment~~ the probe assembly for its intended purpose

~~NOTE The OPERATOR should have received training appropriate for this purpose.~~

3.4.9

RESPONSIBLE BODY

individual or group responsible for the safe use and maintenance of ~~equipment, and for ensuring that OPERATORS are adequately trained~~ probe assemblies

3.4.10

WET LOCATION

location where water or another conductive liquid may be present and is likely to cause reduced human body impedance due to wetting of the contact between the human body and the ~~equipment~~ probe assembly, or wetting of the contact between the human body and the environment

3.4.11

HAZARD

~~potential source of harm (see 1.2)~~

3.4.11

MEASUREMENT CATEGORY

classification of testing and measuring circuits according to the types of mains circuits to which they are intended to be connected

3.4.12

REASONABLY FORESEEABLE MISUSE

use of a product in a way not intended by the supplier, but which may result from readily predictable human behaviour

3.5 Insulation

3.5.1

BASIC INSULATION

insulation, ~~the failure~~ of HAZARDOUS LIVE parts which ~~could cause a risk of electric shock~~ provides basic protection

~~NOTE BASIC INSULATION may serve also for functional purposes.~~

[SOURCE: IEC 60050-195:1998, 195-06-06]

3.5.2

SUPPLEMENTARY INSULATION

independent insulation applied in addition to BASIC INSULATION in order to provide protection against electric shock in the event of a failure of BASIC INSULATION

3.5.3

DOUBLE INSULATION

insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.5.4

REINFORCED INSULATION

insulation which provides a degree of protection against electric shock not less than that provided by DOUBLE INSULATION

~~NOTE REINFORCED INSULATION may comprise several layers which cannot be tested singly as SUPPLEMENTARY INSULATION or BASIC INSULATION.~~

3.5.5

POLLUTION

addition of foreign matter, solid, liquid or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface ~~resistivity~~ resistivity

3.5.6

POLLUTION DEGREE

~~for the purpose of evaluating CLEARANCES one of three degrees of POLLUTION in the micro-environment, which are recognized for use with this International Standard~~
numeral indicating the level of POLLUTION that may be present in the environment

3.5.7

POLLUTION DEGREE 1

no POLLUTION or only dry, non-conductive POLLUTION occurs, which has no influence

~~NOTE The POLLUTION has no influence.~~

3.5.8

POLLUTION DEGREE 2

only non-conductive POLLUTION. ~~Occasionally, however, a temporary conductivity caused by condensation must be expected~~ occurs except that occasionally a temporary conductivity caused by condensation is expected

3.5.9

POLLUTION DEGREE 3

conductive POLLUTION occurs, or dry, non-conductive POLLUTION occurs which becomes conductive due to condensation which is expected

3.5.10

CLEARANCE

shortest distance in air between two conductive parts

3.5.11

CREEPAGE DISTANCE

shortest distance along the surface of a solid insulating material between two conductive parts

~~[IEV 151-03-37~~ SOURCE: IEC 60050-151:2001, 151-15-50]

3.5.12

SPACING

any combination of CLEARANCES and CREEPAGE DISTANCES

4 Tests

4.1 General

Tests in this standard are TYPE TESTS to be carried out on samples of probe assemblies or their parts. Their only purpose is to check that the design and construction ensure conformity with this standard. *In addition, the ROUTINE TESTS of Annex D shall be performed on the PROBE WIRE.*

The probe assembly shall at least meet the requirements of this standard. It is permissible to exceed the requirements. If, in this standard, a lower limit is specified for a conformity value, then the probe assembly may demonstrate a larger value. If an upper limit is specified for a conformity value, the probe assembly may demonstrate a lower value. Manufacturing variations and tolerances shall be taken into account.

Tests on components or parts of the probe assembly meeting the requirements of the relevant standards, *specified in this standard, and used in accordance with them*, need not be repeated during TYPE TESTS of the whole probe assembly.

If a probe assembly is of more than one probe type (see 1.1.1), each type shall be tested according to its applicable requirements.

Conformity with the requirements of this standard is checked by carrying out all applicable tests, except that a test may be omitted if examination of the probe assembly and design documentation demonstrates conclusively that it would pass the test. Tests are carried out both under reference test conditions (see 4.3) and fault conditions (see 4.4).

Where conformity statements in this standard require inspection, this may include examination of the probe assembly by measurement, examination of the markings on the probe assembly, examination of the instructions supplied with the probe assembly, examination of the data sheets of the materials or components from which the probe assembly is manufactured, etc. In each case, the inspection will either demonstrate that the probe assembly meets the applicable requirements, or will indicate that further testing is required.

NOTE 2 *If when carrying out a conformity test, there is any uncertainty about the exact value of the applied or measured quantity (for example, voltage) due to the tolerance,*

- a) the manufacturer should ensure that at least the specified test value is applied;*
- b) the test house should ensure that no more than the specified test value is applied.*

NOTE 4 *If the RATED range of environmental conditions for probe assemblies is wider than that stated in 1.4.1, the manufacturer should make sure (for example, by suitable alteration of test requirements or additional tests) that the safety requirements of this standard are still fulfilled.*

NOTE 3 *Probe assemblies which have been type tested may no longer be suitable for their intended function because of the residual effect of stresses resulting from tests. ~~For this reason TYPE TESTS should never be carried out (for example, by the RESPONSIBLE BODY) after the PROBE ASSEMBLIES have left the manufacturer.~~ A probe assembly which has undergone TYPE TESTS shall not then be put into use.*

4.2 Sequence of tests

The sequence of tests is optional unless otherwise specified ~~in the standard~~. The probe assemblies under test shall be carefully inspected after each test. If the result of a test causes doubt whether any earlier tests would have ~~been~~ passed if the sequence had been reversed, these earlier tests shall be repeated. ~~Tests under fault conditions may be destructive and may follow those under reference test conditions.~~

4.3 Reference test conditions

4.3.1 Environmental conditions

Unless otherwise specified in this standard, the following environmental conditions (but not conflicting with those of 1.4.1, shall exist in the test location:

- a) a temperature of 15 °C to 35 °C;
- b) a relative humidity of not more than 75 %;
- c) an air pressure of 75 kPa to 106 kPa;
- d) no hoarfrost, dew, percolating water, rain, solar irradiation, etc.

4.3.2 State of probe assemblies

Unless otherwise specified, tests shall be carried out on the probe assemblies assembled for NORMAL USE and under the least favourable combination of the conditions given in 4.3.3 to 4.3.9.

In case of doubt, tests shall be performed in more than one combination of conditions.

If dimensions or mass make it unsuitable to carry out particular tests on a complete probe assembly, tests on sub-assemblies are allowed, provided it is verified that the assembled probe assembly will meet the requirements of this standard.

4.3.3 Position of the probe assembly

~~The probe assembly shall be in any position of NORMAL USE and with any ventilation unimpeded.~~ All possible orientations of the probe assembly are considered to be positions of NORMAL USE.

4.3.4 Accessories

Accessories and OPERATOR-interchangeable parts available from, or recommended by, the manufacturer for use with the probe assembly under test shall be either connected or not connected.

4.3.5 Covers and removable parts

Covers or parts which can be removed without using a TOOL shall be removed or not removed ~~whichever is the worst condition.~~

4.3.6 Input and output voltages

Input and output voltages, including floating voltages shall be set to any voltage within the RATED voltage range.

4.3.7 Controls

Controls which the OPERATOR can adjust ~~by hand without the use of a TOOL~~ shall be set to any position except for combinations of settings prohibited by the ~~manufacturer, as shown by~~ ~~manufacturer's~~ marking on the probe assembly.

4.3.8 Connections

The probe assembly shall be connected for ~~its intended purpose,~~ NORMAL USE or not connected ~~whichever is the worst condition.~~

4.3.9 Duty cycle

Probe assemblies for short-term or intermittent operation shall be operated for the longest **RATED** period and **shall** have the shortest **RATED** recovery period consistent with the manufacturer's instructions.

4.4 Testing in SINGLE FAULT CONDITION

4.4.1 General

The following requirements apply.

- a) Examination of the probe assembly and its circuit diagram will generally show the fault conditions which are liable to result in HAZARDS ~~within the meaning of this standard~~ and which, therefore, shall be applied.
- b) Fault tests shall be made **as specified for checking conformity**, unless it can be demonstrated that no HAZARD could arise from a particular fault condition.
- c) The probe assembly shall be operated under the least favourable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they ~~should~~ **shall** be recorded for each test.

4.4.2 Application of fault conditions

4.4.2.1 General

Fault conditions shall include those specified in 4.4.2.2 to 4.4.2.5. They shall be applied only one at a time and shall be applied in turn in the most convenient order. Multiple simultaneous faults shall not be applied unless they are a consequence of an applied fault.

After each application of a fault condition, the probe assembly or part shall pass the applicable tests of 4.4.4.

4.4.2.2 PROTECTIVE IMPEDANCE

The following requirements apply.

- a) If a PROTECTIVE IMPEDANCE is formed by a combination of components, each component shall be short-circuited or disconnected, whichever is less favourable.
- b) If a PROTECTIVE IMPEDANCE is formed with a single component that meets the requirements of 6.4.5, it need not be short-circuited or disconnected.

4.4.2.3 Probe assemblies or parts for short-term or intermittent operation

These shall be operated continuously if continuous operation could occur in a SINGLE FAULT CONDITION.

4.4.2.4 Outputs

Outputs of Type B and Type C probe assemblies shall be short-circuited ~~one at a time~~.

4.4.2.5 Insulation between circuits and parts

Insulation between circuits and parts which is below the level specified for BASIC INSULATION shall be bridged to check against the spread of fire **if the method of 9.1 is used**.

NOTE—See 9.1 for an alternative method of checking protection against spread of fire.

~~4.4.2.4~~ COMPONENTS

~~Components (except HIGH INTEGRITY components) of type B and type C PROBE ASSEMBLIES shall be short-circuited or open-circuited, whichever is less favourable.~~

4.4.3 Duration of tests

The probe assembly shall be operated until further change as a result of the applied fault is unlikely. Each test is normally limited to 1 h since a secondary fault arising from a SINGLE FAULT CONDITION will usually manifest itself within that time. ~~If at the end of 1 h there is an indication that a risk HAZARD of electric shock, spread of fire or injury to persons may eventually occur, the test shall be continued until one of these HAZARDS does occur or~~ for a maximum period of 4 h.

~~If a fault is terminated by the opening of a fuse and if the fuse does not operate within approximately 1 s, the current through the fuse under the relevant fault condition shall be measured. Evaluation with the pre-arcing time/current characteristics shall be made to find out whether the minimum operating current of the fuse is reached or exceeded and what is the maximum time before the fuse operates. The current through the fuse may vary as a function of time. If the minimum operating current of the fuse is not reached in the test, the equipment shall be operated for a period corresponding to the maximum fusing time or continuously for the duration specified in 4.4.3.1.~~

4.4.4 Conformity after application of ~~single~~ fault conditions

4.4.4.1 Electric shock

Conformity with requirements for protection against electric shock after the application of single faults is checked as follows:

- by making the measurements of 6.3.3 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE, except as permitted by 6.1;
- by performing a voltage test on DOUBLE INSULATION or REINFORCED INSULATION to check that ~~there the protection~~ is still ~~one at least at the~~ level of ~~protection by~~ BASIC INSULATION. The voltage tests are made as specified in 6.6 (without humidity preconditioning) with the test voltage for BASIC INSULATION.

4.4.4.2 Temperature

Conformity with requirements for temperature protection is checked by determining the temperature of the outer surface of the probe assembly (see Clause 9).

~~The temperature of the outer surface shall not exceed 105 °C at maximum RATED ambient temperature.~~

This temperature is determined by measuring the temperature rise of the surface or part and adding it to the maximum RATED ambient temperature.

4.4.4.3 Spread of fire

Conformity with requirements for protection against the spread of fire is checked by placing the probe assembly on white tissue-paper covering a softwood surface and covering the probe assembly with cheesecloth. No molten metal, burning insulation, flaming particles, etc. shall fall on the surface on which the probe assembly stands and there shall be no charring, glowing, or flaming of the tissue paper or cheesecloth. Melting of insulation material shall be ignored ~~if the molten material could not contribute to starting a fire, and if it would be obvious to the operator that the PROBE ASSEMBLY needs to be de-energized and allowed to cool before it is touched no HAZARD could arise.~~

4.4.4.4 Other HAZARDS

Conformity with the requirements for protection against other HAZARDS is checked as specified in Clauses 7 to 13.

4.5 Tests in REASONABLY FORESEEABLE MISUSE

4.5.1 General

Tests needed to support a risk assessment pertaining to REASONABLY FORESEEABLE MISUSE are carried out in the combinations of conditions and operations determined during the risk assessment.

4.5.2 Fuses

Fused probe assemblies are used where insufficient protection may be provided by the equipment to which the hand manipulated probe assemblies are connected in particular under the REASONABLY FORESEEABLE MISUSE conditions associated with the equipment that could lead to fire or arc explosion.

For the purposes of this test, it is assumed that the equipment to which the probe assemblies are connected represents a short circuit condition. It is further assumed that the fused probe assembly may be connected to any voltage source within the RATING of the probe assembly. This leads to a test condition where any current level up to the maximum prospective short circuit current may be applied. With respect to prospective short circuit currents associated with MAINS installations, the fuse shall be RATED according to 12.2 and no additional testing related to the interrupt current RATING is necessary. However, testing is necessary at current levels near the RATING of fuse which could potentially lead to excessive temperature rise on hand held parts as well as damage to insulating parts, ENCLOSURES, and barriers.

It shall be demonstrated that the maximum fuse temperature under any current load condition up to 5 times the fuse RATING through the fused probe assembly does not lead to a HAZARD.

Conformity is checked by inspection and measurement.

5 Marking and documentation

5.1 Marking

5.1.1 General

Probe assemblies shall bear markings in accordance with 5.1.2 to 5.2. Markings applying to a probe assembly as a whole shall not be put on parts which can be removed by an OPERATOR without the use of a TOOL.

Letter symbols for quantities and units shall be in accordance with IEC 60027. Graphic symbols shall be in accordance with Table 1 **if applicable**. There are no requirements for size or colour. If there is no applicable symbol in Table 1, any other graphic symbol may be used on a probe assembly provided the symbol is explained in the accompanying documentation (see 5.4.1).

If it is not possible to put all of the required markings on the part, the necessary information shall be included in the documentation. Symbol 7 of Table 1 may also be used.

Conformity is checked by inspection.

5.1.2 Identification

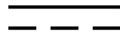
Each probe assembly and ~~separable mating part of a PROBE ASSEMBLY~~, when possible, its accessories shall, ~~as a minimum~~, be marked with:

- the name or registered trade mark of the manufacturer or supplier;
- in addition for Type B and Type C only, the model number or name or other means of identifying the probe assembly or part.

If a probe assembly is designed for use only with a specific model of equipment, this shall be made clear, and the specific equipment or model shall be identified, either by marking on the probe assembly or in the accompanying documentation.

Conformity is checked by inspection.

Table 1 – Symbols

Number	Symbol	Reference	Description
1		IEC 60417-5031 (2002-10)	Direct current
2		IEC 60417-5032 (2002-10)	Alternating current
3		IEC 60417-5033 (2002-10)	Both direct and alternating current
4			Three-phase alternating current
4		IEC 60417-5017 (2006-08)	Earth (ground) TERMINAL
6		IEC 60417-5021	Equipotentiality
7		IEC 60417-5172	Part protected throughout by DOUBLE INSULATION OR REINFORCED INSULATION
5		IEC 60417-6042 (2010-11)	Caution, risk possibility of electric shock
6		IEC 60417-5041 (2002-10)	Caution, hot surface
7		ISO 7000-0434 (2004-01)	Caution, risk of danger (see note 1) ^a
NOTE 1 ^a See 5.4.1 which requires manufacturers to state that documentation must be consulted in all cases where this symbol is marked.			
NOTE 2 There are no requirements for sizes or colours (see 5.1.1).			

5.1.3 Fuses

Probe assemblies which contain fuses intended to be replaced by an OPERATOR shall be marked with all the details necessary for the OPERATOR to obtain the correct fuse. These shall include the voltage RATING and the breaking capacity (the maximum current that the fuse can safely interrupt at the highest RATED voltage). If ~~the OPERATOR has to select a fuse according to the particular application~~, there is not sufficient room, Symbol 7 of Table 1 shall be marked on the probe assembly and the necessary information shall be included in the documentation.

Conformity is checked by inspection.

5.1.4 ~~Terminals~~ CONNECTORS and operating devices

If necessary for safety, an indication shall be given of the purpose of CONNECTORS, TERMINALS, and controls, including any sequence of operations.

Conformity is checked by inspection.

~~5.1.5 PARTS PROTECTED BY double insulation OR reinforced insulation~~

~~Parts protected throughout by DOUBLE INSULATION or REINFORCED INSULATION shall be marked with symbol 7 of table 1.~~

~~Parts which are only partially protected by DOUBLE INSULATION or REINFORCED INSULATION shall not bear symbol 7 of table 1.~~

~~*Conformity is checked by inspection.*~~

5.1.5 RATING

The RATING of probe assemblies shall be marked as follows.

- a) Probe assemblies which do not have a RATING for ~~measurements within category I~~ MEASUREMENT CATEGORIES II, III, or IV (see 6.5.2) shall be marked with the RATED voltage to earth and with Symbol 7 of Table 1 (see also 5.4.3 f) and g)).
- b) Probe assemblies for measurements within MEASUREMENT CATEGORIES II, III and IV (see 6.5.2) shall be marked with the RATED voltages to earth and the relevant MEASUREMENT CATEGORIES. The MEASUREMENT CATEGORY markings shall be "CAT II", "CAT III" or "CAT IV" as applicable.

Marking on a probe assembly shall preferably be on the probe body. The nature of the voltage (a.c., d.c., etc.) shall also be marked, unless the voltage marking applies to both a.c. r.m.s. and d.c. If a reference CONNECTOR is intended for connection to points at a voltage level exceeding the values of 6.3.2, ~~its~~ the RATED voltage ~~RATING~~ shall be marked, ~~preferably~~ on the CONNECTOR or as close to the CONNECTOR as is practicable.

For Type A and Type D probe assemblies only, the ~~maximum~~ RATED current of the probe assembly shall be marked together with the ~~maximum RATED circuit to earth~~ RATED voltage to earth. The ~~maximum~~ RATED current does not need to be marked on probe assemblies which are specified for use only in conjunction with equipment which has high-impedance inputs or limited-current outputs.

Conformity is checked by inspection.

5.2 Warning markings

Warning markings shall be ~~visible legible~~ when the probe assembly is ready for NORMAL USE.

If it is necessary for the OPERATOR to refer to the instruction manual to preserve the protection afforded by the probe assembly, the probe assembly shall be marked with the Symbol 7 of Table 1. If a warning applies to a particular part of the probe assembly, the marking shall be placed on or near this part.

If the instructions for use state that an OPERATOR is permitted to gain access, using a TOOL, to any part which in NORMAL USE may be HAZARDOUS LIVE, there shall be a warning marking which states that the probe assembly must be isolated or disconnected from the HAZARDOUS LIVE voltage before access, or Symbol 7 of Table 1 may be used provided that the information is included in the instructions for use.

Unless their heated state is self-evident or is obvious from the function of the probe assembly, parts which are easily touched and are also permitted by 9.1 to exceed the temperature limits of 9.1 shall be marked with Symbol 6 of Table 1.

Conformity is checked by inspection.

5.3 Durability of markings

Required markings ~~in accordance with 5.1.2 to 5.2~~ shall remain clear and legible under conditions of NORMAL USE and **shall** resist the effects of cleaning agents specified by the manufacturer.

*Conformity is checked ~~by inspection and~~ by performing the following test for durability of markings on the outside of the probe assembly. The markings are rubbed by hand, without undue pressure, for 30 s with a cloth soaked with each specified cleaning agent, **one at a time**, or, if not specified, with **a solution containing a minimum of 70 % isopropyl alcohol in water**.*

After the above treatment the markings shall be clearly legible and adhesive labels shall not have worked loose or become curled at the edges.

5.4 Documentation

5.4.1 General

Probe assemblies shall be accompanied by documentation when necessary for safety purposes. Such documentation shall include as a minimum:

- a) technical specification;
- b) instructions for use;
- c) name and address of manufacturer or supplier from whom technical assistance may be obtained;
- d) the information specified in 5.4.2 to 5.4.4.

If applicable, warning statements and a clear explanation of warning symbols marked on the probe assembly shall be provided in the documentation or shall be durably and legibly marked on the probe assembly. In particular, there shall be a statement that documentation needs to be consulted in all cases where Symbol 7 of Table 1 is used, in order to find out the nature of the potential HAZARD and any actions which have to be taken.

Conformity is checked by inspection.

5.4.2 Ratings Probe assembly RATING

Documentation shall include the ~~maximum~~ voltage and current RATING (as appropriate), **and the MEASUREMENT CATEGORY** as well as a statement of the range of environmental conditions for which the probe assembly is designed (see 1.4 ~~and note 1 of 4.1~~).

Conformity is checked by inspection.

5.4.3 Probe assembly operation

Instructions for use shall include, **if applicable**:

- a) identification of operating controls and their use in all operating modes;
- b) for probe assemblies designed for use only with a specific model of equipment, a clear identification of the equipment;**

- c) an explanation of symbols ~~required by this standard and related to safety~~ which are used on the probe assembly;
- d) a definition of the relevant MEASUREMENT CATEGORY if marking is required on the probe assembly (see 5.1.5);
- e) a specification of limits for intermittent operation, if applicable;
- f) instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts and any special materials;
- g) instructions for cleaning ~~if necessary (see 11.2);~~
- h) instructions for replacement of consumable materials;
- i) for PROBE ASSEMBLIES ~~intended for use within measurement category I, a warning shall be given not to use the PROBE ASSEMBLIES for measurements within the other measurement categories, and there shall be a detailed RATING, including RATED transient overvoltages, in the documentation~~ which do not have PROBE WIRE with a wear indicator, instructions to periodically inspect the PROBE WIRE;
- j) for probe assemblies which do have PROBE WIRE with a wear indicator, a warning not to use the probe assembly if the wear indicator has become visible (see 12.3.2);
- k) for probe assemblies which do not have a RATING for MEASUREMENT CATEGORIES II, III, or IV, a warning not to use the probe assemblies for measurements on mains circuits;
- l) for Type B probe assemblies, if the RATED voltage of the PROBE WIRE is lower than the RATED voltage of the PROBE TIP, a warning that the PROBE WIRE may not provide adequate protection if it comes into contact with a HAZARDOUS LIVE part;
- m) a warning that the applicable MEASUREMENT CATEGORY of a combination of a probe assembly and an accessory is the lower of the MEASUREMENT CATEGORIES of the probe assembly and of the accessory.

~~The RESPONSIBLE BODY shall be made aware that~~ There shall be a statement in the instructions that, if the PROBE ASSEMBLY is used in a manner not specified by the manufacturer, the protection provided by the probe assembly may be impaired.

Conformity is checked by inspection.

5.4.4 ~~MAINTENANCE~~ Probe assembly maintenance and service

Instructions ~~for~~ shall be provided to the RESPONSIBLE BODY ~~concerning preventive maintenance and inspection necessary for safety shall be given~~ in sufficient detail to permit safe maintenance and inspection of the probe assembly, and to ensure continued safety of the probe assembly after the maintenance and inspection procedure.

The manufacturer shall specify any parts which are required to be examined or supplied only by the manufacturer or his agent.

The RATING and characteristics of fuses used shall be stated (see 5.1.3).

Instructions on the following subjects shall be provided for service personnel, as necessary to permit safe servicing and continued safety of the probe assembly after servicing if the probe assembly is suitable to be serviced:

- a) product-specific risks that may affect the service personnel;
- b) protective measures for these risks;
- c) verification of the safe state of the probe assembly after repair.

Instructions for service personnel do not need to be supplied to the RESPONSIBLE BODY, but should be made available to service personnel.

Conformity is checked by inspection.

6 Protection against electric shock

6.1 General

Protection against electric shock shall be maintained in NORMAL CONDITION and SINGLE FAULT CONDITION. ACCESSIBLE parts of probe assemblies shall not be HAZARDOUS LIVE (see 6.3).

6.1.1 EXCEPTIONS

If it is not feasible for operating reasons to prevent the following parts being both ACCESSIBLE and HAZARDOUS LIVE, they are permitted to be ACCESSIBLE to the OPERATOR during NORMAL USE while they are HAZARDOUS LIVE:

- a) parts intended to be replaced by the OPERATOR (for example, fuses) and which may be HAZARDOUS LIVE during replacement, but only if they have warning markings in accordance with 5.2;
- b) PROBE TIPS, provided that they meet the requirements of 6.4.3;
- c) unmated CONNECTORS as specified in 6.4.2 c).

Conformity is checked by the determination of 6.2 and the measurements of 6.3, followed by the tests of 6.4 to 6.7.

6.2 Determination of ACCESSIBLE parts

6.2.1 General

Unless obvious, determination of whether a part is ACCESSIBLE ~~shall be~~ is made as specified in 6.2.2 and 6.2.3. Test fingers (see Annex B) and pins ~~shall be~~ are applied without force ~~unless a force is specified~~. Parts are considered to be ACCESSIBLE if they can be touched with any part of a test finger or pin, or if they ~~can~~ could be touched in the absence of a covering which is not considered to provide suitable insulation (see 6.7.2).

If, in NORMAL USE, an OPERATOR is intended to perform any actions (with or without a TOOL) ~~which will that could~~ increase the accessibility of parts, such actions ~~shall be~~ are taken before performing the examinations of 6.2.2 and 6.2.3.

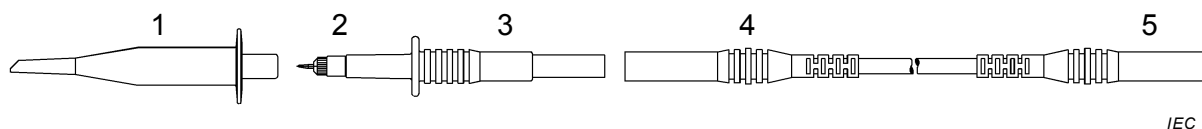
NOTE Examples of such actions include:

- a) removing covers;
- b) adjusting controls;
- c) replacing consumable materials;
- d) removing ~~or installing~~ parts ~~and supplied accessories~~.

Figure 6 gives methods for determination of ACCESSIBLE parts of probe assemblies.

6.2.2 GENERAL Examination

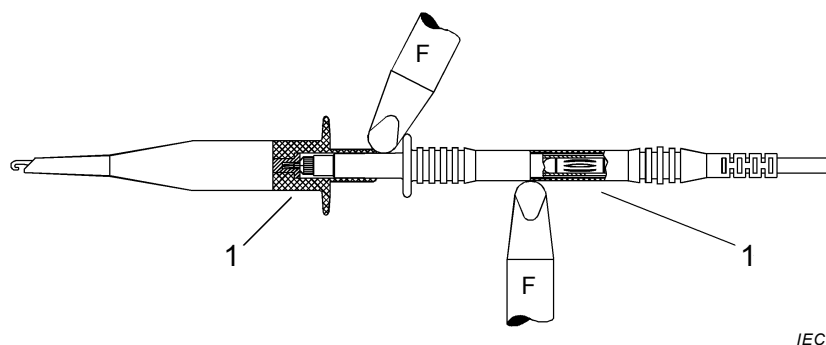
The jointed test finger (see Figure B.2) is applied in every possible position ~~without force. If a force is specified, the rigid test finger (see figure B.1) is applied with the specified force. The force is exerted by the tip of the test finger so as to avoid wedge and lever action.~~ The test is applied to all outer surfaces.



Key

- | | |
|-----------------------|--------------------------|
| 1 accessory PROBE TIP | 4 CONNECTOR |
| 2 PROBE TIP | 5 CONNECTOR to equipment |
| 3 probe body | |

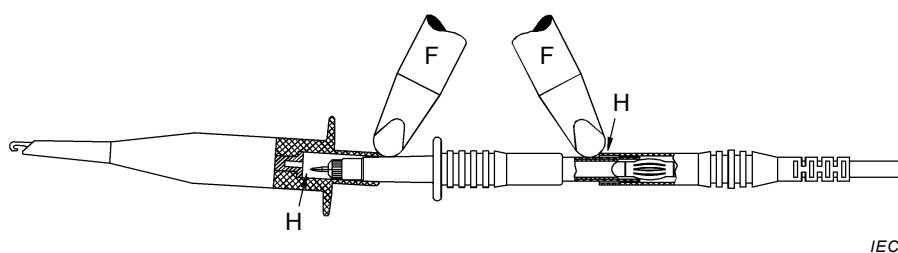
Figure-3a 6a – Parts of a probe assembly



Key

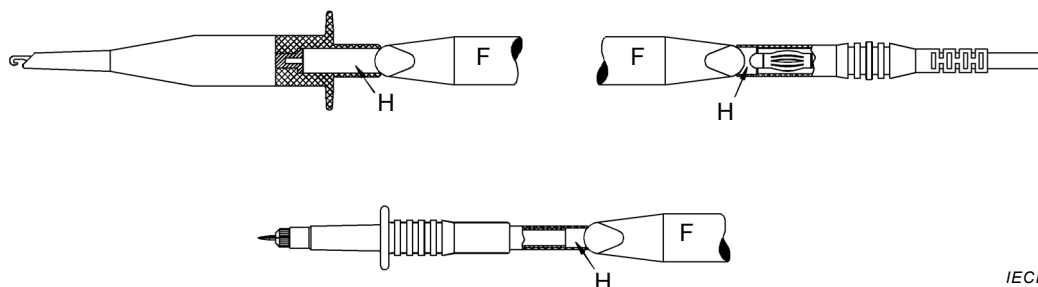
- 1 CONNECTOR

Figure-3b 6b – Fully-mated probe assembly (see 6.2 and 6.4.2 a)



Connecting parts are partially mated so as just to make electrical contact while allowing maximum access to the test finger.

Figure-3c 6c – Partially-mated probe assembly (see 6.2 and 6.4.2 b)



Key

- F rigid test finger (see Figure B.1)
H potentially HAZARDOUS LIVE part

Figure-3d 6d – Unmated parts of a probe assembly (see 6.2 and 6.4.2 c))

Figure-3 6 – Methods for determination of ACCESSIBLE parts (see 6.2) and for voltage tests of (see 6.4.2)

6.2.3 Openings for pre-set controls

A metal test pin 3 mm in diameter is inserted through holes intended to give access to pre-set controls which require the use of a screwdriver or other TOOL. The test pin is applied in every possible direction through the hole. Penetration shall not exceed three times the distance from the ENCLOSURE surface to the control shaft or 100 mm, whichever is smaller.

6.3 ~~Permissible limits~~ Limit values for ACCESSIBLE parts

6.3.1 General

~~To ensure that ACCESSIBLE parts are not HAZARDOUS LIVE~~ Except as permitted in 6.1, the voltage ~~or current~~ between an ACCESSIBLE part and ~~reference test~~ earth, or between any two ACCESSIBLE parts on the same probe assembly, shall not exceed the ~~values~~ levels of 6.3.2 in NORMAL CONDITION or of 6.3.3 in SINGLE FAULT CONDITION.

~~Measurements on probe assemblies are carried out in accordance with figure 4. Foil is wrapped around~~

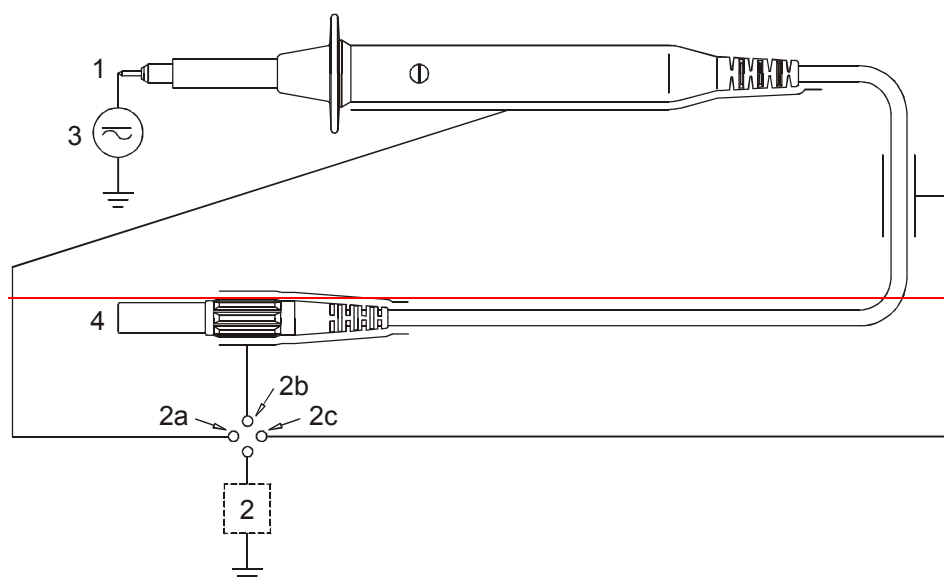
- ~~a) the probe body;~~
- ~~b) 150 mm ± 20 mm of the cable;~~
- ~~c) the connector.~~

~~The RATED voltage is applied to the PROBE TIP (1) and the ACCESSIBLE current is measured with the applicable measuring circuit of annex A, where the circuit (2) is connected in turn to the foil wrapped items (2a, 2b, 2c, etc.).~~

Outer conductors (shields) of probe assemblies, intended to be floating, are considered to be held at the same voltage as the PROBE TIP.

The ACCESSIBLE voltage shall be measured (see 6.3.4). If the voltage is below the ~~limit~~ levels of 6.3.2 a) or 6.3.3 a) as applicable, ~~ACCESSIBLE~~ the touch current and the capacitance need not be measured. If the voltage exceeds that ~~value~~ level, the touch current and the capacitance shall be measured. For high frequencies test probes, the alternative method of 6.3.4.3 can also be used.

Conformity is checked by inspection and as specified in 6.3.2 to 6.3.3.



Key

1 — PROBE TIP

2 — ACCESSIBLE current measuring circuit (see annex A)

IEC 2603/01

- 2a — Connection to metal foil tightly wrapped around parts intended to be hand-held or hand-manipulated
- 2b — Connection to metal foil tightly wrapped around the connector
- 2c — Connection to metal foil tightly wrapped around the cable (see 6.4.3)
- 3 — Maximum RATED voltage
- 4 — Not connected to equipment

Figure 4 — Example of application of metal foil for ACCESSIBLE current measurement

6.3.2 VALUES Levels in NORMAL CONDITION

Values Voltages above the levels of ~~6.3.1.1, 6.3.1.2 and 6.3.1.3 in NORMAL CONDITION a)~~ are deemed to be HAZARDOUS LIVE if any of the levels of b) or c) are exceeded at the same time.

6.3.1.1 — VOLTAGE

- a) The a.c. voltage levels are ~~33 30 V r.m.s. and 46,7 or 42,4 V peak or 70 V d.c.~~ and the d.c. voltage level is 60 V. For probe assemblies ~~which are RATED for~~ intended for use in WET LOCATIONS, the a.c. voltage levels are 16 V r.m.s. ~~and or 22,6 V peak or 35 V d.c.~~ and the d.c. voltage level is 35 V.

6.3.1.2 — CURRENT

- b) ~~If the voltage exceeds one of the values of 6.3.1.1,~~ The touch current levels are:
- 1) 0,5 mA r.m.s. for sinusoidal waveforms, 0,7 mA peak for non-sinusoidal waveforms or mixed frequencies, or 2 mA d.c., when measured with the measuring circuit of Figure A.1. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.5 is used for probe assemblies ~~which are RATED intended~~ for use in WET LOCATIONS;
 - 2) 70 mA r.m.s. when measured with measuring circuit of Figure A.3. This relates to possible burns at ~~higher~~ frequencies ~~above 100 kHz~~.

6.3.1.3 — CAPACITANCE

- c) ~~If the voltage exceeds one of the values of 6.3.1.1, the capacitance~~ The levels of capacitive charge or energy are:
- 1) 45 µC charge for voltages up to 15 kV peak or d.c. Line A of Figure 7 shows the capacitance versus voltage for cases where the charge is 45 µC.
 - 2) 350 mJ stored energy for voltages above 15 kV peak or d.c.

6.3.3 VALUES Levels in SINGLE FAULT CONDITION

In SINGLE FAULT CONDITION, ~~values voltages~~ above the levels of ~~6.3.2.1, 6.3.2.2 and 6.3.2.3 a)~~ are deemed to be HAZARDOUS LIVE if any of the levels of b) or c) are exceeded at the same time.

6.3.2.1 — VOLTAGE

- a) The a.c. voltage levels are ~~55 50 V r.m.s. and 78 or 70,7 V peak or 140 V d.c.~~ and the d.c. voltage level is 120 V. For probe assemblies ~~which are RATED intended~~ for use in WET LOCATIONS, the a.c. voltage levels are 33 V r.m.s. ~~and or 46,7 V peak or 70 V d.c.~~ and the d.c. voltage level is 70 V.

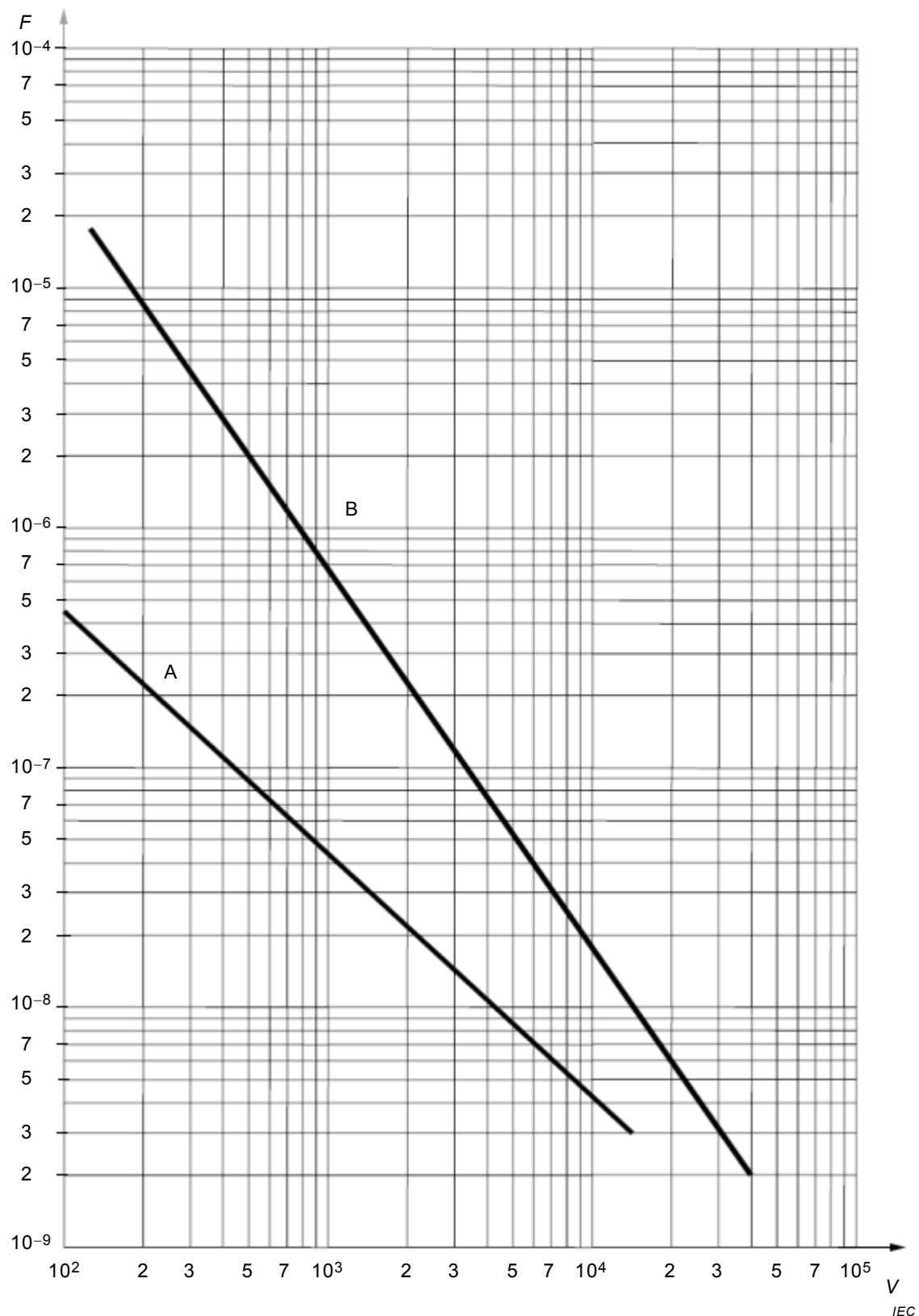
6.3.2.2 — CURRENT

- b) ~~If the voltage exceeds one of the values of 6.3.2.1,~~ The touch current levels are:
- 1) 3,5 mA r.m.s. for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA d.c., when measured with the measuring circuit of Figure A.1. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.5 is used for probe assemblies ~~which are RATED intended~~ for use in WET LOCATIONS;

- 2) 500 mA r.m.s. when measured with the measuring circuit of Figure A.3. This relates to possible burns at ~~higher~~ frequencies ~~above~~ 100 kHz.

~~6.3.2.3~~ CAPACITANCE

- c) ~~If the voltage exceeds one of the values of 6.3.2.1,~~ The capacitance level is ~~that~~ line B of Figure 7.



Key

A = NORMAL CONDITION

B = SINGLE FAULT CONDITION

Figure 5.7 – Charged Capacitance level versus voltage in NORMAL CONDITION and SINGLE-FAULT CONDITION (see 6.3.2.3 6.3.2 c) and 6.3.3 c)



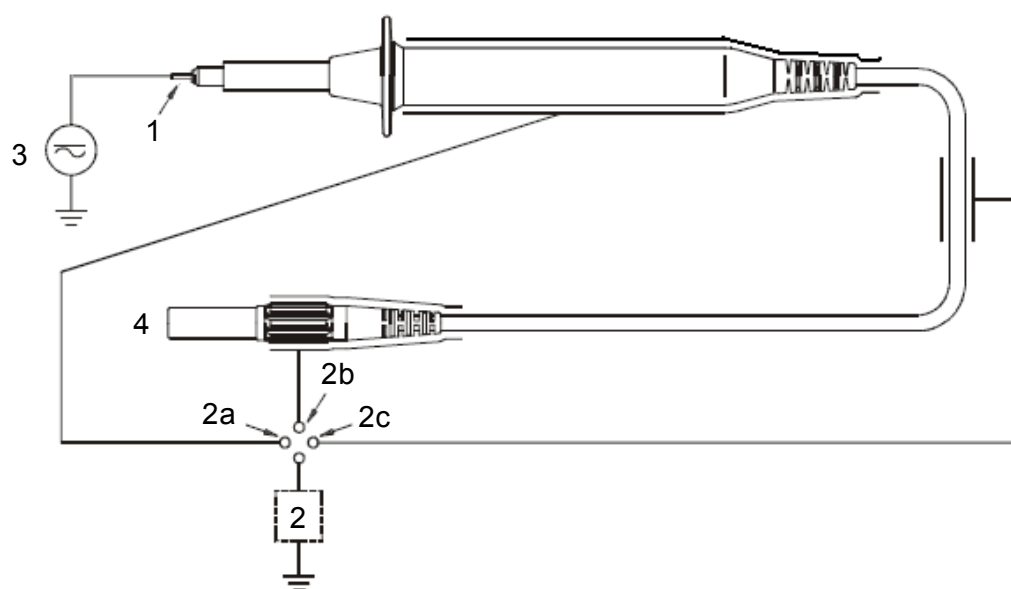
6.3.4 Measurement of voltage and touch current

6.3.4.1 General

Measurement of voltage and touch current on ACCESSIBLE parts of probe assemblies is carried out with metal foil wrapped around each of the following parts, individually:

- a) the probe body;
- b) 150 mm $\pm$ 20 mm of the PROBE WIRE or the maximum length of the cable whichever is shorter;
- c) hand-held or hand-manipulated parts of each CONNECTOR;
- d) other hand-held or hand-manipulated parts.

The RATED voltage to earth is applied between the PROBE TIP (1) and the earth. The voltage is measured between the foil and the earth. If necessary, the measurement circuit is connected in turn (2a – 2b – 2c) between each of the foil-wrapped items and the earth (see Figure 8 and Figure 9).

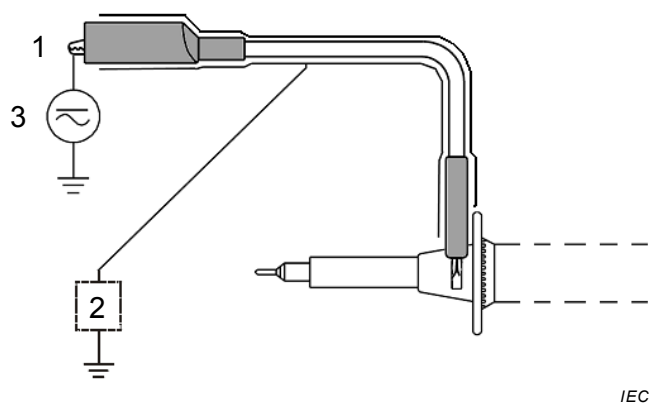


IEC

Key

- 1 PROBE TIP
- 2 Measurement of voltage or touch current (see annex A for applicable measuring circuits for touch current measurements)
 - 2a Connection to metal foil tightly wrapped around parts intended to be hand-held or hand-manipulated
 - 2b Connection to metal foil tightly wrapped around the CONNECTOR
 - 2c Connection to metal foil tightly wrapped around the cable (see 12.3.2)
- 3 Maximum RATED voltage with connection to internal conductor of the PROBE WIRE
- 4 Not connected to test or measuring equipment

Figure 8 – Voltage and touch current measurement



Key

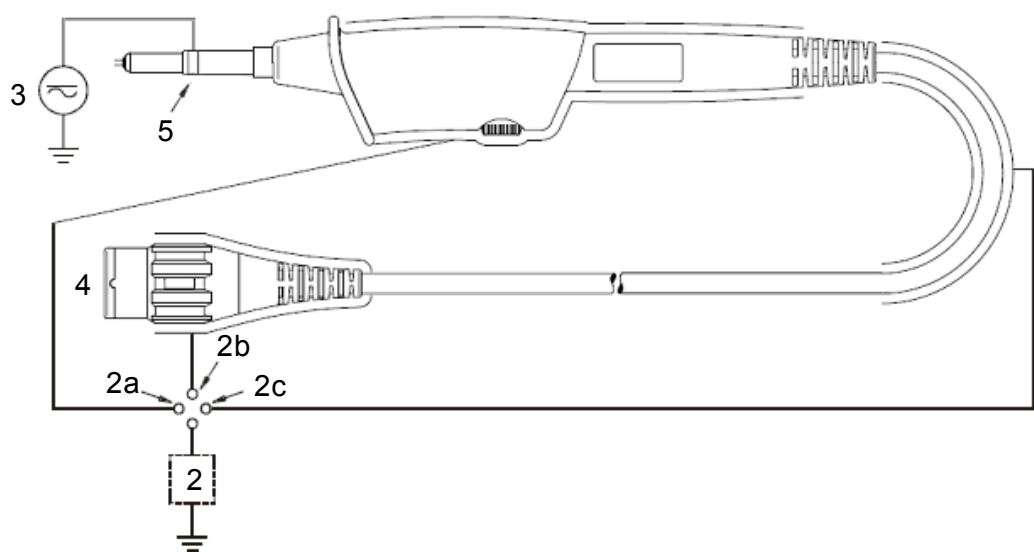
- 1 PROBE TIP of the reference CONNECTOR
- 2 Measurement of voltage or touch current (see annex A for applicable measuring circuits for touch current measurements)
- 3 Maximum RATED voltage for the reference CONNECTOR

Figure 9 – Voltage and touch current measurement for the reference CONNECTOR

6.3.4.2 Probe assemblies with floating outer conductors

For probe assemblies where the outer conductor (shield) connection may be intended to be floating, the test is also performed between the outer conductor PROBE TIP (5) and the earth (see Figure 10).

The touch current is determined by using the applicable measuring circuit of Annex A.



IEC

Key

- 2 Measurement of voltage or current (see Annex A for applicable measuring circuits for touch current measurements)
 - 2a Connection to metal foil tightly wrapped around parts intended to be hand-held or hand-manipulated
 - 2b Connection to metal foil tightly wrapped around the CONNECTOR
 - 2c Connection to metal foil tightly wrapped around the cable (see 12.3.2)
- 3 Maximum RATED voltage with connection to outer conductor PROBE TIP
- 4 Not connected to test or measuring equipment
- 5 A floating PROBE TIP connected to the shield or outer conductor of the PROBE WIRE

Figure 10 – Voltage and touch current measurement with shielded test probe

6.3.4.3 High frequency test probes

In case of test probes RATED for frequencies above 100 kHz, with floating outer conductor (shield), the maximum allowable voltage between the shield and ACCESSIBLE parts of the probe have to be determined to avoid electrical burns. The touch current shall be measured in the whole frequency range and at maximum voltage in each frequency range.

The measurements are made (see Figure 10):

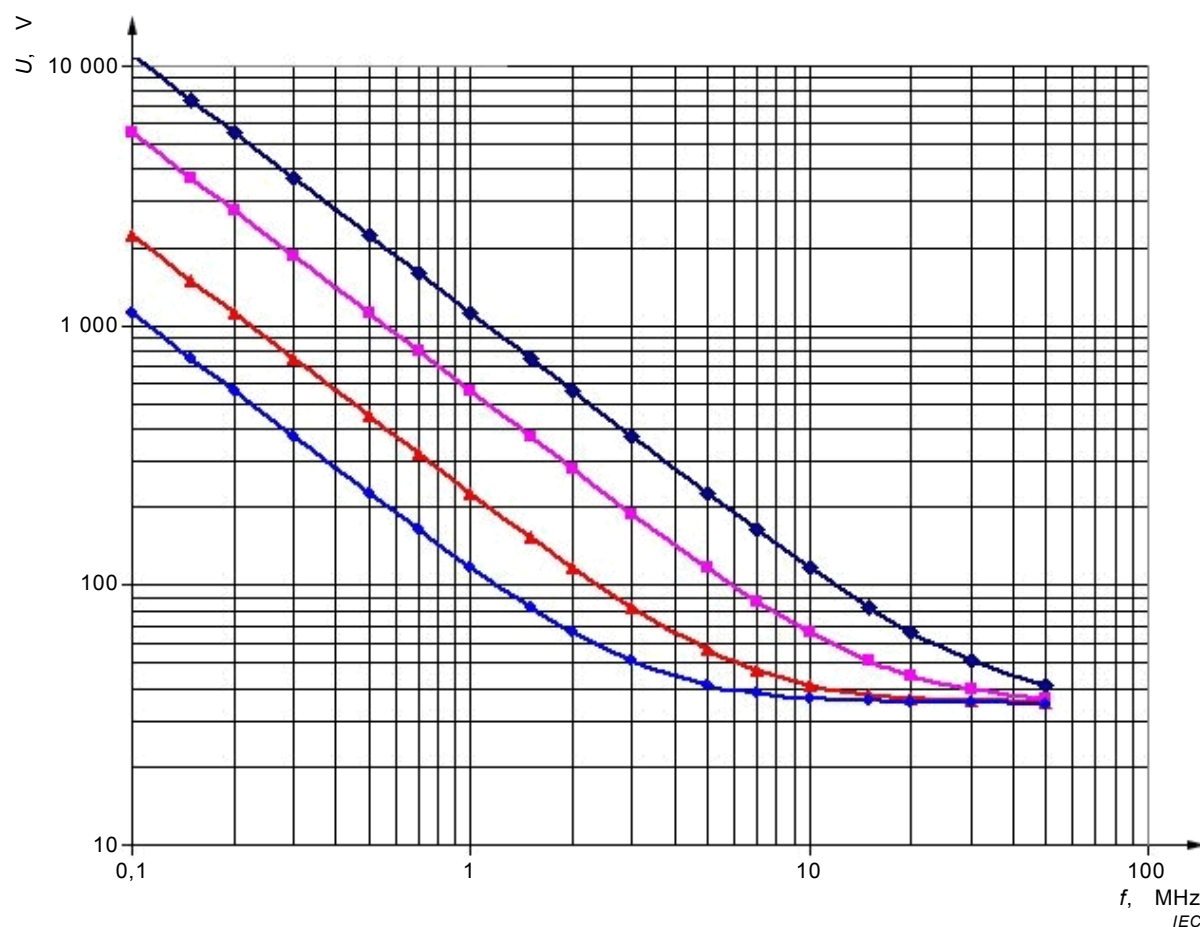
- a) *between the shield and the foil around the probe body (2a), and*
- b) *between the shield and the foil around the coaxial CONNECTOR (2b), and*
- c) *between the shield and the foil around the PROBE WIRE (2c).*

Alternative to the touch current measurement, the capacitance between the shield and the foil can be measured for the cases a) to c).

The capacitance C_s (measured capacitance between the shield and the foil) together with the circuit from A.3 creates the impedance shown in Figure A.4. The variable parameters of this impedance are the capacity C_s and the frequency (R_1 , C_1 and R_2 are fixed). With the means of these two parameters and with regard to electrical burns the maximum allowable voltage for the test probe can be calculated, for example for an allowable touch current of 70 mA (i.e. 35 V over R_2) as shown in Figure 11 for some values of the capacitance C_s .

The maximum voltage for each frequency can then be calculated.

NOTE In practice for the calculation with frequencies above 100 kHz, the values of R_1 and C_1 can be ignored.



Key

- ◆ 10 pF between probe (shield) and foil
- 20 pF between probe (shield) and foil
- ▲ 50 pF between probe (shield) and foil
- 100 pF between probe (shield) and foil

Figure 11 – Maximum test probe input voltage for 70 mA touch current

6.4 ~~Insulation requirements for Means of~~ protection against electric shock

6.4.1 General

CONNECTORS shall meet the requirements of 6.4.2.

PROBE TIPS shall meet the requirements of 6.4.3.

All other ACCESSIBLE parts of probe assemblies shall be prevented from becoming HAZARDOUS LIVE in both NORMAL CONDITION and SINGLE FAULT CONDITION by one or more of the following means:

- A) DOUBLE INSULATION ~~or REINFORCED INSULATION~~, consisting of BASIC INSULATION plus SUPPLEMENTARY INSULATION (see 6.4.6);
- B) BASIC INSULATION plus ENCLOSURES (see 6.7.3) or PROTECTIVE FINGERGUARDS;
- ~~C) ENCLOSURES or BARRIERS~~
- C) BASIC INSULATION plus impedance (see 6.4.4);
- D) REINFORCED INSULATION (see 6.4.6);
- E) PROTECTIVE IMPEDANCE (see 6.4.5).

~~CLEARANCES, CREEPAGE DISTANCES and insulation between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the requirements of 6.5 and the applicable requirements of 6.4.1 to 6.4.4.~~

~~NOTE 1— CLEARANCES and CREEPAGE DISTANCES necessary for safety can be checked by measurement.~~

~~NOTE 2— Solid insulation necessary for safety can be checked by applying the test voltage of table 6 appropriate to the WORKING VOLTAGE. The thickness required for solid insulation can be determined from the test voltage it has to withstand. Partial discharge testing may also be appropriate (see IEC 60664-1 [4]).~~

~~NOTE 3— Under mechanical or thermal stress conditions, insulation may need to be increased to meet the requirements of clauses 7, 8 and 9.~~

~~Except for parts which are not intended to be hand-held or hand-manipulated by the OPERATOR during measurements or tests, insulation covers or sleeves which can be removed by the OPERATOR without the use of a TOOL are not considered to provide the required protection against electric shock (see note 4).~~

~~NOTE 4— For example, retractable insulation sleeves are not considered to provide adequate protection for hand-held parts. The only case in which they are acceptable is where they are needed for connection to equipment that is not provided with TERMINALS which accept fully insulated type connectors.~~

~~NOTE The PROBE WIRE is considered to be hand-held. Also see Clause 12 for requirements pertaining to the PROBE WIRE.~~

Conformity is checked by inspection and as specified in 6.4.2 to 6.4.6 ~~and by the voltage tests of 6.6, as applicable.~~

6.4.2 CONNECTORS

Insulation, ACCESSIBLE parts, ~~CLEARANCES and CREEPAGE DISTANCES of~~ and SPACINGS for CONNECTORS ~~used on~~ of probe assemblies shall meet the applicable requirements of a) to c) below.

Annex E provides information regarding the recommended dimensions of 4 mm CONNECTORS.

a) CONNECTORS in fully-mated position.

- 1) ~~ACCESSIBLE parts of~~ CONNECTORS used only for connecting the probe assembly to the test or measurement equipment and which are not intended to be hand-held ~~after connection during the measurement operation shall be insulated from HAZARDOUS LIVE parts at least by BASIC INSULATION. This does not apply to connectors which can also be used to connect a probe and can become hand-held.~~
- 2) ~~ACCESSIBLE parts of~~ CONNECTORS which, ~~when fully mated,~~ are used for any other purpose or which are intended to be hand-held during the measurement ~~or test, and connectors which are interchangeable between the PROBE ASSEMBLY and the test or measurement equipment,~~ operation shall be insulated from HAZARDOUS LIVE parts by DOUBLE INSULATION OR REINFORCED INSULATION.

~~Conformity is checked by inspection and measurement of CLEARANCES and CREEPAGE DISTANCES, by the voltage tests of 6.6, and by the determination of ACCESSIBLE parts as specified in 6.2 (see Figure 6 b)) and as specified in 6.4.6 for BASIC INSULATION and REINFORCED INSULATION.~~

b) Connectors in partially-mated position.

ACCESSIBLE parts of connectors in partially-mated condition shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

~~Conformity is checked by applying the voltage test of 6.6 for BASIC INSULATION, between the PROBE TIP and a test electrode of the same shape and size as the end of the standard test finger of figure B.1. This electrode is applied without force as near as possible to HAZARDOUS LIVE parts of the connector while it is mated just sufficiently to make electrical contact (see figure 3c)).~~

Conformity is checked by the determination of ACCESSIBLE parts as specified in 6.2 (see Figure 6 c)) and as specified in 6.4.6 for BASIC INSULATION.

c) Connectors in unmated position.

~~i) HAZARDOUS LIVE parts of unmated connectors shall not be ACCESSIBLE.~~

~~ii) The HAZARDOUS LIVE parts of an unmated integrated socket of a stackable connector shall be separated from ACCESSIBLE parts with CLEARANCE and CREEPAGE DISTANCES calculated for BASIC INSULATION.~~

~~The requirements of c) do not apply to locking or screw-held type connectors and to connectors of PROBE ASSEMBLIES where the ACCESSIBLE current is limited by PROTECTIVE IMPEDANCE, provided that all components used in the PROTECTIVE IMPEDANCE are HIGH INTEGRITY components.~~

~~Conformity is checked as follows:~~

~~i) ACCESSIBILITY for connectors carrying voltages up to 1 kV a.c. or 1,5 kV d.c. shall be determined as specified in 6.2, and for connectors carrying voltages above 1 kV a.c. or 1,5 kV d.c. by applying a test voltage between the PROBE TIP and an electrode of the same shape and size as the end of the standard test finger of figure B.1, placed as near as possible to ACCESSIBLE parts (see figure 3d)). The test voltage shall be 1,25 times the RATED voltage of the PROBE ASSEMBLY.~~

~~ii) By measurement of CLEARANCES and CREEPAGE DISTANCES, by the voltage tests of 6.6, and by the determination of ACCESSIBLE parts as specified in 6.2.~~

When the RATED voltages to earth are applied to other CONNECTORS or PROBE TIPS of the probe assembly,

- 1) conductive parts of locking-type or screw-held-type CONNECTORS including CONNECTORS which do not require the use of a TOOL for unlocking or unscrewing are permitted to be ACCESSIBLE while they are in unmated position,
- 2) unmated integrated TERMINALS of STACKABLE CONNECTORS shall be protected by BASIC INSULATION,
- 3) conductive parts of other unmated CONNECTORS shall be prevented from becoming HAZARDOUS LIVE by PROTECTIVE IMPEDANCE (see 6.4.5) or shall have SPACINGS meeting the following requirements:
 - i) for unmated CONNECTORS with voltage RATING up to 1 000 V a.c. or 1 500 V d.c., the applicable SPACINGS of Table 2 from the closest approach of the test finger touching the external parts of the CONNECTOR in the least favorable position (see Figure 6 d), or
 - ii) for unmated CONNECTORS with voltage RATING exceeding 1 000 V a.c. or 1 500 V d.c., the SPACINGS shall not be less than 2.8 mm and shall withstand the voltage test of 6.6 with a test voltage equal to the RATED voltage of the CONNECTOR multiplied by 1,25.

Table 2 – SPACINGS for unmated CONNECTORS RATED up to 1 000 V a.c. or 1 500 V d.c. with HAZARDOUS LIVE conductive parts

Voltage on conductive parts of CONNECTOR	SPACING
V a.c. r.m.s. or V d.c.	mm
> 30 ≤ 300	0,8
> 300 ≤ 600	1,0
> 600 ≤ 1 000	2,6
> 1 000 ≤ 1 500 ^a	2,8
^a only for d.c. voltage	

Conformity is checked by inspection, by measuring the current or voltage to confirm that they do not exceed the applicable levels of 6.3, by the determination of ACCESSIBLE parts as specified in 6.2 (see Figure 6 c)) and measuring the applicable SPACINGS, and if applicable, the voltage test of 6.6.

Insulation covers or sleeves over CONNECTORS which are intended to be hand-held or hand-manipulated by the OPERATOR during measurement or test, and can be removed or displaced by the OPERATOR without the use of a TOOL, are not considered to provide the required protection against electric shock. For example, retractable insulation sleeves are not considered to provide adequate protection. The only case in which they are acceptable is where they are needed for connection to test or measurement equipment that is equipped with TERMINALS which cannot accept fully shrouded CONNECTORS.

Conformity is checked by inspection.

~~6.4.2 HAND-HELD PARTS OTHER THAN CONNECTORS~~

~~Parts of PROBE ASSEMBLIES that are hand-held or hand-manipulated by the OPERATOR during measurements or tests, shall be separated from parts which may become HAZARDOUS LIVE by DOUBLE insulation or REINFORCED INSULATION.~~

~~Conformity is checked by inspection and measurement of CLEARANCES and CREEPAGE DISTANCES, and by the voltage tests of 6.6 between each of a) and b) below on the one hand, and each of c), d), e) and f) below on the other hand.~~

- ~~a) Metal foil tightly wrapped around parts intended to be hand-held or hand-manipulated.~~
- ~~b) Metal foil tightly wrapped around a 150 mm ± 20 mm length of the cable (see figure 4).~~
- ~~c) The PROBE TIP. The test voltage is based on the RATED voltage of the PROBE ASSEMBLY.~~
- ~~d) (For type B only) the conductive parts enclosed by the hand-held area. The test voltage is based on the maximum WORKING VOLTAGE of the conductive parts in NORMAL USE, but is not less than 500 V.~~
- ~~e) (For type B only) the conductor of the REFERENCE CONNECTOR and the conductors of the connector for connecting the PROBE ASSEMBLY to the test or measurement equipment, joined together. The test voltage is based on the maximum RATED voltage of the PROBE ASSEMBLY divided by the divider ratio, but is not less than 500 V.~~
- ~~f) (For type C only) the conductor of the REFERENCE CONNECTOR if it is RATED above the voltage levels of 6.3.1.1. The test voltage is based on the maximum RATED voltage of the REFERENCE CONNECTOR.~~

~~NOTE The voltage tests of insulation which covers parts which are not HAZARDOUS LIVE (for example, the REFERENCE CONNECTOR) are to confirm the integrity of the insulation and not to impose additional requirements.~~

~~6.4.3 CABLES~~

~~Cables shall be RATED for the maximum voltage and current of NORMAL USE. Their conductors shall be separated from hand-held surfaces by DOUBLE INSULATION or REINFORCED INSULATION, based on the following values:~~

- ~~a) for type A PROBE ASSEMBLIES, 125 V or the maximum RATED voltage of the PROBE ASSEMBLY, whichever is greater;~~
- ~~b) for type B PROBE ASSEMBLIES, 500 V or the maximum RATED voltage of the PROBE ASSEMBLY divided by the divider ratio, whichever is greater;~~
- ~~c) for type C PROBE ASSEMBLIES, 125 V or the maximum RATED voltage of the PROBE ASSEMBLY divided by the divider ratio, whichever is greater.~~

~~Conformity is checked by inspection and measurement of CLEARANCES and CREEPAGE DISTANCES, and by the voltage tests of 6.6 (without humidity preconditioning), using metal foil tightly wrapped around a 150 mm ± 20 mm length of cable.~~

6.4.3 Probe tips

6.4.3.1 General

~~If, as permitted by 6.1.1, a PROBE TIP can become HAZARDOUS LIVE, a BARRIER shall be fitted to reduce the danger of touching the PROBE TIP, and to provide an indication of the limit beyond which it may be hazardous to touch the probe body during use.~~

~~CLEARANCE and CREEPAGE DISTANCE between the PROBE TIP and the hand-held side of the BARRIER shall be those specified for DOUBLE INSULATION or REINFORCED INSULATION. Figure 6a) gives examples of probe assemblies with BARRIERS and indicates applicable CLEARANCES and CREEPAGE DISTANCES.~~

PROBE TIPS that can become HAZARDOUS LIVE during NORMAL USE (see also 6.1 b)) shall meet the requirements of one of 6.4.3.2, 6.4.3.3, or 6.4.3.4 .

PROBE TIPS that can be used as CONNECTORS shall also meet the requirements of 6.4.3.5.

NOTE See Clause 13 for additional requirements for the exposed conductive parts of PROBE TIPS.

SPRING-LOADED CLIPS and similar probes that are intended to pierce the insulation of a wire to touch the conductor for measuring voltage purposes shall not have a voltage RATING above the levels of 6.3.2 a).

Conformity is checked by inspection and measurement.

6.4.3.2 Protection by a PROTECTIVE FINGERGUARD

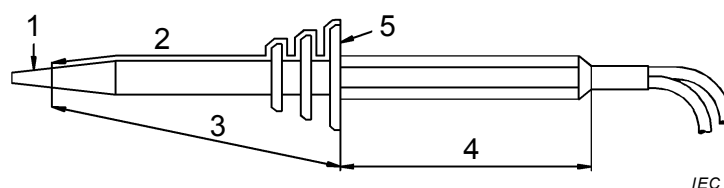
If a conductive part of a PROBE TIP can become HAZARDOUS LIVE, a PROTECTIVE FINGERGUARD shall be fitted to reduce the risk of touching an exposed conductive part of the PROBE TIP, and to provide an indication of the limit beyond which it may be hazardous to touch the probe body during use.

SPACINGS between the HAZARDOUS LIVE part of the PROBE TIP and the hand-held side of the PROTECTIVE FINGERGUARD shall be those specified for REINFORCED INSULATION.

The height of the PROTECTIVE FINGERGUARD from the side where the fingers are intended to be applied shall be at least 2 mm and the thickness shall be less than twice the height.

The PROTECTIVE FINGERGUARD of probe assemblies which have a voltage RATING above the levels of 6.3.2 a) shall extend across at least 80 % of the sides where the fingers are intended to be applied.

Figure 12 gives an example of a probe assembly with a PROTECTIVE FINGERGUARD and indicates applicable SPACINGS.



Key

- 1 PROBE TIP
- 2 CREEPAGE DISTANCE (along surface)
- 3 CLEARANCE (in air)
- 4 hand-held area of probe body
- 5 PROTECTIVE FINGERGUARD

Figure 12 – Protection by a PROTECTIVE FINGERGUARD

6.4.3.3 Protection by distance

~~SPRING-LOADED squeeze probes (see figure 6b)) are acceptable without a BARRIER CLIPS RATED for voltages to earth up to 1 kV are acceptable without a PROTECTIVE FINGERGUARD provided that~~

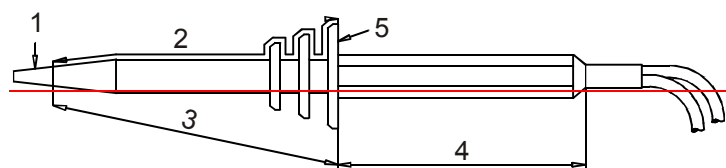
- a) actuation of the spring-loaded mechanism prevents the OPERATOR from touching a HAZARDOUS LIVE part; and
- b) ~~CLEARANCE and CREEPAGE DISTANCE~~ the SPACINGS between the PROBE TIP and the nearest surface which the OPERATOR needs to touch to actuate the mechanism ~~shall be~~ are increased by an additional protective distance of 45 mm.

~~Insulated crocodile and similar clips (see figure 6c)) which require finger pressure at about 90° to the axis of the clip are acceptable without a BARRIER, provided that there is a tactile indicator to indicate the limit of safe access for the OPERATOR. CLEARANCE and CREEPAGE DISTANCE between the BARRIER or tactile indicator and the tip of the clip shall be those specified for DOUBLE INSULATION or REINFORCED INSULATION.~~

~~The exposed conductive part of the PROBE TIP, except for parts of a crocodile clip where the outer jaws are insulated shall not be more than 19 mm long (see figure 6c) ii)).~~

~~NOTE—A shorter length is recommended.~~

~~Conformity is checked by inspection and measurement.~~

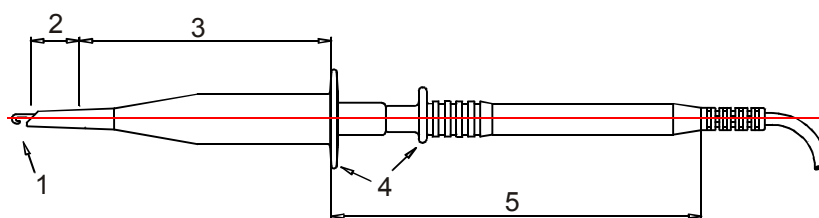


IEC 2605/01

Key

- 1— PROBE TIP
- 2— CREEPAGE-DISTANCE (along surface)
- 3— CLEARANCE (in air)
- 4— Hand-held-area-of-probe-body
- 5— BARRIER

Figure 6a – Protection by BARRIER

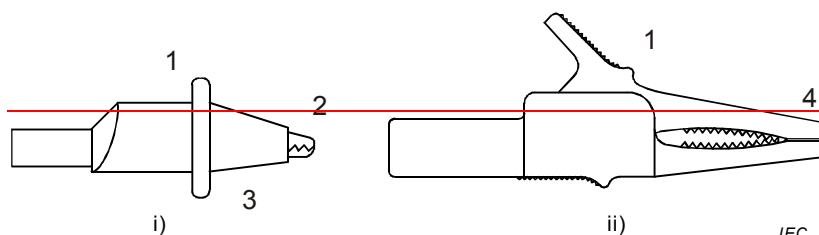


IEC 2606/01

Key

- 1— PROBE TIP
- 2— CLEARANCE and CREEPAGE-DISTANCE as specified in 6.5
- 3— Additional protective distance
- 4— Actuating parts
- 5— Hand-held-area-of-spring-loaded-squeeze-PROBE-ASSEMBLY

Figure 6b – Protection by distance



IEC 2607/01

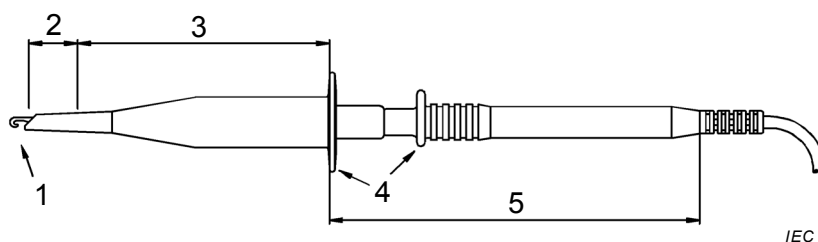
Key

- 1— Indication-of-limit-of-access (around-or-on-both-sides-of-clip)
- 2— Metal jaws
- 3— Insulation
- 4— Insulated metal jaws

Figure 6c – Examples of crocodile clips

Figure 6 – Protection against touching a PROBE TIP (see 6.4.4)

Figure 13 gives an example of a probe assembly protected by distance and indicates applicable SPACINGS.



Key

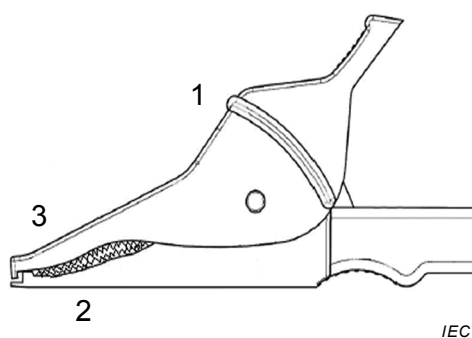
- 1 PROBE TIP
- 2 CLEARANCE and CREEPAGE DISTANCE as specified in 6.5
- 3 additional protective distance
- 4 actuating parts
- 5 hand-held area of the probe assembly

Figure 13 – Protection by distance

6.4.3.4 Protection by tactile indicator

SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY II which require finger pressure at about 90° to the axis of the clip are acceptable without a PROTECTIVE FINGERGUARD, provided that there is a tactile indicator to indicate the limit of safe access for the OPERATOR.

Figure 14 gives an example of a SPRING-LOADED CLIP with a tactile indicator.



Key

- 1 tactile indicator
- 2 metal jaws
- 3 insulated metal jaws

Figure 14 – Protection by tactile indicator

6.4.3.5 PROBE TIPS used as CONNECTORS

PROBE TIPS which can be used as CONNECTORS (for example, a PROBE TIP that is also intended to be connected to a SPRING-LOADED CLIP) shall also meet the requirements for CONNECTORS in fully-mated position and partially-mated position (see also 6.4.2 a) and b)).

6.4.4 Impedance

Impedance used as an additional means of protection in conjunction with BASIC INSULATION shall meet all the following requirements:

- a) it shall limit the current or voltage to not more than the applicable levels of 6.3.3;
- b) it shall be RATED for the WORKING VOLTAGE and for the amount of power that it will dissipate;
- c) SPACINGS between terminations of the impedance shall meet the applicable requirements of 6.5 for BASIC INSULATION.

Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 6.3.3, and by measuring CLEARANCE and CREEPAGE DISTANCE as specified in 6.5.

~~6.4.5 Double insulation AND reinforced insulation~~

~~CLEARANCES and CREEPAGE DISTANCES forming part of DOUBLE INSULATION or REINFORCED INSULATION shall meet the applicable requirements of 6.5. ENCLOSURES shall meet the requirements of 6.7.2.~~

~~Solid insulation forming part of REINFORCED INSULATION shall pass the voltage test of 6.6 with the values for REINFORCED INSULATION.~~

~~Conformity is checked as specified in 6.5, 6.6 and 6.7.2. The parts of DOUBLE INSULATION are tested separately if this is possible; otherwise the tests for REINFORCED INSULATION are used. CLEARANCES and CREEPAGE DISTANCES necessary for safety can be checked by measurement.~~

6.4.5 PROTECTIVE IMPEDANCE

~~A PROTECTIVE IMPEDANCE which ensures that ACCESSIBLE conductive parts cannot become HAZARDOUS LIVE as a result of a SINGLE FAULT CONDITION shall be an appropriate HIGH-INTEGRITY single component (see 12.3).~~

~~Components, wires and connections shall be RATED for both NORMAL CONDITION and SINGLE FAULT CONDITION.~~

~~Conformity is checked by inspection and by the measurements of 6.3 in SINGLE FAULT CONDITION (see 4.4.2.1).~~

A PROTECTIVE IMPEDANCE shall limit the current or voltage to the levels of 6.3.2 in NORMAL CONDITION and 6.3.3 in SINGLE FAULT CONDITION (see also 4.4.2.2).

Insulation between the terminations of the PROTECTIVE IMPEDANCE shall meet the requirements of 6.4.6 for DOUBLE INSULATION or REINFORCED INSULATION.

A PROTECTIVE IMPEDANCE shall be one or more of the following:

- a) an appropriate single component which shall be constructed, selected and tested so that safety and reliability for protection against electric shock is assured. In particular, the component shall be:
 - 1) RATED for twice the WORKING VOLTAGE;
 - 2) if a resistor, RATED for twice the power dissipation for the WORKING VOLTAGE;
 - 3) if a capacitor, RATED for the maximum transient overvoltage;
- b) a combination of components.

When a combination of components is used, the SPACINGS shall take into account the WORKING VOLTAGE across each insulation.

A PROTECTIVE IMPEDANCE shall not be a single electronic device that employs electron conduction in a vacuum, gas or semiconductor.

Conformity is checked by inspection, by measuring the current or voltage to confirm that they do not exceed the applicable levels of 6.3 and by measuring SPACINGS as specified in 6.5. Conformity of a single component is checked by inspection of its RATING.

6.4.6 BASIC INSULATION, SUPPLEMENTARY INSULATION, DOUBLE INSULATION and REINFORCED INSULATION

SPACINGS and solid insulation forming BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION between ACCESSIBLE parts and HAZARDOUS LIVE parts shall meet the applicable requirements of 6.5.

DOUBLE INSULATION is comprised of BASIC INSULATION and SUPPLEMENTARY INSULATION, each of which shall meet the applicable requirements of 6.5.

Conformity is checked as specified in 6.5.

~~**6.5 CLEARANCES and CREEPAGE DISTANCES**~~

~~CLEARANCES and CREEPAGE DISTANCES are specified in 6.5.1 to 6.5.4 so as to withstand the voltages that appear on the system for which the PROBE ASSEMBLY is intended. They also take account of RATED environmental conditions and of any protective devices fitted within the PROBE ASSEMBLY or required by the manufacturer's instructions.~~

~~There are no CLEARANCE or CREEPAGE DISTANCE requirements for the interior of void-free moulded parts, including the inner layers of multi-layer printed circuit boards.~~

~~Conformity is checked by inspection and measurement. When determining a CLEARANCE or CREEPAGE DISTANCE to ACCESSIBLE parts, the ACCESSIBLE surface of an insulating ENCLOSURE is considered to be conductive as if it was covered by metal foil wherever it can be touched with a standard test finger (see annex B). Conformity for homogeneous construction is checked as specified in 6.5.1.1.~~

6.5 Insulation requirements

6.5.1 The nature of insulation

6.5.1.1 General

Insulation between circuits and ACCESSIBLE parts (see 6.2) or between separate circuits consists of SPACINGS, solid insulation, or a combination of SPACINGS and solid insulation. SPACINGS comprise both CLEARANCES and CREEPAGE DISTANCES.

When used to provide protection against a HAZARD, the insulation needs to withstand the electric stresses that are caused by the voltages that may appear on parts of the probe assembly.

The requirements for insulation depend on:

- a) the required level of insulation (BASIC INSULATION, SUPPLEMENTARY INSULATION, or REINFORCED INSULATION);
- b) the maximum transient overvoltage that may appear on the circuit, either as a result of an external event (such as a lightning strike or a switching transient), or as the result of the operation of the probe assembly;
- c) the WORKING VOLTAGE;
- d) the POLLUTION DEGREE of the micro-environment.

6.5.1.2 SPACINGS

6.5.1.2.1 General requirements

SPACINGS are a combination of CLEARANCES and CREEPAGE DISTANCES, which are specified in 6.5.1.2.2 and 6.5.1.2.3 so as to withstand the voltages that appear on the system for which the probe assembly is intended. Also, they are selected to take account of the intended environmental conditions and any protective devices fitted within the probe assembly or required by the manufacturer's instructions.

6.5.1.2.2 CLEARANCES

CLEARANCES are specified to withstand the maximum transient overvoltage that can be present on the circuit to which the probe assembly can be connected in NORMAL USE, ~~either as a result of an external event (such as a lightning strike, or a switching transient), or as the result of the operation of the equipment to which the probe assembly is connected.~~ If transient overvoltages cannot occur, CLEARANCES are based on the ~~maximum~~ WORKING VOLTAGE.

~~The value for clearance depends on~~

- ~~— the type of insulation required (BASIC INSULATION, REINFORCED INSULATION, etc.);~~
- ~~— the POLLUTION degree of the micro-environment of the CLEARANCE.~~

The values for CLEARANCES given in Table 6 and Table 7 are based on absolute inhomogeneous field conditions. Reduced CLEARANCES may apply to ~~homogeneous~~ constructions which are shaped in a way to create a more homogeneous condition, because the dielectric strength of an air gap is dependent on the shape of the electric field within the gap, as well as on the width of the gap. ~~In homogeneous construction, conductive parts are shaped and arranged so that homogeneous or near homogeneous electric field conditions exist between them. As a result, reduced CLEARANCES can be accepted between such conductive parts.~~

No particular value can be specified for a reduced CLEARANCE for ~~these more~~ homogeneous constructions, but it can be tested by a ~~dielectric strength~~ voltage test (see 6.6). ~~The test is a d.c. or a.c. peak test, using the voltage specified in table 6 for the peak impulse test for the CLEARANCE which would apply for inhomogeneous construction. For test site altitude corrections, see table 7.~~ CLEARANCES which meet the values of Table 6 and Table 7 will meet the requirements for any construction and need not be tested by a voltage test, but can be checked by measurement alone.

If the ~~equipment~~ probe assembly is RATED to operate at an altitude greater than 2 000 m, the values for CLEARANCES are multiplied by the applicable factor ~~derived from~~ of Table 3. ~~The factors are not applied to CREEPAGE DISTANCE, but CREEPAGE DISTANCE shall always be at least as large as the value specified for CLEARANCE.~~

Table 2 3 – Multiplication factors for CLEARANCES of probe assembly RATED for operation at altitudes up to 5 000 m

RATED operating altitude m	Multiplication factor
Up to 2 000	1,00
2 001 to 3 000	1,14
3 001 to 4 000	1,29
4 001 to 5 000	1,48

In all cases, the minimum CLEARANCE value for POLLUTION DEGREE 2 is 0,2 mm and for POLLUTION DEGREE 3 is 0,8 mm.