IEC 61010-031

Edition 3.0 2022-12
COMMENTED VERSION

# INTERNATIONAL STANDARD

colour
inside

GROUP SAFETY PUBLICATION

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

IEC 61010-031:2022-12 CMV(en)

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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## Safety requirements for electrical equipment for measurement, control, and laboratory use –
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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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

## FOREWORD

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**This commented version (CMV) of the official standard IEC 61010-031:2022 edition 3.0 allows the user to identify the changes made to the previous IEC 61010-031:2015+AMD1:2018 CSV edition 2.1. Furthermore, comments from IEC TC 66 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.**

**A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.**

**This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.**

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

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

This third edition cancels and replaces the second edition published in 2015, and Amendment 1:2018. IEC 61010-031 is a stand-alone standard.

This edition includes the following significant technical changes with respect to the previous edition:

a) the scope has been made succinct. General information from the scope of Edition 2 has been moved to a new Clause 4. Consequently, Clause 4 to Clause 8 of Edition 2 have been renumbered. Clause 9 of Edition 2 has been deleted;
b) in Clause 2, normative references have been dated and new normative references have been added;
c) in 3.1.4, the definition of PROBE TIP has been modified;
d) in 4.1, there is no longer any differentiation between high voltage and low voltage probe assemblies. Type C probe assemblies have been merged with Type B probe assemblies;
e) in 4.1 d) "Kelvin" probes have been added to the list of probe assemblies as a new Type E and a new Figure 5;
f) in 4.1 e), probes for voltage measurement without electrical connection to conductors have been added to the list of probe assemblies as a new Type F and a new Figure 6;
g) in 4.2.1, spread of fire is no longer considered as a HAZARD;
h) Subclause 4.4.2.5 from Edition 2 has been deleted;
i) Subclause 4.4.4.3 from Edition 2 has been deleted;
j) in 5.4.4.1 consideration has been given to SPACINGS and impedance;
k) in 6.1.1, removable parts of PROBE TIPS which bear markings are allowed;
l) in 6.1.5, the voltage to be marked for MEASUREMENT CATEGORIES is the AC line-to-neutral or DC voltage;
m) in 7.4.2, requirements for unmated CONNECTORS have been modified as follows:
    1) Table 2 has been modified and expanded,
    2) a calculation method for CLEARANCES of CONNECTORS above 20 kV has been defined,
    3) CREEPAGE DISTANCES have been aligned with CLEARANCES;
n) in 7.4.3.1 and 7.4.3.5, requirements for IP2X PROBE TIPS with retractable sleeve have been added;
o) in 7.4.3.2, PROBE TIPS are now applicable to non-contact probe assemblies;
p) in 7.5.2.3.2, the values of Table 5 have been modified;
q) in 7.6.2, voltage tests of CLEARANCES are done without humidity preconditioning;
r) pre-treatments for rigidity test from Clause 10 of Edition 2 have been moved to 9.2;
s) Subclause 11.1 of Edition 2 has been deleted;
t) addition of an exception for Type E probe assembly in 13.2. Removable parts of PROBE TIPS which bear markings are allowed;
u) Figure F.1 has been modified;
v) Annex G has been added, for determination of CLEARANCES for Table 2**;**
w) Annex H has been added, covering line-to-neutral voltages for common mains supply systems.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 66/770/FDIS | 66/771/RVD |

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

In this document 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 document which have been defined in Clause 3: SMALL ROMAN CAPITALS.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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# SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE –

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

## 1 Scope ~~and object~~ 1

### ~~1.1 Scope~~

### ~~1.1.1 Probe assemblies included in scope~~

This part of IEC 61010 specifies safety requirements for hand-held and hand-manipulated probe assemblies ~~of the types described below~~ for electrical test and measurement, and their related accessories. These probe assemblies are for non-contact 2 or direct electrical connection between a part and electrical test and measurement equipment. They ~~may~~ can be fixed to the equipment or be detachable accessories for the equipment.

This group safety publication focusing on safety essential requirements is primarily intended to be used as a product safety standard for the products mentioned in the scope, but is also intended to be used by technical committees in the preparation of publications for products similar to those mentioned in the scope of this group safety publication, in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications and/or group safety publications in the preparation of its publications. 3

## 2 Normative references 4

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*
IEC 60027-1:1992/AMD1:1997
IEC 60027-1:1992/AMD2:2005

IEC 60027-2:2019, *Letter symbols to be used in electrical technology – Part 2: Telecommunications and electronics*

IEC 60027-4:2006, *Letter symbols to be used in electrical technology – Part 4: Rotating electric machines*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*
IEC 61010-1:2010/AMD1:2016

IEC 61180:2016, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

~~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*~~

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply (see Annex I for index of defined terms).

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

### 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, etc.

**3.1.2**
**ENCLOSURE**
part providing protection of a probe assembly against certain external influences and, in any direction, protection against direct contact

**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~~ can touch **5** 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.~~

**3.1.5**
**CONNECTOR**
component which is attached to the PROBE WIRE, to connect the probe assembly to a TERMINAL of the equipment or to another probe assembly

**3.1.6**
**REFERENCE CONNECTOR** **6**
CONNECTOR for connection to a reference point

### 3.1.7

**TOOL**

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

### 3.1.8

**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

### 3.1.9

**SPRING-LOADED CLIP**

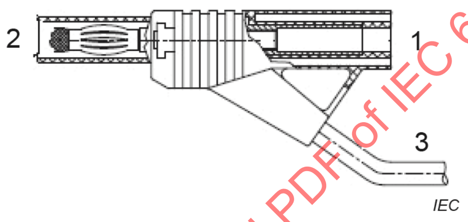
probe or probe accessory with one or more hooks or jaws forced by a spring to grip the part being measured or tested

### 3.1.10

**STACKABLE CONNECTOR**

CONNECTOR assembly which contains an additional TERMINAL

EXAMPLE Figure 1 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 1 – Example of a STACKABLE CONNECTOR with a male CONNECTOR and a female TERMINAL**

## 3.2 Quantities

### 3.2.1

**RATED ~~(condition or value)~~**

RATED value

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

### 3.2.2

**RATING**

set of RATED values and operating conditions

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

### 3.2.3

**WORKING VOLTAGE**

highest RMS value of the AC or DC voltage across any particular insulation which can continuously appear during NORMAL USE

Note 1 to entry: 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 a probe assembly (or parts of a probe assembly) made to a particular design, to show that the design and construction meet the requirements of this document

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

### 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**

able to be touched with a standard test finger or test pin, when used as specified in 7.2

### 3.4.2

**HAZARDOUS LIVE**

capable of rendering an electric shock or electric burn

### 3.4.3

**HAZARD**

potential source of harm

### 3.4.4

**PROTECTIVE IMPEDANCE**

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

### 3.4.6

**NORMAL CONDITION**

condition in which all means for protection against HAZARDS are intact

### 3.4.7

**SINGLE FAULT CONDITION** 7

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

Note 1 to entry: If a SINGLE FAULT CONDITION results unavoidably in one or more other fault conditions, all the failures are considered as one SINGLE FAULT CONDITION.

### 3.4.8

**OPERATOR**

person operating the probe assembly for its intended purpose

### 3.4.9

**RESPONSIBLE BODY**

individual or group responsible for the safe use and maintenance of 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 probe assembly, or wetting of the contact between the human body and the environment

**3.4.11**
**MEASUREMENT CATEGORY 8**
classification of testing and measuring circuits according to the types of mains to which they are intended to be connected

Note 1 to entry: MEASUREMENT CATEGORIES take into account overvoltage categories, short-circuit current levels, the location where the test or measurement is to be made and some forms of energy limitation or transient protection included in the building installation (see Annex F for more information).

**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 9**
insulation~~ of HAZARDOUS LIVE parts~~ which provides basic protection

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

[SOURCE: IEC 60050-195:~~1998~~2021, 195-06-06]

**3.5.2**
**SUPPLEMENTARY INSULATION 10**
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~~ that provides fault protection

[SOURCE: IEC 60050-195:2021, 195-06-07]

**3.5.3**
**DOUBLE INSULATION**
insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

[SOURCE: IEC 60050-195:~~1998~~2021, 195-06-08]

**3.5.4**
**REINFORCED INSULATION 11**
insulation that provides a degree of protection against electric shock~~ not less than that provided by~~ equivalent to DOUBLE INSULATION

Note 1 to entry: REINFORCED INSULATION can comprise several layers that cannot be tested singly as BASIC INSULATION or SUPPLEMENTARY INSULATION.

[SOURCE: IEC 60050-195:2021, 195-06-09]

**3.5.5**
**POLLUTION**
addition of foreign matter, solid, liquid or gaseous (ionized gases), that~~ may~~ can produce a reduction of dielectric strength or surface resistivity

**3.5.6**
**POLLUTION DEGREE**
numeral indicating the level of POLLUTION that~~ may~~ can be present in the environment

**3.5.7**
**POLLUTION DEGREE 1**
no POLLUTION or only dry, non-conductive POLLUTION occurs, which has no influence

**3.5.8**
**POLLUTION DEGREE 2**
only non-conductive POLLUTION occurs except that occasionally a temporary conductivity caused by condensation is expected

**3.5.9**
**POLLUTION DEGREE 3** **12**
conductive POLLUTION occurs, or dry, non-conductive POLLUTION occurs which becomes conductive due to condensation which is expected

Note 1 to entry: In such conditions, probe assembly is normally protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity is controlled.

**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

[SOURCE: IEC 60050-151:2001, 151-15-50]

**3.5.12**
**SPACING**
any combination of CLEARANCES and CREEPAGE DISTANCES

# 4 General

## 4.1 Type of probe assemblies

The safety of the following types of probe assemblies are covered by this document.

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 30 V AC RMS, 42,4 V peak, or 60 V DC, but not exceeding 63 kV. They do not incorporate components which are intended to provide a voltage divider function or a signal conditioning function, but they~~ may~~ can contain non-attenuating components such as fuses (see Figure 2).

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.~~ 30 V AC RMS, 42,4 V peak, or 60 V DC but not exceeding 63 kV~~ r.m.s. or d.c~~. The divider function~~ may~~ can 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 3 a) and Figure 3 b)).

~~b) Type C: low-voltage attenuating or divider probe assemblies. Attenuating or divider probe assemblies for direct connection to voltages 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).~~ **13**

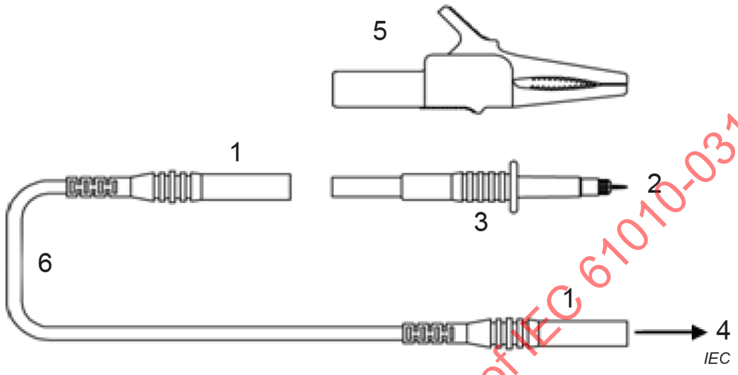
c) Type D:~~ low-voltage~~ attenuating, non-attenuating or other signal conditioning probe assemblies that are RATED for direct connection only to voltages not exceeding 30 V AC RMS, 42,4 V peak, or 60 V DC, and are suitable for currents exceeding 8 A (see Figure 4).

d) Type E: non-attenuating probe assemblies for 4-pole precise resistance measurements (see Figure 5). **14**

EXAMPLE: Kelvin probes.

e) Type F: probe assemblies for non-contact AC voltage test and measurement. These probe assemblies are intended for use on insulated or non-insulated conductors without electrical contact (see Figure 6). **15**

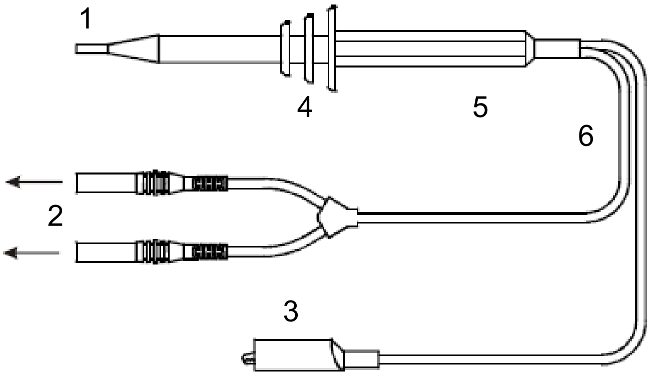
NOTE Type F probe assemblies can be stand-alone probes or connected by a PROBE WIRE to equipment.

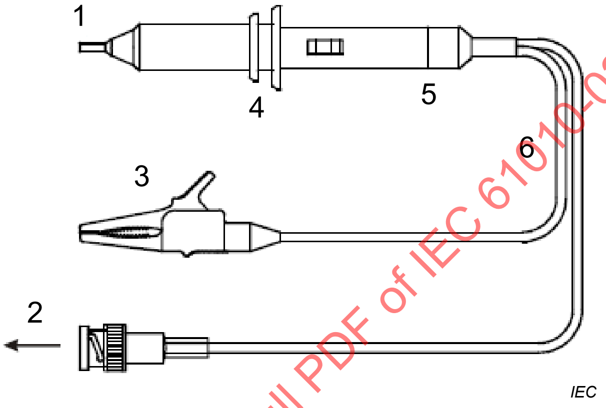


**Key**

| | | | |
|---|---|---|---|
| 1 | CONNECTOR (typical~~ CONNECTORS~~) | 4 | to equipment |
| 2 | PROBE TIP | 5 | SPRING-LOADED CLIP |
| 3 | hand-held area of probe body | 6 | PROBE WIRE |

Figure 2 – Examples of Type A probe assemblies





~~**Key**~~

~~1 PROBE TIP~~

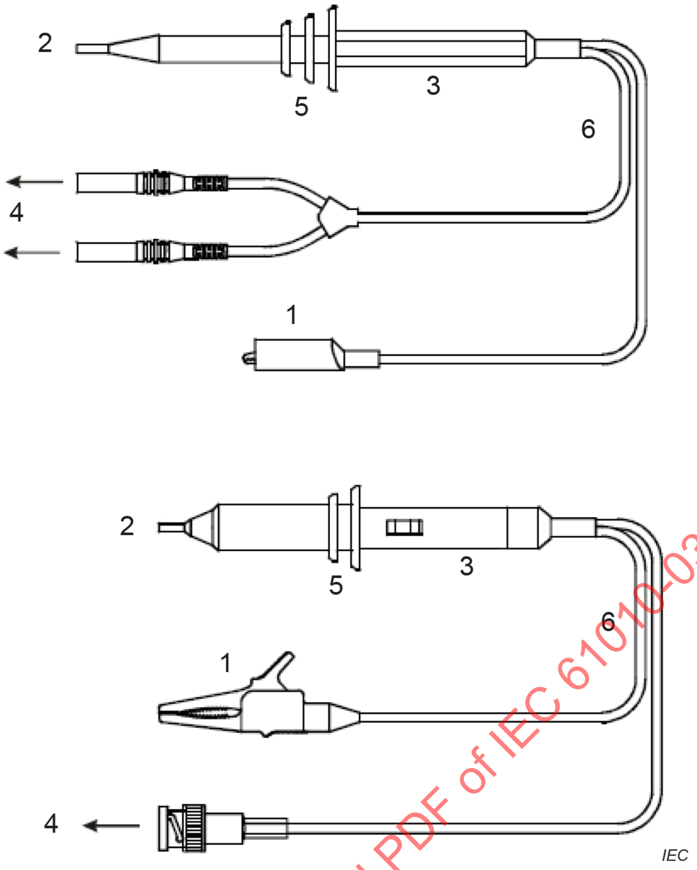
~~2 to equipment~~

~~3 reference CONNECTOR~~

~~4 PROTECTIVE FINGERGUARD~~

~~5 hand-held area of probe body~~

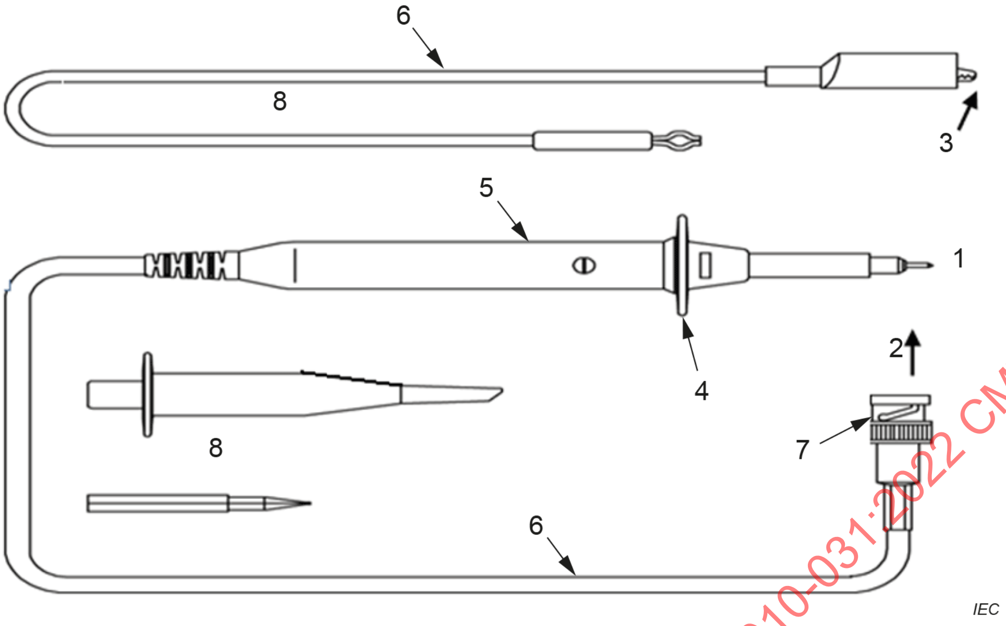
~~6 PROBE WIRE~~



**Key**

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

Figure 3 a) – High-voltage Type B probe assemblies

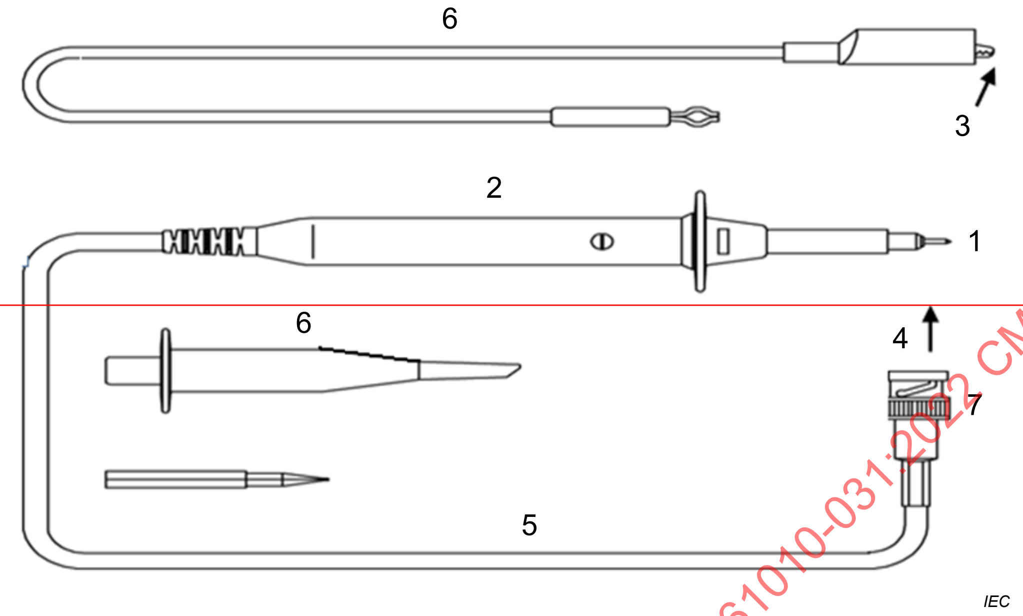


**Key**

| | | | |
|---|---|---|---|
| 1 | PROBE TIP | 5 | hand-held area of probe body |
| 2 | to equipment | 6 | PROBE WIRE |
| 3 | REFERENCE CONNECTOR | 7 | BNC CONNECTOR |
| 4 | PROTECTIVE FINGERGUARD | 8 | examples of accessories |

**Figure 3 b) – Low-voltage Type B probe assemblies**

**Figure 3 – Example of Type B probe assemblies**



~~**Key**~~

~~1 PROBE TIP~~

~~2 probe body~~

~~3 reference CONNECTOR~~

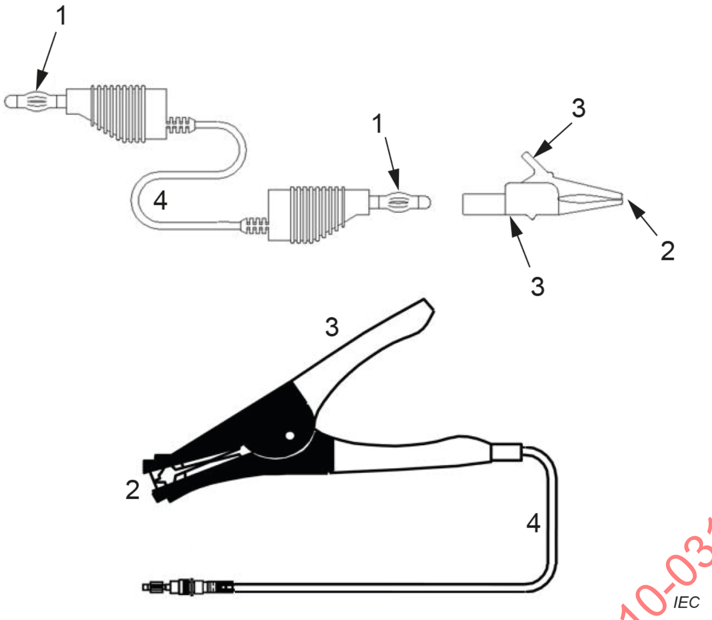
~~4 to equipment~~

~~5 PROBE WIRE~~

~~6 examples of accessories~~

~~7 BNC CONNECTOR~~

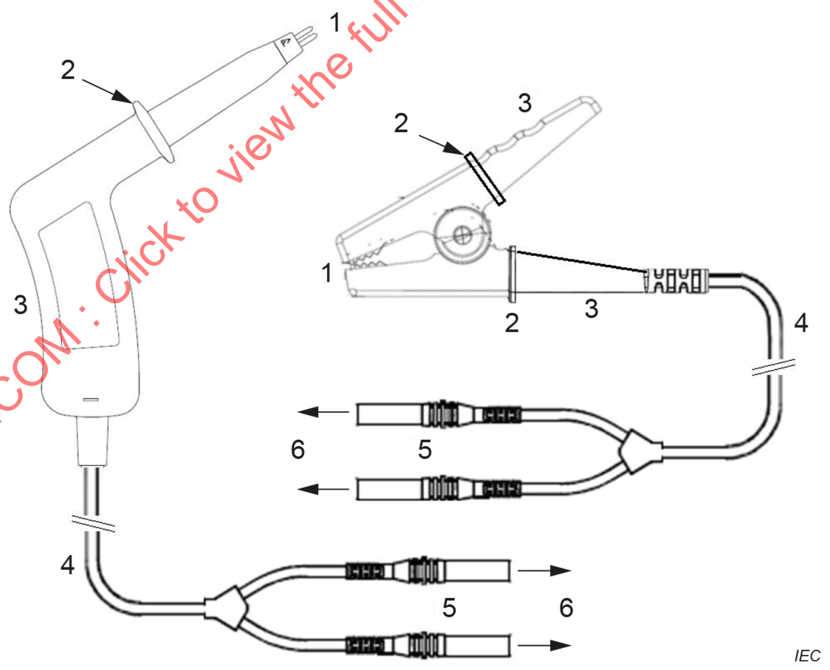
~~**Figure 3 – Examples of type C probe assemblies**~~



**Key**

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

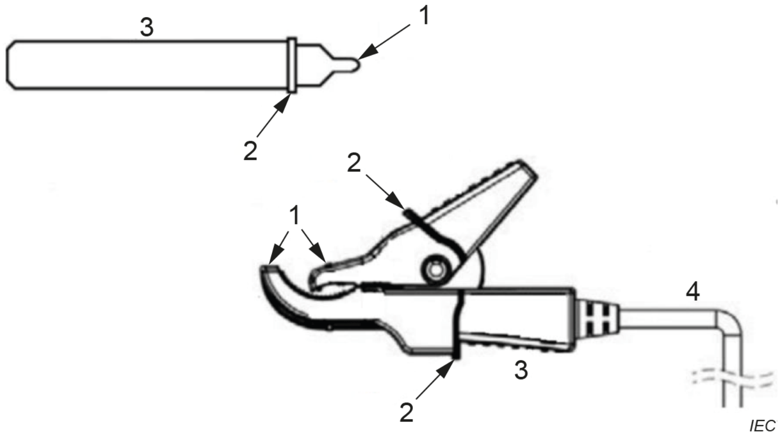
**Figure 4 – Examples of Type D probe assemblies**



**Key**

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

**Figure 5 – Examples of Type E probe assemblies**



**Key**

1 PROBE TIP

2 PROTECTIVE FINGERGUARD

3 hand-held area of probe body

4 PROBE WIRE to equipment

**Figure 6 – Examples of Type F probe assemblies**

### ~~1.1.2 Probe assemblies excluded from scope~~

This document does not apply to current sensors within the scope of IEC 61010-2-032:2019 ~~(Hand-held and hand-manipulated current sensors), but may apply to their input measuring circuit leads and accessories~~.

## 4.2 ~~Object~~ Safety aspects

### 4.2.1 ~~Aspects included in scope~~ Identified HAZARDS

The purpose of the requirements of this document is to ensure that HAZARDS to the OPERATOR and the surrounding area are reduced to a tolerable level.

Requirements for protection against particular types of HAZARDS are given in Clause 7 to Clause 11 and Clause 13, as follows:

a) electric shock or burn (see Clause 7);

b) mechanical HAZARDS (see Clause 8 and Clause 9);

c) excessive temperature (see Clause 10); **16**

~~d) spread of fire from the probe assembly (see Clause 9);~~

d) effects of fluids (see Clause 11); **17**

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 document are in other parts of IEC 61010. **18**

NOTE Attention is drawn to the possible existence of additional requirements regarding the health and safety of labour forces.

### 4.2.2 Aspects excluded ~~from scope~~

This document does not cover:

a) reliable function, performance, or other properties of the probe assembly;

b) effectiveness of transport packaging.

## 4.3 Verification

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

## 4.4 Environmental conditions

### 4.4.1 Normal environmental conditions

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

a) altitude up to 2 000 m;

b) ambient temperature of 5 °C to 40 °C;

c) maximum relative humidity of 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;

d) applicable POLLUTION DEGREE of the intended environment.

### 4.4.2 Extended environmental conditions

This document applies to probe assemblies designed to be safe not only in the environmental conditions specified in 4.4.1, but also in any of the following conditions as RATED by the manufacturer of the probe assembly:

a) outdoor use;

b) altitude above 2 000 m;

c) ambient temperatures below 5 °C or above 40 °C;

d) relative humidity above the levels specified in 4.4.1;

e) WET LOCATION.

# 5 Tests

## 5.1 General

Tests in this document 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 to this document. 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 document. It is permissible to exceed the requirements. If, in this document, 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 document, and used in accordance with them, need not be repeated during TYPE TESTS of the whole probe assembly.

If a probe assembly consists of more than one probe type (see 4.1), each type shall be tested in accordance with its applicable requirements.

*Conformity to the requirements of this document 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 5.3) and fault conditions (see 5.4).*

*Where conformity statements in this document 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.*

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

*a) manufacturers should ensure that at least the specified test value is applied;*

*b) test houses should ensure that no more than the specified test value is applied.*

If the RATED range of environmental conditions for probe assemblies is wider than that stated in 4.4.1, the manufacturer should make sure (for example, by suitable alteration of test requirements or additional tests) that the safety requirements of this document are still fulfilled.

Probe assemblies which have undergone TYPE TESTS may no longer be suitable for their intended function because of the residual effect of stresses resulting from tests. A probe assembly which has undergone TYPE TESTS shall not then be put into use.

## 5.2 Sequence of tests

The sequence of tests is optional unless otherwise specified. The probe assemblies under test shall be carefully inspected after each test. If the result of a test causes doubt as to whether any earlier tests would have passed if the sequence had been reversed, these earlier tests shall be repeated.

## 5.3 Reference test conditions

### 5.3.1 Environmental conditions

Unless otherwise specified in this document, the following environmental conditions (but not conflicting with those of 4.4.1) 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.

### 5.3.2 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 5.3.3 to 5.3.9.

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 document.

### 5.3.3 Position of the probe assembly

All possible orientations of the probe assembly are considered to be positions of NORMAL USE.

### 5.3.4 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.

### 5.3.5 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.

### 5.3.6 Input and output voltages

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

### 5.3.7 Controls

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

### 5.3.8 Connections

The probe assembly shall be connected for NORMAL USE or not connected whichever is the worst condition.

### 5.3.9 Short-term or intermittent operation

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.

## 5.4 Testing in SINGLE FAULT CONDITION

### 5.4.1 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 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 5.3). These combinations may be different for different faults and they shall be recorded for each test.

### 5.4.2 Application of fault conditions

#### 5.4.2.1 General

Fault conditions shall include those specified in 5.4.2.2 to 5.4.2.4. 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 5.4.4.

#### 5.4.2.2 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 7.4.5, it need not be short-circuited or disconnected.

#### 5.4.2.3 Probe assemblies or parts for short-term or intermittent operation

Probe assemblies or parts for short-term or intermittent operation shall be operated continuously if continuous operation could occur in a SINGLE FAULT CONDITION.

#### 5.4.2.4 Outputs

Outputs of Type B ~~and Type C~~ probe assemblies shall be short-circuited.

#### ~~4.4.2.5 Insulation between circuits and parts~~ 19

~~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.~~

### 5.4.3 Duration of tests

The probe assembly shall be operated until the point when it is unlikely that further change as a result of the applied fault ~~is unlikely~~ will occur. 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 there is an indication that a HAZARD of electric shock~~, spread of fire~~ or injury to persons may eventually occur, the test shall be continued for a maximum period of 4 h.

### 5.4.4 Conformity after application of fault conditions

#### 5.4.4.1 Electric shock

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

a) *by making the measurements of 7.3.3 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE, except as permitted by 7.1;*

b) *by performing a voltage test on DOUBLE INSULATION, REINFORCED INSULATION or BASIC INSULATION plus impedance* **20** *when the impedance is short-circuited to check that the protection is still at least at the level of BASIC INSULATION. The voltage tests are made as specified in 7.6 (without humidity preconditioning) with the test voltage for BASIC INSULATION;*

c) *by inspection and measurements of the SPACINGS for the levels of BASIC INSULATION. This also applies to impedance or PROTECTIVE IMPEDANCE.*

#### 5.4.4.2 Temperature

*Conformity with requirements for temperature protection is checked by determining the temperature of the outer surface of the probe assembly (see Clause 10).*

*This temperature is determined by measuring the temperature rise of the surface or part and adding it to the ambient temperature of 40 °C, or to the maximum RATED ambient temperature, if higher.*

#### ~~4.4.4.3 Spread of fire~~ 21

~~*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 no* HAZARD *could arise.*~~

#### 5.4.4.3 Other HAZARDS

*Conformity with the requirements for protection against other* HAZARDS *is checked as specified in Clause 8 to Clause 13.*

### 5.5 Tests in REASONABLY FORESEEABLE MISUSE

#### 5.5.1 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.

#### 5.5.2 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~~ flash.

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 the 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.*

## 6 Marking and documentation

### 6.1 Marking

#### 6.1.1 General

Probe assemblies shall bear markings in accordance with 6.1.2 to 6.2. 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, except for removable parts of PROBE TIPS if they comply with 13.2. **22**

Letter symbols for quantities and units shall be in accordance with IEC 60027-1:1992, IEC 60027-1:1992:AMD1:1997, and IEC 60027-1:1992/AMD2:2005, IEC 60027-2:2019 and IEC 60027-4:2006. Graphical 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 graphical symbol may be used on a probe assembly provided the symbol is explained in the accompanying documentation (see 6.4.1).

If it is not possible to put all of the required markings on the part, the necessary information shall be included in the documentation specified in 6.4.1. Symbol 7 of Table 1 ~~may~~ shall also be used.

*Conformity is checked by inspection.*

### 6.1.2 Identification

Each probe assembly and, when possible, its accessories shall be marked with:

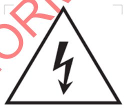
a) the name or registered trademark of the manufacturer or supplier;

b) 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 |  | IEC 60417-5017 (2006-08) | Earth (ground) TERMINAL |
| 5 |  | IEC 60417-6042 (2010-11) | Caution, ~~possibility~~ risk of electric shock |
| 6 |  | IEC 60417-5041 (2002-10) | Caution, hot surface |
| 7 |  | ISO 7000-0434A (2004-01) or<br>ISO 7000-0434B (2004-01) | Caution [a] |

[a] See 6.4.1 which requires manufacturers to state that documentation must be consulted in all cases where this symbol is marked.

### 6.1.3 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 there is not sufficient ~~room~~ space to mark these details, 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.*

### 6.1.4 CONNECTORS and operating devices

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

*Conformity is checked by inspection.*

### 6.1.5 RATING

The RATING of probe assemblies shall be marked as follows:

a) probe assemblies which do not have a RATING for MEASUREMENT CATEGORIES ~~II, III, or IV (see 6.5.1.3)~~ shall be marked with the RATED voltage to earth and with symbol 7 of Table 1 (see also 6.4.3 k));

b) probe assemblies for measurements within MEASUREMENT CATEGORIES II, III and IV ~~(see 6.5.1.3)~~ shall be marked with the RATED ~~voltages to earth~~ AC RMS line-to-neutral or DC voltage **23** and the relevant MEASUREMENT CATEGORIES.

   The MEASUREMENT CATEGORY markings shall be "CAT II", "CAT III" or "CAT IV" as applicable.

   NOTE CLEARANCES and solid insulation are specified for nominal AC RMS line-to-neutral or DC voltages of mains being measured. Neutral is considered to be earthed (see Annex H).

If it is possible (see 6.1.1), marking on a probe assembly shall ~~preferably~~ be on the probe body. The nature of the voltage (AC, DC, etc.) shall also be marked, unless the voltage marking applies to both AC RMS and DC. If a REFERENCE CONNECTOR is intended for connection to points at a voltage level exceeding the values of 7.3.2, the RATED voltage to earth shall be marked on the CONNECTOR or as close to the CONNECTOR as is practicable.

For Type A, Type D and Type E probe assemblies only, the RATED current of the probe assembly shall be marked together with the RATED voltage ~~to earth~~. The 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.*

## 6.2 Warning markings

Warning markings shall be 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 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 Clause 10 to exceed the temperature limits shall be marked with symbol 6 of Table 1.

*Conformity is checked by inspection.*

### 6.3 Durability of markings

Required markings shall remain clear and legible under conditions of NORMAL USE and shall resist the effects of cleaning agents specified by the manufacturer (see 11.1).

*Conformity is checked 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.*

### 6.4 Documentation

#### 6.4.1 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 6.4.2 to 6.4.4.

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~~ must 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.*

#### 6.4.2 Probe assembly RATING

Documentation shall include the 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 4.4).

*Conformity is checked by inspection.*

#### 6.4.3 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 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 6.1.5);

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;

h) instructions for replacement of consumable materials;

i) for probe assemblies 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 RATED for voltages above 1 000 V AC RMS or 1 500 V DC, 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~~ will 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 lowest of the MEASUREMENT CATEGORIES of the probe assembly and of the accessory.

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.*

### 6.4.4 Probe assembly maintenance and service

Instructions shall be provided to the RESPONSIBLE BODY 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 its agent.

The RATING and characteristics of fuses used shall be stated (see 6.1.3).

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.*

# 7 Protection against electric shock

## 7.1 General

Protection against electric shock shall be maintained in NORMAL CONDITION and in SINGLE FAULT CONDITION. ACCESSIBLE parts of probe assemblies shall not be HAZARDOUS LIVE (see 7.3).

If it is not feasible for operating reasons to prevent the following parts from 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 6.2;

b) PROBE TIPS, provided that they meet the requirements of 7.4.3;

c) unmated CONNECTORS as specified in 7.4.2.4 1).

*Conformity is checked by the determination of 7.2 and the measurements of 7.3, followed by the inspection and tests of 7.4 to 7.7.*

## 7.2 Determination of ACCESSIBLE parts

### 7.2.1 General

*Unless obvious, determination of whether a part is ACCESSIBLE is made as specified in 7.2.2 and 7.2.3. Test fingers (see Figure B.1 and Figure B.2 of Annex B) and pins are applied without force. Parts are considered to be ACCESSIBLE if they can be touched with any part of a test finger or pin, or if they could be touched in the absence of a covering which is not considered to provide suitable insulation (see 7.7.2).*

*If in NORMAL USE an OPERATOR is intended to perform any actions (with or without a TOOL) that could increase the accessibility of parts, such actions are taken before performing the examinations of 7.2.2 and 7.2.3.*

*NOTE Examples of such actions include:*

*a) removing covers;*

*b) adjusting controls;*

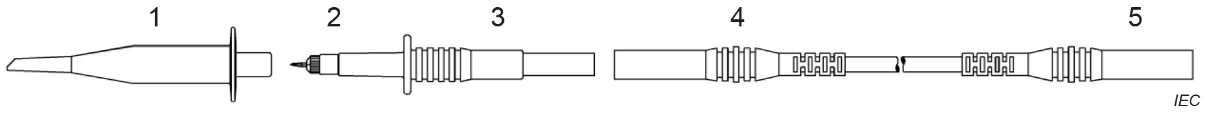
*c) replacing consumable materials;*

*d) removing or installing parts and supplied accessories.*

*Figure 7 gives methods for determination of ACCESSIBLE parts of probe assemblies.*

### 7.2.2 Examination

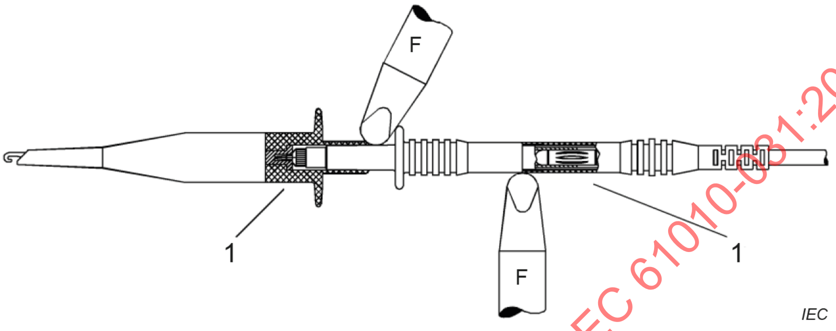
*The jointed test finger (see Figure B.2) is applied in every possible position without force. The test is applied to all outer surfaces.*



**Key**

| | | | |
|---|---|---|---|
| 1 | accessory PROBE TIP | 4 | CONNECTOR |
| 2 | PROBE TIP | 5 | CONNECTOR to equipment |
| 3 | hand-held area of probe body | | |

Figure 7 a) – Parts of a probe assembly

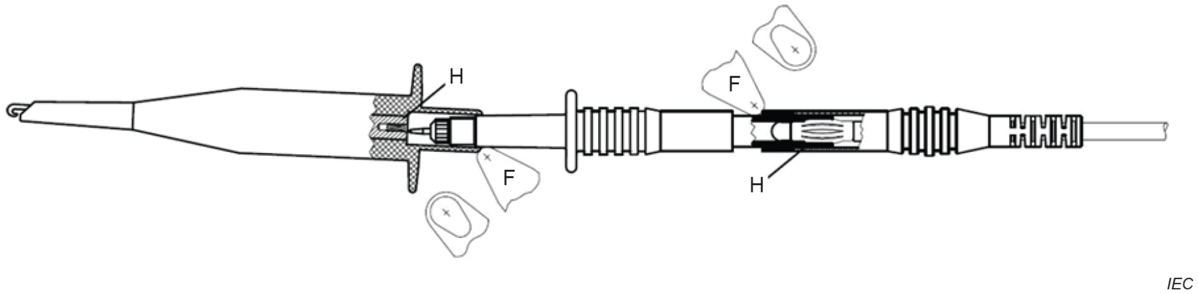


**Key**

1 CONNECTOR

F jointed test finger (see Figure B.2)

Figure 7 b) – Fully mated probe assembly (see 7.4.2.2)



**Key**

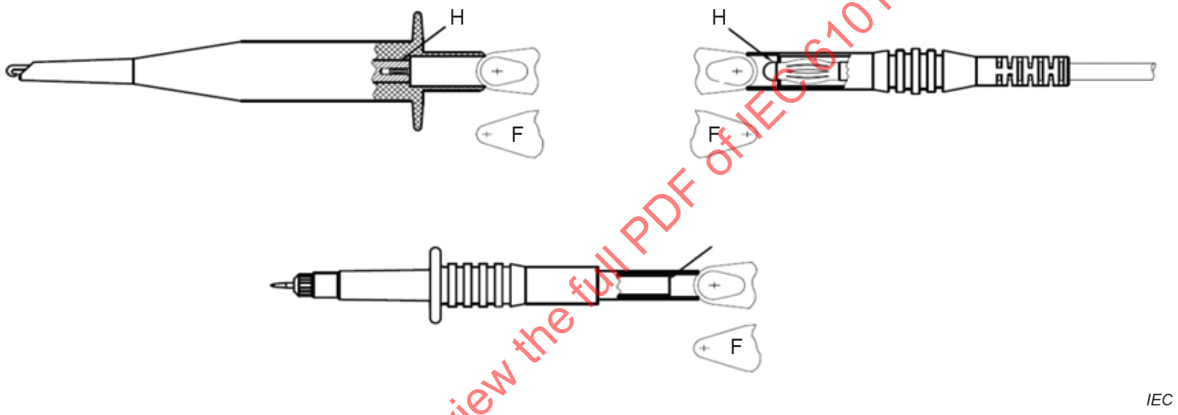
F jointed test finger (see Figure B.2)

H potentially HAZARDOUS LIVE part

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

Note the two possible positions of the test finger.

**Figure 7 c) – Partially mated probe assemblies (see 7.4.2.3)**



**Key**

F jointed test finger (see ~~Figure B.1~~ Figure B.2)

H potentially HAZARDOUS LIVE part

Note the two possible positions of the test finger.

**Figure 7 d) – Unmated parts of a probe assembly (see 7.4.2.4)**

**Figure 7 – Methods for determination of ACCESSIBLE parts ~~(see 6.2) and for voltage tests of (see 6.4.2)~~**

### 7.2.3 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.*

## 7.3 Limit values for ACCESSIBLE parts

### 7.3.1 General

Except as permitted in 7.1, the voltage between an ACCESSIBLE part and earth, or between any two ACCESSIBLE parts on the same probe assembly, shall not exceed the levels of 7.3.2 in NORMAL CONDITION or of 7.3.3 in SINGLE FAULT CONDITION.

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 7.3.4). If the voltage is below the levels of 7.3.2 a) or 7.3.3 a) as applicable, the touch current and the capacitance need not be measured. If the voltage exceeds that level, the touch current and the capacitance shall be measured. For high frequencies test probes RATED for frequencies above 100 kHz, the alternative method of 7.3.4.3 can also be used.

*Conformity is checked by inspection and as specified in 7.3.2, 7.3.3 and 7.3.4.*

### 7.3.2 Levels in NORMAL CONDITION

Voltages above the levels of 7.3.2 a) are deemed to be HAZARDOUS LIVE if any of the levels of 7.3.2 b) or 7.3.2 c) are exceeded at the same time.

a) The AC voltage level is 30 V RMS or 42,4 V peak, and the DC voltage level is 60 V. For probe assemblies intended for use in WET LOCATIONS, the AC voltage level is 16 V RMS or 22,6 V peak, and the DC voltage level is 35 V.

b) The touch current levels are:

   1) 0,5 mA RMS for sinusoidal waveforms, 0,7 mA peak for non-sinusoidal waveforms or mixed frequencies, or 2 mA DC, 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 intended for use in WET LOCATIONS.

   2) 70 mA RMS when measured with measuring circuit of Figure A.3. This relates to possible burns at frequencies above 100 kHz.

c) The levels of capacitive charge or energy are:

   1) 45 μC charge for voltages up to 15 kV peak or 15 kV DC. Line A of Figure 8 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 15 kV DC.

### 7.3.3 Levels in SINGLE FAULT CONDITION

In SINGLE FAULT CONDITION, voltages above the levels of 7.3.3 a) are deemed to be HAZARDOUS LIVE if any of the levels of 7.3.3 b) or 7.3.3 c) are exceeded at the same time.

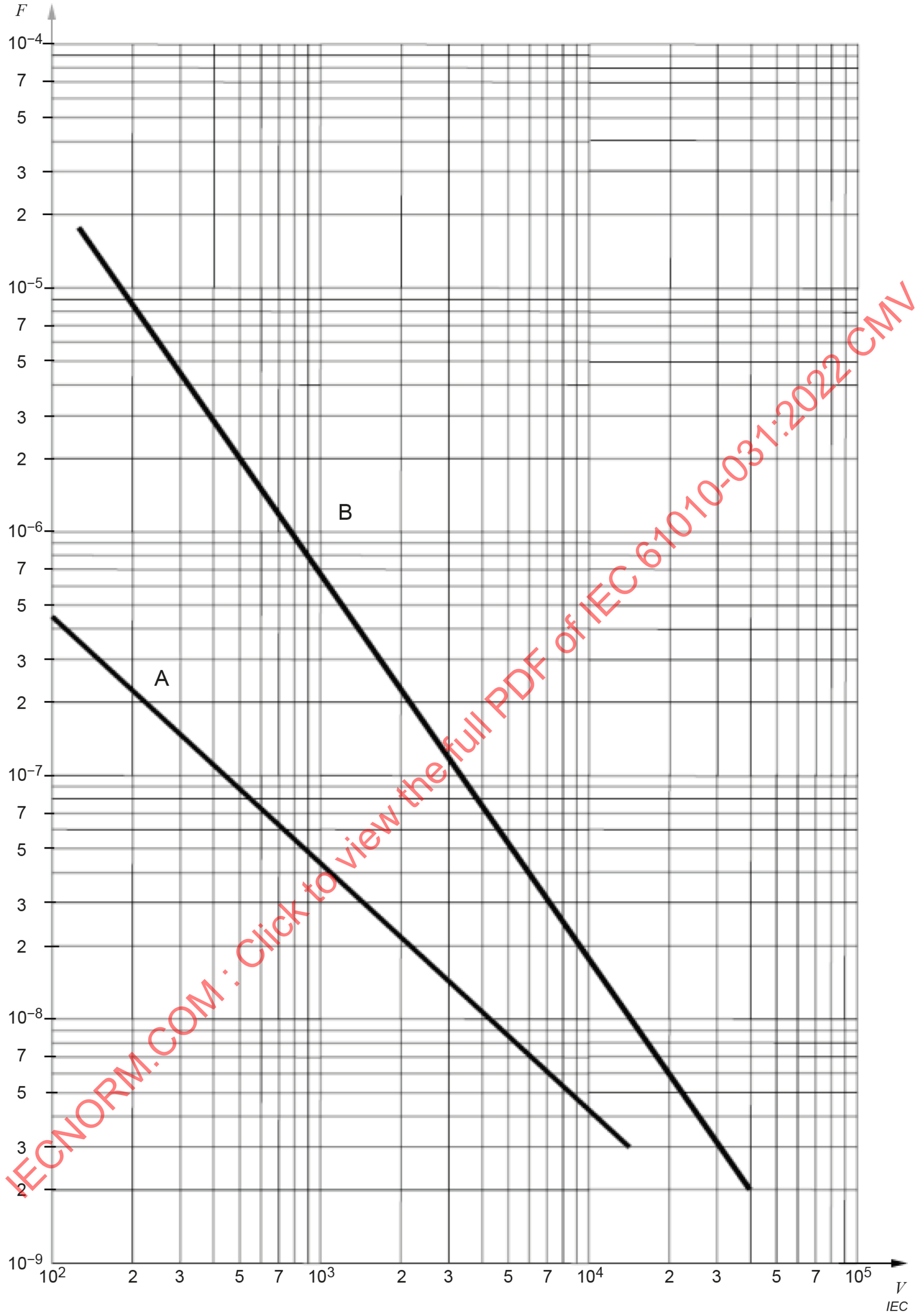
a) The AC voltage level is 50 V RMS or 70,7 V peak, and the DC voltage level is 120 V. For probe assemblies intended for use in WET LOCATIONS, the AC voltage level is 33 V RMS or 46,7 V peak, and the DC voltage level is 70 V.

b) The touch current levels are:

   1) 3,5 mA RMS for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA DC, 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 intended for use in WET LOCATIONS.

   2) 500 mA RMS when measured with the measuring circuit of Figure A.3. This relates to possible burns at frequencies above 100 kHz.

c) The capacitance level is line B of Figure 8.



**Key**

A = NORMAL CONDITION

B = SINGLE FAULT CONDITION

Figure 8 – Capacitance level versus voltage in NORMAL CONDITION and SINGLE FAULT CONDITION (see 7.3.2 c) and 7.3.3 c))

### 7.3.4 Measurement of voltage and touch current

#### 7.3.4.1 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:*

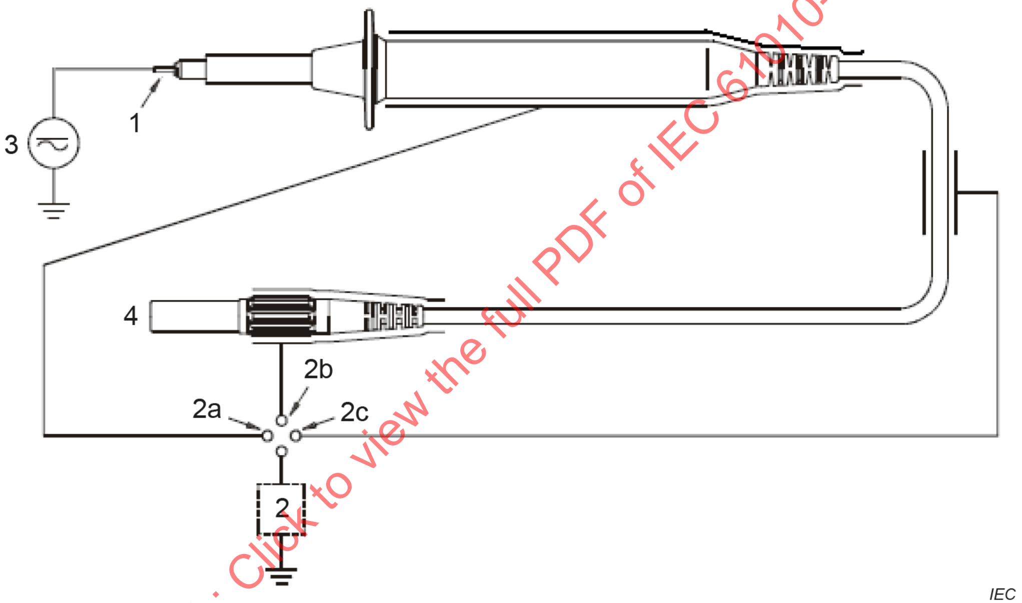
*a) the probe body;*

*b) hand-held or hand-manipulated parts of each CONNECTOR;*

*c) 150 mm ± 20 mm of the PROBE WIRE or the maximum length of the cable whichever is shorter;*

*d) other hand-held or hand-manipulated parts.*

*The highest 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, then 2b, and then 2c of Figure 9) between each of the foil-wrapped items and the earth (see Figure 9 and Figure 10).*



**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

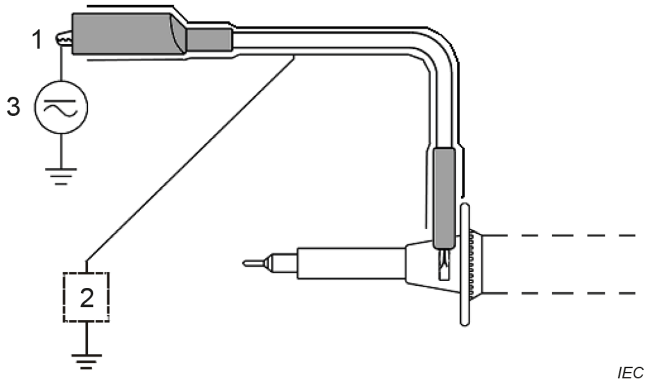
2b connection to metal foil tightly wrapped around the CONNECTOR

2c connection to metal foil tightly wrapped around the cable

3 ~~Maximum~~ highest RATED voltage with connection to internal conductor of the PROBE WIRE

4 not connected to test or measuring equipment

Figure 9 – 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)

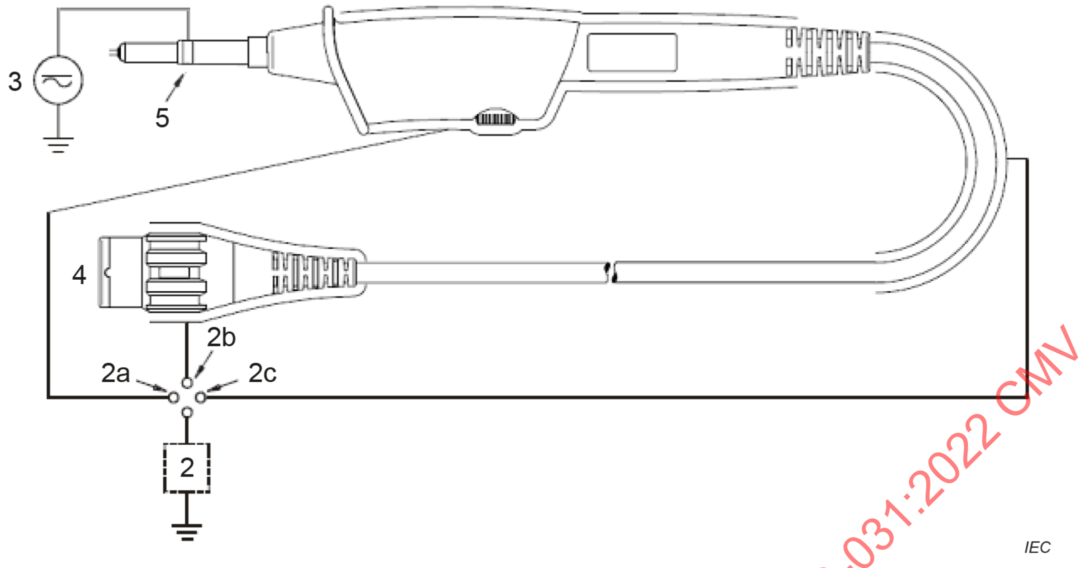
3 ~~Maximum~~ highest RATED voltage for the REFERENCE CONNECTOR

**Figure 10 – Voltage and touch current measurement for the REFERENCE CONNECTOR**

### 7.3.4.2 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 *(Figure 11, item 5) and the earth (see Figure 11).*

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



**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

3 ~~Maximum~~ highest 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 11 – Voltage and touch current measurement with shielded test probe**

### 7.3.4.3 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~~ is determined to avoid electrical burns. The touch current ~~shall be~~ is measured in the whole frequency range and at maximum voltage in each frequency range.*

*The measurements are made (see Figure 11):*

*a) between the shield and the foil around the probe body (Figure 11, item 2a), and*

*b) between the shield and the foil around the coaxial CONNECTOR (Figure 11, item 2b), and*

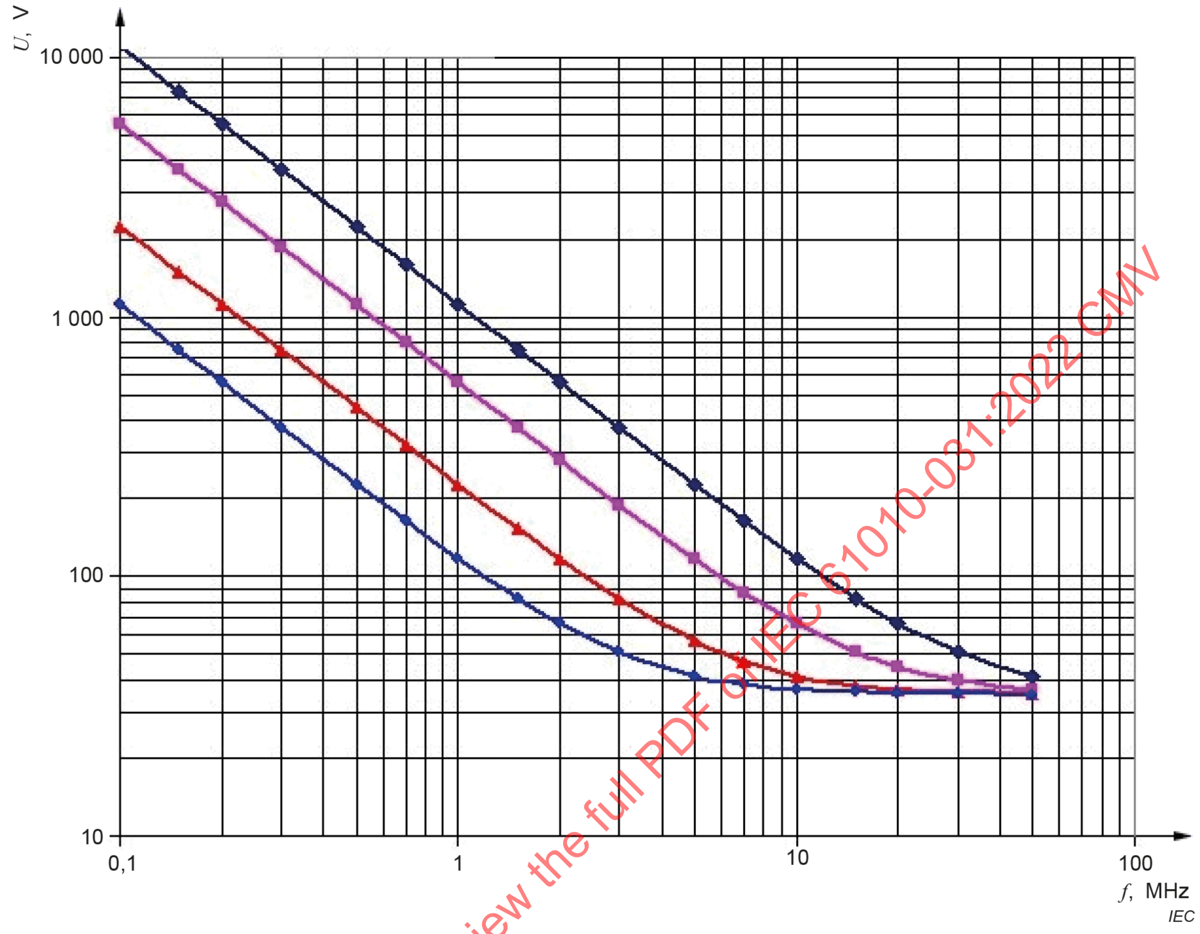
*c) between the shield and the foil around the PROBE WIRE (Figure 11, item 2c).*

*As an 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 Cs (measured capacitance between the shield and the foil) together with the circuit from Figure A.3 creates the impedance shown in Figure A.4. The variable parameters of this impedance are the ~~capacity~~ capacitance Cs and the frequency (R1, C1 and R2 are fixed). Through 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 R2) as shown in Figure 12 for some values of the capacitance Cs.*

*The maximum voltage for each frequency can then be calculated.*

*~~NOTE~~ In practice for the calculation with frequencies above 100 kHz, the values of R1 and C1 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 12 – Maximum test probe input voltage for 70 mA touch current**

## 7.4 Means of protection against electric shock

### 7.4.1 General

Connectors shall meet the requirements of 7.4.2.

Probe tips shall meet the requirements of 7.4.3.

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) basic insulation plus impedance (see 7.4.4);

b) protective impedance (see 7.4.5);

c) double insulation, consisting of basic insulation plus supplementary insulation (see 7.4.6);

d) REINFORCED INSULATION (see 7.4.6).

NOTE The PROBE WIRE is considered to be hand-held. See also Clause 12 for requirements pertaining to the PROBE WIRE.

*Conformity is checked by inspection and as specified in 7.4.2 to 7.4.6, as applicable.*

### 7.4.2 CONNECTORS

#### 7.4.2.1 General

Insulation, ACCESSIBLE parts and SPACINGS for CONNECTORS of probe assemblies shall meet the applicable requirements of 7.4.2.2 to 7.4.2.4. When a CONNECTOR is intended to mate with another CONNECTOR or a TERMINAL having different RATINGS, the lower RATING applies. 24

Insulation covers or sleeves over CONNECTORS which are intended to be hand-held or hand-manipulated by the OPERATOR during measurement or test, and which 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 except when they are needed for connection to test or measurement equipment that is equipped with TERMINALS which cannot accept fully shrouded CONNECTORS. For example, retractable insulation sleeves are not considered to provide adequate protection.

Annex E provides information regarding the recommended dimensions of 4 mm CONNECTORS up to 1 000 V.

*Conformity is checked by inspection.*

#### 7.4.2.2 CONNECTORS in fully mated position

a) 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 during the measurement operation shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

b) ACCESSIBLE parts of CONNECTORS which are used for any other purpose or which are intended to be hand-held during the measurement operation shall be insulated from HAZARDOUS LIVE parts by DOUBLE INSULATION or REINFORCED INSULATION.

*Conformity is checked by the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 b) and as specified in 7.4.6 for BASIC INSULATION and REINFORCED INSULATION.*

#### 7.4.2.3 CONNECTORS in partially mated position

ACCESSIBLE parts of CONNECTORS in partially mated ~~condition~~ position shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

*Conformity is checked by the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 c) and as specified in 7.4.6 for BASIC INSULATION.*

#### 7.4.2.4 CONNECTORS in unmated position

When RATED voltages ~~to earth~~ are applied to other CONNECTORS or to PROBE TIPS of the probe assembly, the following requirements apply to CONNECTORS in unmated position.

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 (see Figure 5),~~

~~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.~~*

1) ACCESSIBLE parts of locking-type or screw-held-type CONNECTORS in unmated position, including CONNECTORS which do not require the use of a TOOL for unlocking or unscrewing are permitted to be HAZARDOUS LIVE.

   *Conformity is checked by inspection.*

2) ACCESSIBLE parts of unmated integrated TERMINALS of STACKABLE CONNECTORS shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

   *Conformity is checked by the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 d) for the part defined by key 1 of Figure 1 and measurement of the CLEARANCES as specified in 7.5.2 for BASIC INSULATION.*

3) ACCESSIBLE parts of other unmated CONNECTORS shall be insulated from HAZARDOUS LIVE parts by PROTECTIVE IMPEDANCE (see 7.4.5) or SPACINGS meeting the requirements of a) and b) below.

   a) For CONNECTORS with a voltage RATING up to 20 kV **25**, the CLEARANCE shall be at least the applicable value of Table 2.

**Table 2 – CLEARANCES for unmated CONNECTORS**

| Maximum voltage applied to the conductive parts of the CONNECTORS<br>V | CLEARANCE | |
|---|---|---|
| | AC RMS<br>mm | DC<br>mm |
| 600 | 0,8 | 0,8 |
| 1 000 | 1,0 | 0,8 |
| 1 500 | 2,0 | 1,1 |
| 2 000 | 3,2 | 1,8 |
| 3 000 | 6,4 | 3,5 |
| 5 000 | 13 | 8,3 |
| 10 000 | 30 | 20 |
| 15 000 | 48 | 32 |
| 20 000 | 67 | 44 |

For maximum voltages above 30 V AC RMS or 60 V DC up to 600 V, CLEARANCES are 0,8 mm.

Linear interpolation is allowed above 600 V.

NOTE See Annex G.

For CONNECTORS with a RATING above 20 kV, the CLEARANCE shall be at least the $D_2$ value of Table 5 with $U_m$ equal to 1,25 times the peak value of the RATED voltage (see 7.5.2.3.2).

If the probe assembly is RATED to operate at an altitude greater than 2 000 m, the value of the CLEARANCE shall be multiplied by the applicable factor of Table 3.

*Conformity is checked by one of the following tests:*

i) *the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 d)) and the measurement of the CLEARANCE, or*

ii) *the AC voltage test of 7.6.5.1 or the DC voltage test of 7.6.5.2 for probe assemblies stressed only by DC with a duration of at least 5 s, or the impulse voltage test of 7.6.5.3, using the test voltage of Table 11 for the required CLEARANCE.* **26**

*Correction factors of Table 12 are applicable to the values of the test voltages for CLEARANCES given in Table 11.*

b) The CREEPAGE DISTANCE values shall be at least the applicable CLEARANCE values defined in a). **27**

*Conformity is checked by determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 d)) and measurement of the CREEPAGE DISTANCE.*

### 7.4.3 PROBE TIPS

#### 7.4.3.1 General

PROBE TIPS that can become HAZARDOUS LIVE during NORMAL USE (see also 7.1 b)) shall meet the requirements of one of the following subclauses, 7.4.3.2 (if protection by a PROTECTIVE FINGERGUARD), 7.4.3.3 (if protection by distance) or 7.4.3.4 (if protection by tactile indicator). In addition, IP 2X PROBE TIPS with retractable sleeve shall meet the requirements of 7.4.3.5.

PROBE TIPS that can be used as CONNECTORS shall also meet the requirements of 7.4.3.6.

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 7.3.2 a).

*Conformity is checked by inspection and measurement.*

### 7.4.3.2 Protection by a PROTECTIVE FINGERGUARD

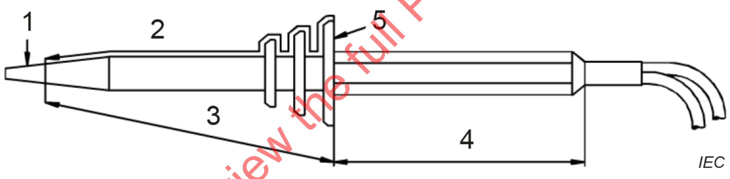
If a conductive part of a PROBE TIP can become HAZARDOUS LIVE, or if the end of a PROBE TIP can touch a HAZARDOUS LIVE conductor, a PROTECTIVE FINGERGUARD shall be fitted to reduce the risk of touching an exposed ~~conductive~~ part of the PROBE TIP, and to provide an indication of the limit beyond which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

The PROTECTIVE FINGERGUARD of probe assemblies which have a voltage RATING above the levels of 7.3.2 a) shall extend across at least 80 % of the sides where the fingers are intended to be applied.

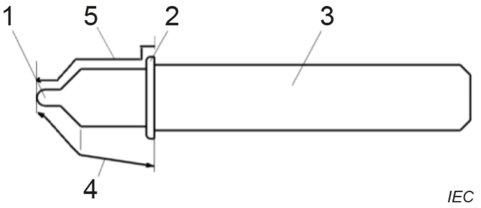
Figure 13 gives examples of probe assemblies with a PROTECTIVE FINGERGUARD and indicates applicable SPACINGS.



**Key**

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

**Figure 13 a) – Probe assembly for direct electrical connection**



**Key**

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

**Figure 13 b) – Type F probe assembly for non-contact measurement**

**Figure 13 – Protection by a PROTECTIVE FINGERGUARD**

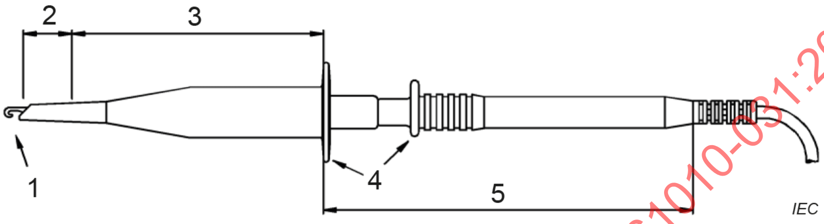
### 7.4.3.3 Protection by distance

SPRING-LOADED 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) the SPACINGS between the PROBE TIP and the nearest surface which the OPERATOR needs to touch to actuate the mechanism are increased by an additional protective distance of 45 mm.

Figure 14 gives an example of a probe assembly protected by distance and indicates applicable SPACINGS.



**Key**

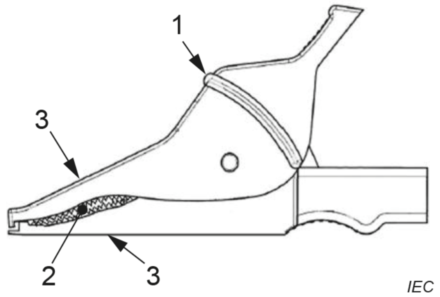
| | |
|---|---|
| 1 | PROBE TIP |
| 2 | ~~CLEARANCE and CREEPAGE DISTANCE~~ SPACINGS as specified in 7.5 |
| 3 | additional protective distance |
| 4 | actuating parts |
| 5 | hand-held area of the probe assembly |

**Figure 14 – Protection by distance**

### 7.4.3.4 Protection by tactile indicator

SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY II or without MEASUREMENT CATEGORY for maximum 300 V 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.

EXAMPLE Figure 15 gives an example of a SPRING-LOADED CLIP with a tactile indicator.



**Key**

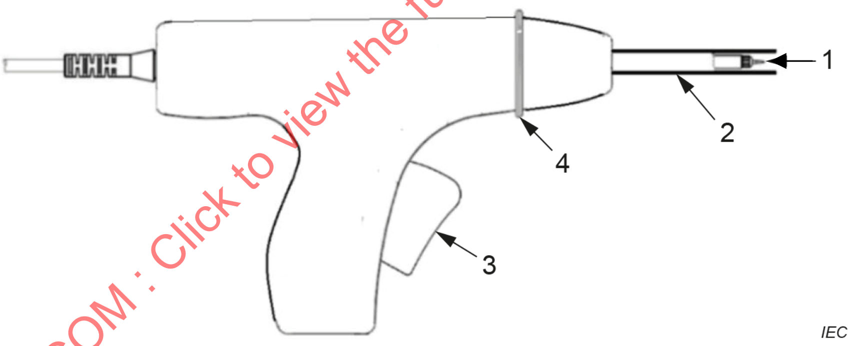
| | | | |
|---|---|---|---|
| 1 | tactile indicator | 3 | insulated metal jaws |
| 2 | metal jaws | | |

Figure 15 – Protection by tactile indicator

#### 7.4.3.5 IP2X PROBE TIPS with retractable sleeve

IP2X probe assemblies are probe assemblies with an IP2X protection of the PROBE TIP. HAZARDOUS LIVE parts of the PROBE TIP with an IP2X degree of protection are prevented by a retractable sleeve from being ACCESSIBLE. In non-operative position, the sleeve covers the PROBE TIP. The sleeve can be retracted voluntarily by pressing on a trigger or by applying a strength force exceeding the value as set out in Table 6 of IEC 60529:1989. When the sleeve is retracted, the OPERATOR's hand holds onto the probe body.

EXAMPLE Figure 16 gives an example of probe assembly with an IP2X PROBE TIP.



**Key**

| | | | |
|---|---|---|---|
| 1 | PROBE TIP | 3 | trigger |
| 2 | retractable sleeve | 4 | PROTECTIVE FINGERGUARD |

Figure 16 – Example of probe assembly with IP2X PROBE TIP

IP2X PROBE TIPS with retractable sleeve do not provide particular protection against risk of short circuits.

The conductive parts of PROBE TIPS of IP2X probe assemblies shall not be ACCESSIBLE when the sleeve is in the non-operative position.

*Conformity is checked by determination of the ACCESSIBLE parts when performing the test from IEC 60529:1989, 12.2.* **28**

#### 7.4.3.6 PROBE TIPS used as CONNECTORS

PROBE TIPS which can be used as CONNECTORS and are intended to be connected to specified accessories (for example to a SPRING-LOADED CLIP) shall, in combination with those accessories, also meet the requirements for CONNECTORS in fully mated position (see 7.4.2.2) and partially mated position (see 7.4.2.3).

### 7.4.4 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 7.3.3;

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 7.5 for BASIC INSULATION.

*Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 7.3.3, and by measuring ~~CLEARANCE and CREEPAGE DISTANCE~~ SPACINGS as specified in 7.5.*

### 7.4.5 PROTECTIVE IMPEDANCE

A PROTECTIVE IMPEDANCE shall limit the current or voltage to the levels of 7.3.2 in NORMAL CONDITION and to the levels of 7.3.3 in SINGLE FAULT CONDITION (see also 5.4.2.2).

Insulation between the terminations of the PROTECTIVE IMPEDANCE shall meet the requirements of 7.4.6 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~~ ensured. 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 7.3 and by measuring SPACINGS as specified in 7.5. Conformity of a single component is checked by inspection of its RATINGS.*

### 7.4.6 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 7.5.

DOUBLE INSULATION is ~~comprised~~ composed of BASIC INSULATION and SUPPLEMENTARY INSULATION, each of which shall meet the applicable requirements of 7.5.

*Conformity is checked as specified in 7.5.*

## 7.5 Insulation requirements

### 7.5.1 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.~~

Measuring circuits are subjected to WORKING VOLTAGES and transient stresses from the circuit to which they are connected during measurement or test. When the measuring circuit is used to measure mains supplies or circuits directly connected to them, the transient stresses can be estimated by the location within the installation at which the measurement is performed. When the measuring circuit is used to measure any other electrical signal, the transient stresses should be considered by the OPERATOR to ensure that they do not exceed the capabilities 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;
e) insulation between circuits and ACCESSIBLE parts (see 7.2) or between separate circuits consists of SPACINGS, solid insulation, or a combination of SPACINGS and solid insulation.

### ~~6.5.1.2 SPACINGS~~

### ~~6.5.1.2.1 General~~

SPACINGS are a combination of CLEARANCES and CREEPAGE DISTANCES, which are specified in 7.5.2 and 7.5.3 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.

### 7.5.2 CLEARANCES

### 7.5.2.1 General

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. If transient overvoltages cannot occur, CLEARANCES are based on the WORKING VOLTAGE.

The values for CLEARANCES given in Table 4 and Table 5 are based on absolute inhomogeneous field conditions. Reduced CLEARANCES may apply to 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.

No particular value can be specified for a reduced CLEARANCE for these more homogeneous constructions, but it can be tested by a voltage test (see 7.6). CLEARANCES which meet the values of Table 4 and Table 5 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 probe assembly is RATED to operate at an altitude greater than 2 000 m, the values for CLEARANCES are multiplied by the applicable factor of Table 3.

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

| RATED operating altitude<br>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~~ For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, the minimum CLEARANCE value for POLLUTION DEGREE 2 is 0,2 mm and for POLLUTION DEGREE 3 is 0,8 mm.

See Annex C for details of how to measure CLEARANCES.

CLEARANCES for CONNECTORS are defined in 7.4.2; CLEARANCES for probe assemblies RATED for MEASUREMENT CATEGORIES are defined in 7.5.2.2, and CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES are defined in 7.5.2.3.

*Conformity is checked ~~by inspection, measurement, and in the case of more homogeneous construction by the voltage test of 6.6~~ as specified in 7.4.2.4, 7.5.2.2 and 7.5.2.3.*

### 7.5.2.2 CLEARANCES for probe assemblies ~~of~~ RATED for MEASUREMENT CATEGORIES ~~II, III and IV~~

CLEARANCES for probe assemblies ~~of~~ RATED for MEASUREMENT CATEGORIES ~~II, III and IV~~ are specified in Table 4.

**Table 4 – CLEARANCES for probe assemblies RATED for MEASUREMENT CATEGORIES**

| Nominal AC RMS line-to-neutral or DC voltage of mains ~~to which the probe assembly is designed to be connected~~ being measured<br>V | CLEARANCE<br>mm | | | | | |
|---|---|---|---|---|---|---|
| | BASIC INSULATION and SUPPLEMENTARY INSULATION | | | REINFORCED INSULATION | | |
| | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV |
| ≤ 50 | 0,04 | 0,10 | 0,50 | 0,10 | 0,32 | 1,4 |
| > 50 ≤ 100 | 0,10 | 0,50 | 1,5 | 0,32 | 1,4 | 3,0 |
| > 100 ≤ 150 | 0,50 | 1,5 | 3,0 | 1,4 | 3,0 | 6,0 |
| > 150 ≤ 300 | 1,5 | 3,0 | 5,5 | 3,0 | 6,0 | 10,4 |
| > 300 ≤ 600 | 3,0 | 5,5 | 8,0 | 6,0 | 10,4 | 15,0 |
| > 600 ≤ 1 000 | 5,5 | 8,0 | 14,0 | 10,4 | 15,0 | 23,9 |
| > 1 000 ≤ 1 500 | 8,0 | 11,0 | 18,0 | 16,0 | 22 | 36 |
| > 1 500 ≤ 2 000 | 14,0 | 18,0 | 22,0 | 28,0 | 36 | 44 |
| > 2 000 ≤ 3 000 | 18,0 | 22,0 | 25,0 | 36 | 44 | 50 |

~~*Conformity is checked by inspection and measurement, or by the AC voltage test of 6.6.5.1 with a duration of at least 5 s or the impulse voltage test of 6.6.5.3, or for probe assemblies stressed only by d.c., the 1 min d.c. voltage test of 6.6.5.2 or the impulse voltage test of 6.6.5.3, using the test voltage of Table 10 for the required CLEARANCE.*~~

*Conformity is checked by inspection and measurement, or by the AC voltage test of 7.6.5.1 or the DC voltage test of 7.6.5.2 for probe assemblies stressed only by DC with a duration of at least 5 s, or the impulse voltage test of 7.6.5.3, using the test voltage of Table 11 for the required CLEARANCE.*

### 7.5.2.3 CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES ~~II, III, or IV~~

#### 7.5.2.3.1 General

CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES ~~II, III, or IV~~ are calculated according to 7.5.2.3.2.

If they have either one of the following characteristics in a) or b), CLEARANCES are determined according to 7.5.2.3.3, and the larger of the two CLEARANCES is the required CLEARANCE:

a) the WORKING VOLTAGE includes a recurring peak voltage that may include a periodic non-sinusoidal waveform or a non-periodic waveform that occurs with some regularity;

b) the WORKING VOLTAGE has a frequency above 30 kHz.

#### 7.5.2.3.2 CLEARANCE calculation

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION are determined from the following formula:

$$D_{BI} = D_1 + F \times (D_2 - D_1)$$

where

$D_{BI}$ is the CLEARANCE to determine;

$F$ is a factor, determined from one of the equations:

$F = (1{,}25 \times U_w/U_m) - 0{,}25$ if $U_w/U_m > 0{,}2$;

$F = 0$ if $U_w/U_m \leq 0{,}2$;

where

$U_m = U_w + U_t$;

$U_w$ = the maximum peak value of the WORKING VOLTAGE;

$U_t$ = the maximum additional transient overvoltage;

$D_1$ and $D_2$ are values taken from Table 5 for $U_m$:

where

$D_1$ represents the CLEARANCE that would be applicable to a transient overvoltage with the shape of a 1,2 × 50 µs impulse;

$D_2$ represents the CLEARANCE that would be applicable to the peak WORKING VOLTAGE without any transient overvoltage.

CLEARANCES for REINFORCED INSULATION are twice the values for BASIC INSULATION.

*Conformity is checked by inspection and measurement, or by the AC voltage test of 7.6.5.1 with a duration of at least 5 s, or the DC voltage test of 7.6.5.2 for probe assemblies stressed only by DC with a duration of at least 5 s, or the impulse voltage test of 7.6.5.3, using the applicable test voltage from Table 11 for the required CLEARANCE.*

*Correction factors of Table 12 are applicable to the values of test voltages.*

### Table 5 – CLEARANCE values for the calculation of 7.5.2.3.2 29

| Maximum voltage $U_m$ V | CLEARANCE $D_1$ mm | CLEARANCE $D_2$ mm | Maximum voltage $U_m$ V | CLEARANCE $D_1$ mm | CLEARANCE $D_2$ mm |
|---|---|---|---|---|---|
| 14,1 to 266 | 0,010 | 0,010 | 4 000 | ~~2,93~~ 3,00 | ~~6,05~~ 3,80 |
| 283 | 0,010 | ~~0,013~~ 0,010 | 4 530 | 3,53 | ~~7,29~~ 4,80 |
| 330 | 0,010 | ~~0,020~~ 0,010 | 5 660 | ~~4,92~~ 4,99 | ~~10,1~~ 7,15 |
| 354 | ~~0,013~~ 0,012 | ~~0,025~~ 0,013 | 6 000 | ~~5,37~~ 5,50 | ~~10,8~~ 7,90 |
| 453 | ~~0,027~~ 0,030 | ~~0,052~~ 0,030 | 7 070 | ~~6,86~~ 6,84 | ~~13,1~~ 9,55 |
| 500 | ~~0,036~~ 0,040 | ~~0,071~~ 0,040 | 8 000 | ~~8,25~~ 8,00 | ~~15,2~~ 11,0 |
| 566 | ~~0,052~~ 0,053 | ~~0,10~~ 0,053 | 8 910 | ~~9,69~~ 9,37 | ~~17,2~~ 12,9 |
| 707 | 0,081 | ~~0,20~~ 0,097 | 11 300 | ~~12,9~~ 13,0 | ~~22,8~~ 17,7 |
| 800 | ~~0,099~~ 0,10 | ~~0,29~~ 0,13 | 14 100 | ~~16,7~~ 16,8 | ~~29,5~~ 23,2 |
| 891 | 0,12 | ~~0,41~~ 0,19 | 17 700 | 21,8 | ~~38,5~~ 29,9 |
| 1 130 | ~~0,19~~ 0,22 | ~~0,83~~ 0,36 | 22 600 | ~~29,0~~ 29,2 | ~~51,2~~ 39,2 |
| 1 410 | ~~0,38~~ 0,43 | ~~1,27~~ 0,66 | 28 300 | ~~37,8~~ 37,6 | ~~66,7~~ 51,3 |
| 1 500 | ~~0,45~~ 0,50 | ~~1,40~~ 0,76 | 35 400 | ~~49,1~~ 50,8 | ~~86,7~~ 66,9 |
| 1 770 | ~~0,75~~ 0,77 | ~~1,79~~ 1,04 | 45 300 | ~~65,5~~ 68,0 | ~~116~~ 89,2 |
| 2 260 | ~~1,25~~ 1,26 | ~~2,58~~ 1,55 | 56 600 | 85,0 | ~~150~~ 115 |
| 2 500 | ~~1,45~~ 1,50 | ~~3,00~~ 1,80 | 70 700 | ~~110~~ 111 | ~~195~~ 148 |
| 2 830 | ~~1,74~~ 1,83 | ~~3,61~~ 2,2 | 89 100 | ~~145~~ 148 | ~~255~~ 190 |
| 3 540 | ~~2,44~~ 2,54 | ~~5,04~~ 3,16 | 100 000 | ~~165~~ 170 | ~~290~~ 215 |
| Linear interpolation is allowed | | | | | |

NOTE The following is an example calculation:

CLEARANCE $D_{RI}$ for REINFORCED INSULATION for a WORKING VOLTAGE with peak value of 3 500 V and an additional transient voltage of 4 500 V (this can be expected within an electronic switching-circuit):

Maximum voltage $U_m = U_w + U_t$ = 3 500 + 4 500 = 8 000 V

$U_w / U_m$ = 3 500 / 8 000 = 0,44 > 0,2

thus $F = (1,25 \times U_w / U_m) - 0,25$ = (1,25 × 3 500 / 8 000) − 0,25 = 0,297

Values derived from Table 5 at 8 000 V:

~~$D_1$ = 8,25 mm, $D_2$ = 15,2 mm~~

~~CLEARANCE = $D_1 + F \times (D_2 - D_1)$ = 8,25 + 0,297 × (15,2 – 8,25) = 8,25 + 2,06 = 10,3 mm~~

$D_1$ = 8,00 mm, $D_2$ = 11,0 mm

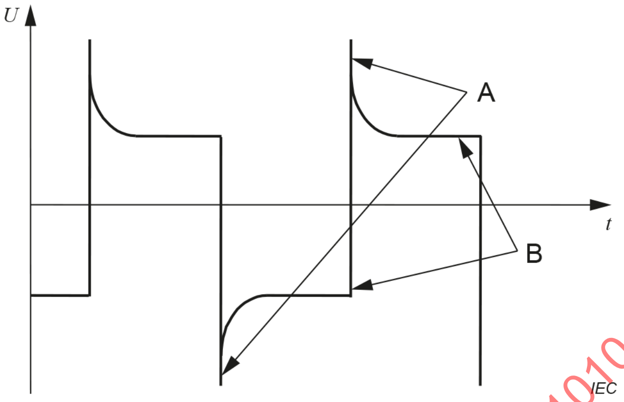
$D_{BI} = D_1 + F \times (D_2 - D_1)$ = 8,00 + 0,297 × (11,0 − 8,00) = 8,00 + 0,89 = 8,89 mm

For REINFORCED INSULATION the value is doubled~~. CLEARANCE = 20,6 mm~~ $D_{RI} = D_{BI} \times 2$ = 17,8 mm.

#### 7.5.2.3.3 CLEARANCES for probe assemblies subjected to recurring peak voltages, or WORKING VOLTAGES with frequencies above 30 kHz, or both

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for probe assemblies subjected to recurring peak voltages with frequencies not exceeding 30 kHz shall meet the values of the second column of Table 6, using the recurring peak voltage as the index (see Figure 17 for an example of a recurring peak voltage).

NOTE In most practical recurring waveforms, the fundamental frequency has a substantially higher amplitude than the harmonics. Therefore, the fundamental frequency is used for determining whether the frequency of the waveform exceeds 30 kHz. However, the peak amplitude of the waveform, and not the peak amplitude of the fundamental component of the waveform, is used for determining SPACINGS. For more information, see Clause E.2 of IEC 60664-4:2005.



**Key**

A peak value of recurring voltage

B WORKING VOLTAGE value

Figure 17 – Example of recurring peak voltage

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for probe assemblies that are subjected to WORKING VOLTAGES with frequencies above 30 kHz shall meet the values of the third column of Table 6, using the peak value of the WORKING VOLTAGE as the index.

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for probe assemblies that may be subjected to both recurring peak voltages and WORKING VOLTAGES with frequencies above 30 kHz shall meet the higher of these requirements.

CLEARANCES for REINFORCED INSULATION are twice the values for BASIC INSULATION.

*Conformity is checked by inspection and measurement.*

**Table 6 – CLEARANCES for BASIC INSULATION in probe assemblies subjected to recurring peak voltages or WORKING VOLTAGES with frequencies above 30 kHz**

| Voltage peak value<br>V | CLEARANCE | |
|---|---|---|
| | Frequencies up to 30 kHz<br>mm | Frequencies above 30 kHz<br>mm |
| 0 to 330 | 0,01 | 0,02 |
| 400 | 0,02 | 0,04 |
| 500 | 0,04 | 0,07 |
| 600 | 0,06 | 0,11 |
| 800 | 0,13 | 0,26 |
| 1 000 | 0,26 | 0,48 |
| 1 200 | 0,42 | 0,76 |
| 1 500 | 0,76 | 1,1 |
| 2 000 | 1,27 | 1,8 |
| 2 500 | 1,8 | 2,6 |
| 3 000 | 2,4 | 3,5 |
| 4 000 | 3,8 | 5,7 |
| 5 000 | 5,7 | 8 |
| 6 000 | 7,9 | 10 |
| 8 000 | 11 | 15 |
| 10 000 | 15,2 | 20 |
| 12 000 | 19 | 25 |
| 15 000 | 25 | 32 |
| 20 000 | 34 | 44 |
| 25 000 | 44 | 58 |
| 30 000 | 55 | 72 |
| 40 000 | 77 | 100 |
| 50 000 | 100 | |
| Linear interpolation is allowed. | | |

### 7.5.3 CREEPAGE DISTANCES

~~CREEPAGE DISTANCES shall be based on the actual WORKING VOLTAGE which stresses the insulation (see Table 9). Linear interpolation of CREEPAGE DISTANCE is permissible.~~

CREEPAGE DISTANCES protect against tracking on the surface of an insulation, which is a long-term phenomenon. Therefore, they cannot be confirmed by voltage testing, but have to be measured as specified in Annex C.

CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION for probe assemblies shall meet the applicable values of Table 7, based on the WORKING VOLTAGE which stresses the insulation.

Values for REINFORCED INSULATION are twice the values for BASIC INSULATION.

Coatings that meet the requirements of IEC 61010-1:2010, Annex H and IEC 61010-1:2010/AMD1:2016, Annex H when applied to the outer surfaces of printed wiring boards reduce the POLLUTION DEGREE of the coated area to POLLUTION DEGREE 1.

*Conformity is checked by inspection and measurement.*

**Table 7 – CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION**

| **WORKING VOLTAGE AC RMS or DC** | **CREEPAGE DISTANCE** | | | | |
|---|---|---|---|---|---|
| | **Printed wiring board material** | | **Other insulating material** | | |
| | **POLLUTION DEGREE** | | **POLLUTION DEGREE** | | |
| | **1** | **2** | **1** | **2** | **3** |
| V | mm | mm | mm | mm | mm |
| 10 | 0,025 | 0,04 | 0,08 | 0,40 | 1,00 |
| 12,5 | 0,025 | 0,04 | 0,09 | 0,42 | 1,05 |
| 16 | 0,025 | 0,04 | 0,10 | 0,45 | 1,10 |
| 20 | 0,025 | 0,04 | 0,11 | 0,48 | 1,20 |
| 25 | 0,025 | 0,04 | 0,125 | 0,50 | 1,25 |
| 32 | 0,025 | 0,04 | 0,14 | 0,53 | 1,3 |
| 40 | 0,025 | 0,04 | 0,16 | 0,56 | 1,4 |
| 50 | 0,025 | 0,04 | 0,18 | 0,60 | 1,5 |
| 63 | 0,040 | 0,063 | 0,20 | 0,63 | 1,6 |
| 80 | 0,063 | 0,10 | 0,22 | 0,67 | 1,7 |
| 100 | 0,10 | 0,16 | 0,25 | 0,71 | 1,8 |
| 125 | 0,16 | 0,25 | 0,28 | 0,75 | 1,9 |
| 160 | 0,25 | 0,40 | 0,32 | 0,80 | 2,0 |
| 200 | 0,40 | 0,63 | 0,42 | 1,00 | 2,5 |
| 250 | 0,56 | 1,0 | 0,56 | 1,25 | 3,2 |
| 320 | 0,75 | 1,6 | 0,75 | 1,60 | 4,0 |
| 400 | 1,0 | 2,0 | 1,0 | 2,0 | 5,0 |
| 500 | 1,3 | 2,5 | 1,3 | 2,5 | 6,3 |
| 630 | 1,8 | 3,2 | 1,8 | 3,2 | 8,0 |
| 800 | 2,4 | 4,0 | 2,4 | 4,0 | 10,0 |
| 1 000 | 3,2 | 5,0 | 3,2 | 5,0 | 12,5 |
| 1 250 | 4,2 | 6,3 | 4,2 | 6,3 | 16 |
| 1 600 | 5,6 | 8,0 | 5,6 | 8,0 | 20 |
| 2 000 | 7,5 | 10,0 | 7,5 | 10,0 | 25 |
| 2 500 | 10,0 | 12,5 | 10,0 | 12,5 | 32 |
| 3 200 | 12,5 | 16 | 12,5 | 16 | 40 |
| 4 000 | 16 | 20 | 16 | 20 | 50 |
| 5 000 | 20 | 25 | 20 | 25 | 63 |
| 6 300 | 25 | 32 | 25 | 32 | 80 |
| 8 000 | 32 | 40 | 32 | 40 | 100 |
| 10 000 | 40 | 50 | 40 | 50 | 125 |
| 12 500 | 50 | 63 | 50 | 63 | 156 |
| 16 000 | 63 | 80 | 63 | 80 | 200 |
| 20 000 | 80 | 100 | 80 | 100 | 250 |
| 25 000 | 100 | 125 | 100 | 125 | 315 |
| 32 000 | 125 | 160 | 125 | 160 | 400 |
| 40 000 | 160 | 200 | 160 | 200 | 500 |
| 50 000 | 200 | 250 | 200 | 250 | 625 |
| 63 000 | 250 | 320 | 250 | 320 | 790 |
| Linear interpolation is allowed. | | | | | |

### 7.5.4 Solid insulation for probe assemblies

#### 7.5.4.1 General

The term "solid insulation" is used to describe many different types of construction, including monolithic blocks of insulating material and insulation subsystems composed of multiple insulating materials, organized in layers or otherwise.

The electric strength of a thickness of solid insulation is considerably greater than that of the same thickness of air. The insulating distances through solid insulation are therefore typically smaller than the distances through air. As a result, electric fields in solid insulation are typically higher, and often are less homogeneous.

Solid insulation material may contain gaps or voids. When a solid insulation system is constructed from layers of solid materials, there are also likely to be gaps or voids between layers. These voids will perturb the electric field so that a disproportionately large part of the electric field is located in the void, potentially causing ionization within the void, resulting in partial discharge. These partial discharges will influence the adjacent solid insulation and may reduce its service life.

Solid insulation is not a renewable medium: damage is cumulative over the life of the equipment. Solid insulation is also subject to ageing and to degradation from repeated high voltage testing.

*Conformity is checked as specified in 7.5.4.2 and 7.5.4.3.*

#### 7.5.4.2 Solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES

##### 7.5.4.2.1 General

Solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES shall withstand the electrical and mechanical stresses that may occur in NORMAL USE and in all RATED environmental conditions (see 4.4) during the intended life of the probe assembly.

~~The manufacturer should take the expected life of the probe assembly into account when selecting insulating materials.~~

*Conformity is checked by both of the following tests:*

a) *~~the a.c. voltage test of 6.6.5.1 with a duration of at least 5 s using the applicable test voltage of Table 4 or the impulse voltage test of 6.6.5.3 using the applicable test voltage of Table 14;~~*

   *the impulse voltage test of 7.6.5.3 using the applicable test voltage of Table 8 or as an alternative* **30***, the AC voltage test of 7.6.5.1 using the applicable test voltage of Table 9 with a duration of at least 5 s;*

b) *~~the a.c. voltage test of 6.6.5.1 or if stressed only by d.c., the d.c. voltage test of 6.6.5.2, with a duration of at least 1 min using the test voltage determined by 6.5.2.5.1.2.~~*

   *for probe assemblies stressed by AC or AC plus DC, the AC voltage test of 7.6.5.1, or for probe assemblies stressed only by pure DC, the DC voltage test of 7.6.5.2 using the test voltage determined by 7.5.4.2.2 with a duration of at least 1 min.*

*NOTE Test a) checks the effects of transient overvoltages, while test b) checks the effects of long-term stress of solid insulation.*

### Table 8 – Impulse test voltages for testing electric strength of solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES 31

| Nominal AC RMS line-to-neutral or DC voltage of mains being measured<br>V | Impulse test voltage<br>V peak | | | | | |
|---|---|---|---|---|---|---|
| | BASIC INSULATION and SUPPLEMENTARY INSULATION | | | REINFORCED INSULATION | | |
| | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV |
| ≤ 50 | 500 | 800 | 1 500 | 800 | 1 280 | 2 400 |
| > 50 ≤ 100 | 800 | 1 500 | 2 500 | 1 280 | 2 400 | 4 000 |
| > 100 ≤ 150 | 1 500 | 2 500 | 4 000 | 2 400 | 4 000 | 6 400 |
| > 150 ≤ 300 | 2 500 | 4 000 | 6 000 | 4 000 | 6 400 | 9 600 |
| > 300 ≤ 600 | 4 000 | 6 000 | 8 000 | 6 400 | 9 600 | 12 800 |
| > 600 ≤ 1 000 | 6 000 | 8 000 | 12 000 | 9 600 | 12 800 | 19 200 |
| > 1 000 ≤ 1 500 | 8 000 | 10 000 | 15 000 | 13 500 | 17 900 | 27 100 |
| > 1 500 ≤ 2 000 | 12 000 | 15 000 | 18 000 | 21 400 | 27 100 | 32 000 |
| > 2 000 ≤ 3 000 | 15 000 | 18 000 | 20 000 | 27 100 | 32 000 | 36 000 |

### Table 9 – AC test voltages for testing electric strength of solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES

| Nominal AC RMS line-to-neutral or DC voltage of mains being measured<br>V | AC test voltage<br>V ~~r.m.s~~ | | | | | |
|---|---|---|---|---|---|---|
| | BASIC INSULATION and SUPPLEMENTARY INSULATION | | | REINFORCED INSULATION | | |
| | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV |
| ≤ 50 | 370 | 500 | 840 | 500 | 720 | 1 300 |
| > 50 ≤ 100 | 500 | 840 | 1 400 | 720 | 1 300 | 2 200 |
| > 100 ≤ 150 | 840 | 1 400 | 2 200 | 1 300 | 2 200 | 3 500 |
| > 150 ≤ 300 | 1 400 | 2 200 | 3 300 | 2 200 | 3 500 | 5 100 |
| > 300 ≤ 600 | 2 200 | 3 300 | 4 300 | 3 500 | 5 100 | 7 000 |
| > 600 ≤ 1 000 | 3 300 | 4 300 | 6 600 | 5 100 | 7 000 | 10 000 |
| > 1 000 ≤ 1 500 | 4 300 | 5 400 | 8 200 | 7 400 | 9 700 | 15 000 |
| > 1 500 ≤ 2 000 | 6 600 | 8 200 | 9 700 | 12 000 | 15 000 | 18 000 |
| > 2 000 ≤ 3 000 | 8 200 | 9 700 | 11 000 | 15 000 | 18 000 | 20 000 |

#### 7.5.4.2.2 Long term stress test voltage value calculation

Test voltage values for testing long term stress of solid insulation are determined as follows:

The test voltage value for BASIC INSULATION and SUPPLEMENTARY INSULATION is calculated with the following formula:

$$U_T = A \times U_N + B$$

where

$U_T$ is the AC or DC test voltage;

$U_N$ is the nominal AC RMS line-to-neutral or DC voltage of mains being measured;

$A$ and $B$ are parameters determined as follows:

when $U_N \leq 1\,000$ V  $A = 1$  and $B = 1\,200$ V;

when $U_N > 1\,000$ V  $A = 1{,}5$  and $B = 750$ V.

~~The a.c. test voltage is equal to $U_T$ and the d.c. test voltage is equal to 1,414 × $U_T$.~~

NOTE Parameter values up to 1 000 V are derived from 442.2.2 of IEC 60364-4-44:2007 and parameter values over 1 000 V are derived from 6.1.3.1 of IEC TS 62993:2017.

For REINFORCED INSULATION, the test voltage value is twice the value for BASIC INSULATION.

### 7.5.4.2.3 Constructional requirements

#### 7.5.4.2.3.1 General

Solid insulation shall also meet the following requirements, as applicable:

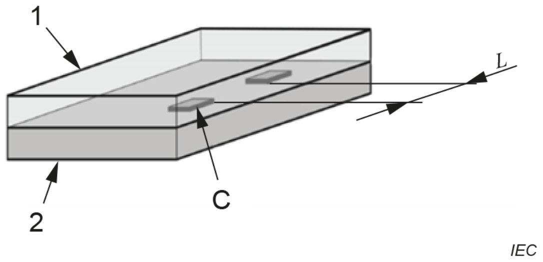
1) for solid insulation used as an ENCLOSURE or PROTECTIVE FINGERGUARD, the requirements of Clause 9;
2) for moulded and potted parts, the requirements of 7.5.4.2.3.2;
3) for insulating layers of printed wiring boards, the requirements of 7.5.4.2.3.3;
4) for thin-film insulation, the requirements of 7.5.4.2.3.4.

*Conformity is checked as specified in 7.5.4.2.3.2 to 7.5.4.2.3.4, and in Clause 9, as applicable.*

#### 7.5.4.2.3.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, conductors located between the same two layers moulded together (see Figure 18, item *L*) shall be separated by at least the applicable minimum distance of Table 10 after the moulding is completed.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*



**Key**

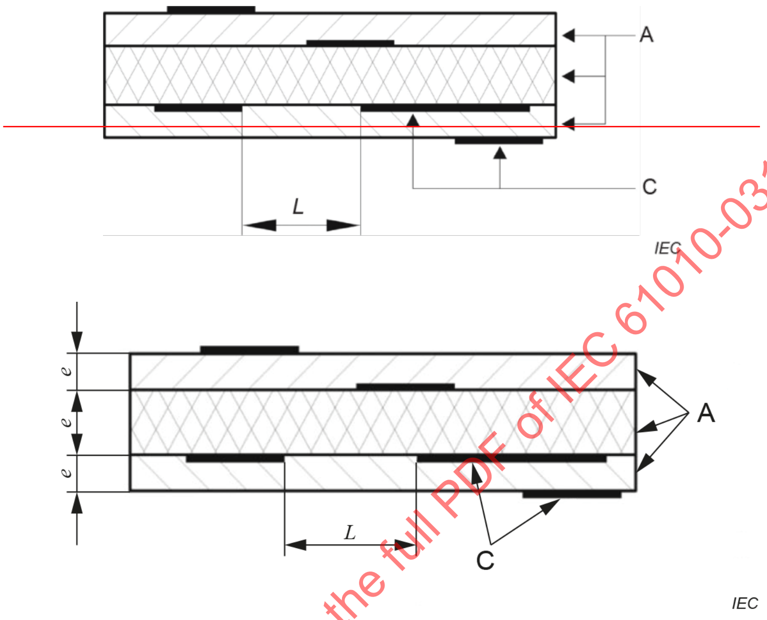
| | |
|---|---|
| 1 | layer 1 |
| 2 | layer 2 |
| C | conductor |
| *L* | distance between conductors |

**Figure 18 – Distance between conductors on an interface between two layers**

#### 7.5.4.2.3.3 Insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure 19, item *L*) shall be separated by at least the applicable minimum distance of Table 10.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*



**Key**

*L* distance between conductors on the same surface

*e* thickness

A layers

C conductors

**Figure 19 – Distance between adjacent conductors along an interface of two layers**

**Table 10 – Minimum values for distance or thickness of solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES**

| ~~WORKING~~ Nominal AC RMS line-to-neutral or DC voltage 32<br>V | Minimum thickness *e* [b]<br>mm | Minimum distance *L* (see Figure 18 and Figure 19) [a]<br>mm |
|---|---|---|
| ≤ 300 | 0,4 | 0,4 |
| > 300 ≤ 600 | 0,6 | 0,6 |
| > 600 ≤ 1 000 ~~b~~ | 1,0 | 1,0 |

[a] These values apply for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION.

[b] For voltages above 1 000 V, a partial discharge test should be used (see IEC 60664-1:2020, 6.4.6 for the test procedure ~~under consideration~~). 33

REINFORCED INSULATION of insulating layers of printed wiring boards (see Figure 19, item A) shall also have adequate electric strength through the respective layers. One of the following methods shall be used.

a) The thickness of the insulation is at least the value set out in Table 10.

   *Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*

b) The insulation is assembled from at least two separate layers of printed wiring board materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the ~~value of the applicable test voltage of Table 4 or Table 14 for BASIC INSULATION~~ applicable values for BASIC INSULATION of the test voltages and durations of 7.5.4.2.1.

   *Conformity is checked by inspection of the manufacturer's specifications.*

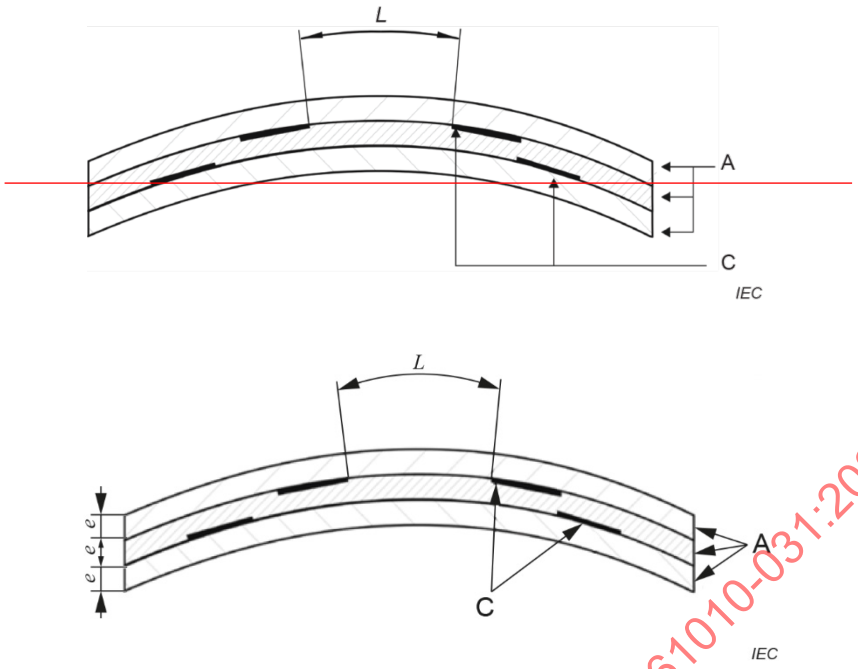
c) The insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength of at least the ~~value of the applicable test voltage of Table 4 or Table 14 for REINFORCED INSULATION~~ applicable values for REINFORCED INSULATION of the test voltages and durations of 7.5.4.2.1.

   *Conformity is checked by inspection of the manufacturer's specifications.*

#### 7.5.4.2.3.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, conductors located between the same two layers (see Figure 20, item *L*) shall be separated by at least the applicable SPACINGS of 7.5.2.2 and 7.5.3.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*



**Key**

| | |
|---|---|
| *L* | distance between adjacent conductors |
| *e* | thickness |
| A | layers of thin-film material such as tape and polyester film |
| C | conductors |

NOTE There ~~might~~ can be air present between the layers.

**Figure 20 – Distance between adjacent conductors located between the same two layers**

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used.

a) The thickness through the insulation is at least the value set out in Table 10.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*

b) The insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the ~~value of the applicable test voltage of Table 4 or Table 14 for BASIC INSULATION~~ applicable values for BASIC INSULATION of the test voltages and durations of 7.5.4.2.1.

*Conformity is checked by inspection of the manufacturer's specifications.*

c) The insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength.

*Conformity is checked by ~~the a.c. voltage test of 6.6.5.1 with a duration of at least 5 s applied to two of the three layers using the applicable test voltage of Table 4 for REINFORCED INSULATION~~ the voltage tests of 7.5.4.2.1 a) and b) applied to two of the three layers for REINFORCED INSULATION.*

*For the purposes of these tests, a special sample can be assembled with only two layers of the material.*

### 7.5.4.3 Solid insulation for probe assemblies which are not RATED for MEASUREMENT CATEGORIES

#### 7.5.4.3.1 General

Solid insulation for probe assemblies which are not RATED for MEASUREMENT CATEGORIES shall withstand the electrical and mechanical stresses that may occur in NORMAL USE and in all RATED environmental conditions (see 4.4) during the intended life of the probe assembly.

~~The manufacturer should take the expected life of the probe assembly into account when selecting insulating materials.~~

*Conformity is checked by both of the following tests:*

a) ~~*by the a.c. voltage test of 6.6.5.1 with a duration of at least 5 s or The impulse voltage test of 6.6.5.3 using the test voltage determined by the following procedure:*~~

  ~~*i) a theoretically required CLEARANCE for BASIC INSULATION or SUPPLEMENTARY INSULATION is calculated according to 6.5.2.3.*~~

  ~~*Minimum CLEARANCES for POLLUTION DEGREES 2 and 3 do not apply;*~~

  ~~*ii) for REINFORCED INSULATION, CLEARANCE is twice the value for BASIC INSULATION;*~~

  ~~*iii) the applicable test voltage is from Table 10 for the calculated required CLEARANCE;*~~

  *The impulse voltage test of 7.6.5.3 using the applicable test voltage of Table 11, or as an alternative, the AC voltage test of 7.6.5.1 using the applicable test voltage of Table 11 with a duration of at least 5 s.*

  *The required CLEARANCE for Table 11 is determined by the following procedure:*

  *1) the theoretically required CLEARANCE for BASIC INSULATION or SUPPLEMENTARY INSULATION is calculated according to 7.5.2.3;*

  *2) for REINFORCED INSULATION, CLEARANCE is twice the value for BASIC INSULATION.*

  *The minimum CLEARANCE for POLLUTION DEGREES 2 and 3 do not apply.*

b) ~~*by the a.c. voltage test of 6.6.5.1 or if stressed only by d.c., the d.c. voltage test of 6.6.5.2, with a duration of at least 1 min using the test voltage determined as follows:*~~

  ~~*i) for BASIC INSULATION and SUPPLEMENTARY INSULATION, the test voltage is 1,5 times the WORKING VOLTAGE;*~~

  ~~*ii) for REINFORCED INSULATION, the test voltage is twice the value for BASIC INSULATION.*~~

  *For probe assemblies stressed by AC or AC plus DC, the AC voltage test of 7.6.5.1 or for probe assemblies stressed only by pure DC, the DC voltage test of 7.6.5.2, using the test voltage determined as follows with a duration of at least 1 min:*

  *1) for BASIC INSULATION and SUPPLEMENTARY INSULATION, the test voltage is 1,5 times the WORKING VOLTAGE;*

  *2) for REINFORCED INSULATION, the test voltage is twice the value for BASIC INSULATION.*

*NOTE Test a) checks the effects of transient overvoltages, while test b) checks the effects of long-term stress of solid insulation.*

#### 7.5.4.3.2 Constructional requirements

Solid insulation shall also meet the following requirements, as applicable:

1) for solid insulation used as an ENCLOSURE or PROTECTIVE FINGERGUARD, the requirements of Clause 9;
2) for moulded and potted parts, the requirements of 7.5.4.2.3.2;
3) for insulating layers of printed wiring boards, the requirements of 7.5.4.2.3.3, except that the applicable test voltages are determined using the procedure of 7.5.4.3.1 a) and b);

4) for thin-film insulation, the requirements 7.5.4.2.3.4, except that the applicable SPACINGS are as set out in 7.5.2.3 and 7.5.3, and the applicable test voltages are determined using the procedure of 7.5.4.3.1 a) and b).

*Conformity is checked as specified in 7.5.4.2.3.2 to 7.5.4.2.3.4 with the test voltages of 7.5.4.3.1 a) and b), and Clause 9 as applicable.*

## 7.6 Procedure for voltage tests

### 7.6.1 General

*The following test procedures apply ~~to TYPE testing~~ when carrying out TYPE TESTS, and deterioration of the test specimen may occur. It is possible that further use of the test specimen ~~may~~ will not be appropriate.*

*Test equipment for the voltage tests is specified in ~~IEC 61180-1 and IEC 61180-2~~ IEC 61180:2016.*

*The reference point for the voltage tests is one or more of the following items a) to d), bonded together if more than one.*

a) *Any ACCESSIBLE conductive part, except for any live parts permitted to be ACCESSIBLE because they do not exceed the values of 7.3.2 and any ACCESSIBLE conductive parts which are allowed to be HAZARDOUS LIVE by the exceptions given in 7.1 a) to 7.1 c).*

b) *Any ACCESSIBLE insulating part of the ENCLOSURE, covered with metal foil everywhere except around CONNECTORS. For test voltages up to 10 kV AC peak or 10 kV DC, the distance from foil to CONNECTOR is not more than 20 mm. For higher voltages, the distance is the minimum to prevent flashover.*

c) *ACCESSIBLE parts of controls with parts made of insulating material being wrapped in metal foil or having soft conductive material pressed against them.*

d) *For testing CONNECTORS in unmated position, the test finger is applied to the external parts of the CONNECTOR in the least favourable position with the closest approach (see Figure 7 d)).* **34**

### 7.6.2 Humidity preconditioning

*To ensure that the probe assembly does not become hazardous in the humidity conditions of 4.4, it is subjected to humidity preconditioning before the voltage tests of solid insulation. There is no humidity preconditioning before the voltage tests of CLEARANCES* **35***. The probe assembly is not operated during preconditioning.*

*If wrapping in foil is required by 7.6.1, the foil is applied after humidity preconditioning and recovery.*

*Electrical components, covers, and other parts which can be removed by hand are removed and subjected to the humidity preconditioning together with the main part.*

*Preconditioning is carried out in a humidity chamber containing air with a humidity of 93 % RH ± 3 % RH. The temperature of the air in the chamber is maintained at 40 °C ± 2 °C.*

*Before applying humidity, the probe assembly is brought to a temperature of 42 °C ± 2 °C, normally by keeping it at this temperature for at least 4 h before the humidity preconditioning.*

*The air in the chamber is stirred and the chamber is designed so that condensation will not precipitate on the probe assembly.*

*The probe assembly remains in the chamber for 48 h, after which it is removed and allowed a recovery period of 2 h under the environmental conditions of 5.3.1, after which parts removed (see third paragraph of this Subclause 7.6.2) are re-installed.*

### 7.6.3 Conduct of tests

*The tests are performed and completed within 1 h of the end of the recovery period after humidity preconditioning. The probe assembly is not operated during the tests.*

*Voltage tests are not made between two circuits, or between a circuit and an ACCESSIBLE conductive part, if they are connected to each other or not separated from each other.*

*PROTECTIVE IMPEDANCE in parallel with the insulation to be tested is disconnected.*

~~*If two or more protective means are used in combination (see 6.4), it is likely that the voltages specified for DOUBLE INSULATION and REINFORCED INSULATION would be applied to parts of circuits which are not required to withstand these voltages.*~~ *When testing REINFORCED INSULATION, the test voltages specified can be applied to parts of circuits where two or more protective means are used in combination (see 7.4) and which are not required to withstand these test voltages. To avoid this, such parts may be disconnected during the tests, or the parts of circuits where* ~~*DOUBLE INSULATION or*~~ *REINFORCED INSULATION is required may be tested separately.* **36**

### 7.6.4 Test voltages

*Voltage tests for solid insulation are applied using the values specified in 7.5.4.2 and 7.5.4.3.*

~~*The CLEARANCE in case of homogeneous construction (see 6.5.1.2.2), is tested with an a.c., d.c., or peak impulse voltage with the peak value specified in Table 10 for the value of CLEARANCE specified for inhomogeneous construction.*~~

*Voltage tests for CLEARANCES* **37** *are applied using the test voltage values of Table 11. The values of Table 11 are for test sites located at 2 000 m altitude. For other test site altitudes, the correction factors of Table 12 are applied to the values of Table 11 when testing CLEARANCES but not when testing solid insulation.*

*NOTE The electric testing of CLEARANCES will also stress the associated solid insulation.*

## Table 11 – Test voltages based on CLEARANCES

| Required CLEARANCE<br>mm | Impulse 1,2/50 µs<br>V peak | AC RMS 50/60 Hz<br>V | AC peak 50/60 Hz or DC<br>V | Required CLEARANCE<br>mm | Impulse 1,2/50 µs<br>V peak | AC RMS 50/60 Hz<br>V | AC peak 50/60 Hz or DC<br>V |
|---|---|---|---|---|---|---|---|
| 0,010 | 330 | 230 | 330 | 16,5 | 14 000 | 7 600 | 10 700 |
| 0,025 | 440 | 310 | 440 | 17,0 | 14 300 | 7 800 | 11 000 |
| 0,040 | 520 | 370 | 520 | 17,5 | 14 700 | 8 000 | 11 300 |
| 0,063 | 600 | 420 | 600 | 18,0 | 15 000 | 8 200 | 11 600 |
| 0,1 | 806 | 500 | 700 | 19 | 15 800 | 8 600 | 12 100 |
| 0,2 | 1 140 | 620 | 880 | 20 | 16 400 | 9 000 | 12 700 |
| 0,3 | 1 310 | 710 | 1 010 | 25 | 19 900 | 10 800 | 15 300 |
| 0,5 | 1 550 | 840 | 1 200 | 30 | 23 300 | 12 600 | 17 900 |
| 1,0 | 1 950 | 1 060 | 1 500 | 35 | 26 500 | 14 400 | 20 400 |
| 1,4 | 2 440 | 1 330 | 1 880 | 40 | 29 700 | 16 200 | 22 900 |
| 2,0 | 3 100 | 1 690 | 2 400 | 45 | 32 900 | 17 900 | 25 300 |
| 2,5 | 3 600 | 1 960 | 2 770 | 50 | 36 000 | 19 600 | 27 700 |
| 3,0 | 4 070 | 2 210 | 3 130 | 55 | 39 000 | 21 200 | 30 000 |
| 3,5 | 4 510 | 2 450 | 3 470 | 60 | 42 000 | 22 900 | 32 300 |
| 4,0 | 4 930 | 2 680 | 3 790 | 65 | 45 000 | 24 500 | 34 600 |
| 4,5 | 5 330 | 2 900 | 4 100 | 70 | 47 900 | 26 100 | 36 900 |
| 5,0 | 5 720 | 3 110 | 4 400 | 75 | 50 900 | 27 700 | 39 100 |
| 5,5 | 6 100 | 3 320 | 4 690 | 80 | 53 700 | 29 200 | 41 300 |
| 6,0 | 6 500 | 3 520 | 4 970 | 85 | 56 610 | 30 800 | 43 500 |
| 6,5 | 6 800 | 3 710 | 5 250 | 90 | 59 400 | 32 300 | 45 700 |
| 7,0 | 7 200 | 3 900 | 5 510 | 95 | 62 200 | 33 800 | 47 900 |
| 7,5 | 7 500 | 4 080 | 5 780 | 100 | 65 000 | 35 400 | 50 000 |
| 8,0 | 7 800 | 4 300 | 6 030 | 110 | 70 500 | 38 400 | 54 200 |
| 8,5 | 8 200 | 4 400 | 6 300 | 120 | 76 000 | 41 300 | 58 400 |
| 9,0 | 8 500 | 4 600 | 6 500 | 130 | 81 300 | 44 200 | 62 600 |
| 9,5 | 8 800 | 4 800 | 6 800 | 140 | 86 600 | 47 100 | 66 700 |
| 10,0 | 9 100 | 4 950 | 7 000 | 150 | 91 900 | 50 000 | 70 700 |
| 10,5 | 9 500 | 5 200 | 7 300 | 160 | 97 100 | 52 800 | 74 700 |
| 11,0 | 9 900 | 5 400 | 7 600 | 170 | 102 300 | 55 600 | 78 700 |
| 11,5 | 10 300 | 5 600 | 7 900 | 180 | 107 400 | 58 400 | 82 600 |
| 12,0 | 10 600 | 5 800 | 8 200 | 190 | 112 500 | 61 200 | 86 500 |
| 12,5 | 11 000 | 6 000 | 8 500 | 200 | 117 500 | 63 900 | 90 400 |
| 13,0 | 11 400 | 6 200 | 8 800 | 210 | 122 500 | 66 600 | 94 200 |
| 13,5 | 11 800 | 6 400 | 9 000 | 220 | 127 500 | 69 300 | 98 000 |
| 14,0 | 12 100 | 6 600 | 9 300 | 230 | 132 500 | 72 000 | 102 000 |
| 14,5 | 12 500 | 6 800 | 9 600 | 240 | 137 300 | 74 700 | 106 000 |
| 15,0 | 12 900 | 7 000 | 9 900 | 250 | 142 200 | 77 300 | 109 400 |
| 15,5 | 13 200 | 7 200 | 10 200 | 264 | 149 000 | 81 100 | 115 000 |
| 16,0 | 13 600 | 7 400 | 10 500 | | | | |

Linear interpolation is allowed.

**Table 12 – Correction factors according to test site altitude for test voltages for CLEARANCES**

| | Correction factor | | | |
|---|---|---|---|---|
| **Test voltage** peak | **≥ 327 V < 600 V** | **≥ 600 V < 3 500 V** | **≥ 3 500 V < 25 kV** | **≥ 25 kV** |
| **Test voltage** RMS | **≥ 231 V < 424 V** | **≥ 424 V < 2 475 V** | **≥ 2 475 V < 17,7 kV** | **≥ 17,7 kV** |
| **Test site altitude** m | | | | |
| 0 | 1,08 | 1,16 | 1,22 | 1,24 |
| 500 | 1,06 | 1,12 | 1,16 | 1,17 |
| 1 000 | 1,04 | 1,08 | 1,11 | 1,12 |
| 2 000 | 1,00 | 1,00 | 1,00 | 1,00 |
| 3 000 | 0,96 | 0,92 | 0,89 | 0,88 |
| 4 000 | 0,92 | 0,85 | 0,80 | 0,79 |
| 5 000 | 0,88 | 0,78 | 0,71 | 0,70 |
| Linear interpolation is allowed. | | | | |

### 7.6.5 Test procedures

#### 7.6.5.1 The AC voltage test

*The voltage ~~test equipment~~ tester shall have a regulated output capable of maintaining the test voltage throughout the test within ±3 % of the specified value. The waveform of the power frequency test voltage shall be substantially sinusoidal. This requirement is fulfilled if the ratio between the peak value and the RMS value is √2 ± 3 %.*

*The test voltage is raised uniformly from 0 V to the specified value within 5 s and held at that value for at least the specified time.*

*No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test.*

#### 7.6.5.2 The ~~1 min~~ DC voltage test

*The voltage ~~test equipment~~ tester shall have a regulated output capable of maintaining the test voltage throughout the test within ±3 % of the specified value. The DC test voltage shall be substantially free of ripple. This requirement is fulfilled if the ratio between the peak value of the voltage and the average value is 1,0 ± 3 %.*

*The DC test voltage is raised uniformly from 0 V to the specified value within 5 s and held at that value for at least ~~1 min~~ the specified time.*

*No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test.*

#### 7.6.5.3 The impulse voltage test

*The test shall be conducted for five impulses of each polarity with an interval of at least 1 s between impulses. The impulse voltage test is carried out with a 1,2/50 µs waveform (see ~~IEC 61180-1:1992~~ IEC 61180:2016, Figure 1). The wave shape of each impulse shall be observed.*

*When verifying CLEARANCES within the probe assembly by an impulse voltage test, it is necessary to ensure that the specified impulse voltage appears at the CLEARANCE.*

*No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test, but partial discharges are allowed.*

## 7.7 Constructional requirements for protection against electric shock

### 7.7.1 General

If a failure could cause a HAZARD,

a) the security of wiring connections subject to mechanical stresses shall not depend on soldering;

b) screws securing removable covers shall be captive if their length determines a SPACING between ACCESSIBLE conductive parts and HAZARDOUS LIVE parts;

c) accidental loosening or freeing of the wiring, screws, etc., shall not cause ACCESSIBLE parts to become HAZARDOUS LIVE.

NOTE Screws or nuts with lock washers are not regarded as likely to become loose, nor are wires which are mechanically secured by more than soldering alone.

*Conformity is checked by inspection and by measurement of SPACINGS.*

### 7.7.2 Insulating materials

The following shall not be used as insulation for safety purposes:

a) materials which can easily be damaged (for example, lacquer, enamel, oxides, anodic films);

b) non-impregnated hygroscopic materials (for example, paper, fibres, fibrous materials).

*Conformity is checked by inspection.*

### 7.7.3 ENCLOSURES of probe assemblies with DOUBLE INSULATION or REINFORCED INSULATION

A probe assembly which relies on DOUBLE INSULATION or REINFORCED INSULATION throughout for protection against electric shock shall have an ENCLOSURE which surrounds all metal parts. This requirement does not apply to small metal parts such as nameplates, screws or rivets, if they are separated from parts which are HAZARDOUS LIVE by REINFORCED INSULATION or its equivalent.

ENCLOSURES or parts of ENCLOSURES made of insulating material shall meet the requirements for DOUBLE INSULATION or REINFORCED INSULATION.

Protection for ENCLOSURES or parts of ENCLOSURES made of metal shall be provided by one of the means from a) or b), except for parts where PROTECTIVE IMPEDANCE is used:

a) an insulating coating or a barrier on the inside of the ENCLOSURE which shall surround all metal parts and all places where loosening of a part which is HAZARDOUS LIVE ~~might~~ can cause it to touch a metal part of the ENCLOSURE;

b) SPACINGS between the ENCLOSURE and parts which are HAZARDOUS LIVE that cannot be reduced below the values specified in 7.5 by loosening of parts or wires.

*Conformity is checked by inspection and measurement and as specified in 7.5.*

### 7.7.4 PROBE WIRE attachment

#### 7.7.4.1 General

The attachment of the PROBE WIRE to the probe body and to the equipment (or to the CONNECTORS if the attachment is not fixed) shall withstand forces likely to be encountered in NORMAL USE without damage which could cause a HAZARD. Solder alone, without mechanical gripping, shall not be used for strain relief. The insulation of the PROBE WIRE shall be mechanically secured to avoid retraction.

*Conformity is checked by inspection and by applying the tests of 7.7.4.2 to 7.7.4.4. After the tests,*

a) *the insulation of the PROBE WIRE shall not have been cut or torn, and shall not have moved more than 2 mm in the bushing;*

b) *SPACINGS shall not have been reduced below the applicable values of 7.5.2 and 7.5.3;*

c) *the PROBE WIRE shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b);*

d) *no more than 75 % of the copper strands of the PROBE WIRE shall be broken.*

NOTE For test purposes, it ~~could~~ can be useful to prepare a special sample of the probe, manufactured in all respects like the probe being investigated but in which no solder has been applied.

#### 7.7.4.2 Pull test

*With the probe body or equipment or CONNECTOR clamped so that it cannot move and any soldered connection is severed, the PROBE WIRE is subjected for 1 min to a steady axial pull at the values shown in a) or b) below:*

a) *for probe bodies and for locking CONNECTORS, twice the pull force value from Table 13;*

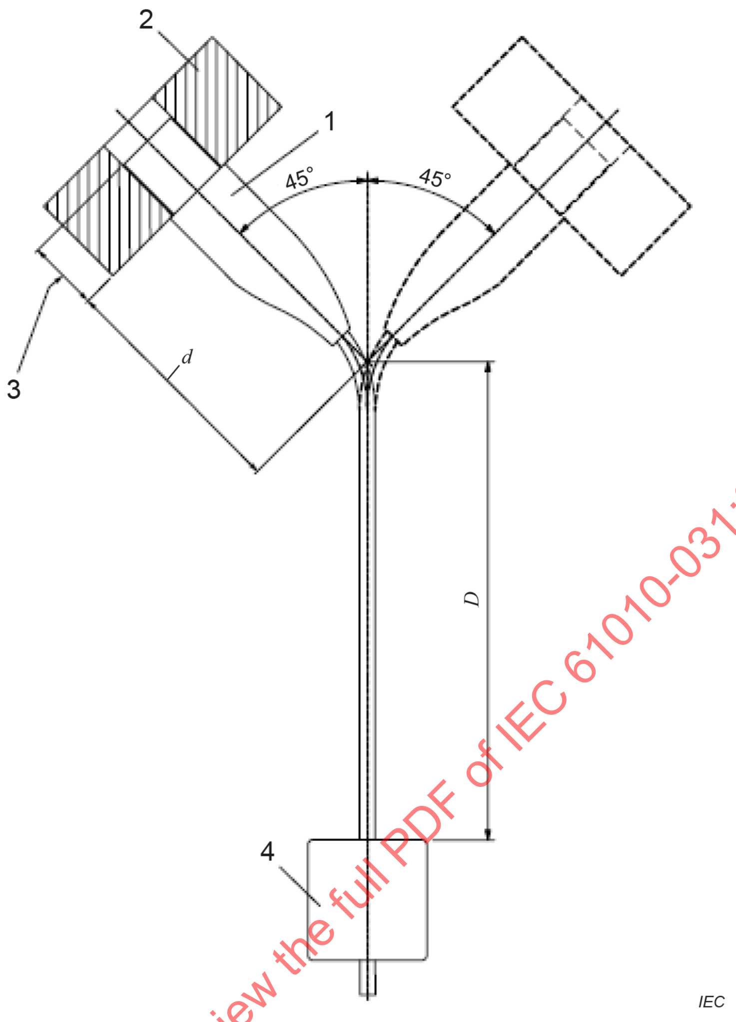
b) *for non-locking CONNECTORS, twice the pull force value from Table 13 or four times the axial pull force required to disconnect the CONNECTOR, whichever is less.*

#### 7.7.4.3 Flexing~~/pull~~ test

*CONNECTORS shall be subjected to a flexing test in an apparatus similar to that shown in Figure 21.*

*The CONNECTOR is fixed to the oscillating member of the apparatus so that, when this is at the midpoint of its travel, the axis of the flexible PROBE WIRE, where it enters the CONNECTOR, is vertical and passes through the axis of oscillation.*

*The oscillating member is, by variation of distance d shown in Figure 21, so positioned that the flexible PROBE WIRE makes a minimum lateral movement when the oscillating member of the test apparatus is moved over its full travel.*



**Key**

| | |
|---|---|
| *D* | > 300 mm |
| 1 | CONNECTOR |
| 2 | part of oscillating member for fixing the CONNECTOR |
| 3 | depth specified for the shroud of corresponding equipment TERMINAL |
| 4 | weight |

**Figure 21 – Flexing test**

*The PROBE WIRE is loaded with a weight such that the force from Table 13 is applied.*

*The oscillating member is moved to each side of vertical through a total angle of 90° (45° on each side of vertical). The total number of flexings is 5 000. The rate of flexing is 60 per minute. A complete cycle is two flexings.*

*CONNECTORS with PROBE WIRE of nominally circular cross-sectional area are rotated approximately 90° around the vertical axis within the oscillating member after 2 500 flexings; CONNECTORS with flat flexible PROBE WIRE are not so rotated, and are only flexed in a direction perpendicular to the thinner dimension of the cross-section.*

*If a HAZARD can result from the breaking of a conductor or a short-circuit between conductors, a current equal to the RATED current of the probe assembly is passed through each conductor, the voltage between them being the RATED voltage. During the test, there shall be no interruption of the test current and no short-circuit between the conductors.*

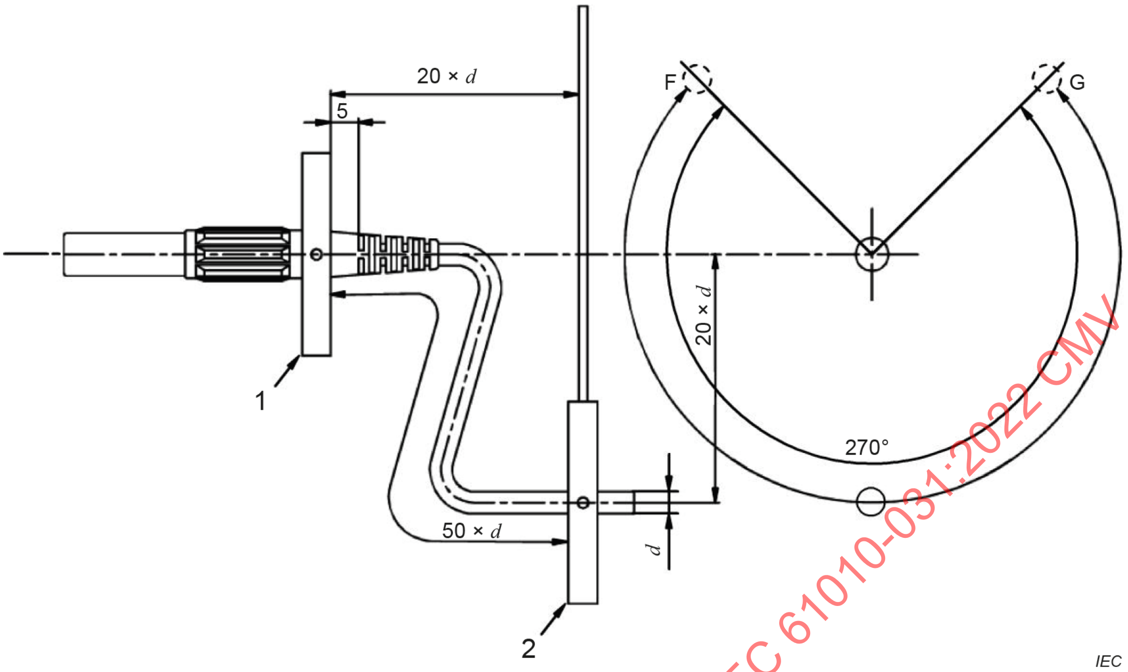
**Table 13 – Pull forces for PROBE WIRE attachment tests**

| Cross sectional area of the conductor *(a)*<br>mm$^2$ | Pull force<br>N |
|---|---|
| 0,25 | 2,5 |
| 0,50 | 5 |
| 1,0 | 10 |
| 2,5 | 18 |
| 4 | 25 |
| 6 | 30 |
| 10 | 40 |
| 16 | 45 |
| Linear interpolation is allowed.<br>For PROBE WIRES with multiple conductors, the cross-sectional area (*a*) is calculated as the sum of the cross-sectional areas of the individual conductors.<br>For the purpose of this calculation, the cross-sectional area of any shield is ignored. | |

### 7.7.4.4 Rotational flexing test

*The probe assembly is mounted in the test fixture as shown in Figure 22, so that the fixed clamp holds the probe body, CONNECTOR, or equipment with at least 5 mm of the solid portion protruding through the clamp. The rotating clamp is attached to the PROBE ~~lead~~ WIRE at a point 50 times the diameter of the PROBE WIRE, measured along the surface of the ~~lead~~ PROBE WIRE from the fixed clamp. The rotating clamp rotates in a plane at a distance equal to 20 times the diameter of the PROBE WIRE from the fixed clamp. The rotating clamp is rotated from point F to point G and back to point F (one complete oscillation) at a rate of 20 oscillations per minute for a total of 250 swings. The probe body or CONNECTOR is turned 90° about its axis and the test continued for a further 250 oscillations.*

Dimensions in millimetres



**Key**

| | |
|---|---|
| *d* | diameter of PROBE WIRE |
| F | start point, end point |
| G | middle point (F + 270°) |
| 1 | fixed clamp |
| 2 | rotating clamp |

**Figure 22 – Rotational flexing test**

# 8 Protection against mechanical HAZARDS

Handling of a probe assembly or an accessory during NORMAL USE shall not lead to a HAZARD.

Easily touched edges, projections, etc. should be smooth and rounded so as not to cause injury. This does not apply to PROBE TIPS.

*Conformity is checked by inspection.*

# 9 Resistance to mechanical stresses

## 9.1 General

Probe assemblies shall not cause a HAZARD when subjected to mechanical stresses likely to occur in NORMAL USE. To achieve this requirement, probe assemblies shall have adequate mechanical strength, components shall be reliably secured and electrical connections shall be secure.

*Conformity is checked by performing the tests of 9.2 to 9.4. The probe assembly is not operated during the tests.*

*After completion of the tests, the probe assembly shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) without humidity preconditioning and is inspected to check that:*

a) *parts which are* HAZARDOUS LIVE *have not become* ACCESSIBLE*;*

b) ENCLOSURES *show no cracks which could cause a* HAZARD*;*

c) SPACINGS *are not less than their permitted values and the insulation of internal wiring remains undamaged;*

d) PROTECTIVE FINGERGUARDS *have not been damaged or loosened.*

~~e) there has been no damage which could cause spread of fire.~~

*Damage to the finish, small dents which do not reduce* SPACINGS *below the applicable values of 7.5.2 and 7.5.3, and small chips which do not adversely affect the protection against electric shock or moisture, are ignored.*

## 9.2 Rigidity test

*If the probe assembly produces an appreciable amount of heat, the probe assembly is operated under the reference test conditions of 5.3, except that the ambient temperature is 40 °C or the maximum* RATED *ambient temperature if higher. The temperature of parts of the* ENCLOSURE *is measured during this treatment.*

*The probe assembly, not energized, is stored for 7 h at a temperature of 70 °C. However, if during the previous operative treatment, a higher temperature is measured, the storage temperature is to be 10 °C above that measured temperature. If the probe assembly contains components which can be damaged by this treatment, an empty* ENCLOSURE *may be treated, followed by assembly of the probe at the end of the treatment.*

~~The non-operative treatment of 10.2 is performed.~~ *Within 2 min of the end of the non-operative treatment, the probe assembly is held firmly against a rigid support and subjected to a force of 20 N applied by the hemispherical end of a hard rod of 12 mm diameter. The rod is applied three times to any part of the probe assembly which is* ACCESSIBLE *when the probe assembly is ready for use, and which could cause a* HAZARD *if distorted.*

## 9.3 Drop test

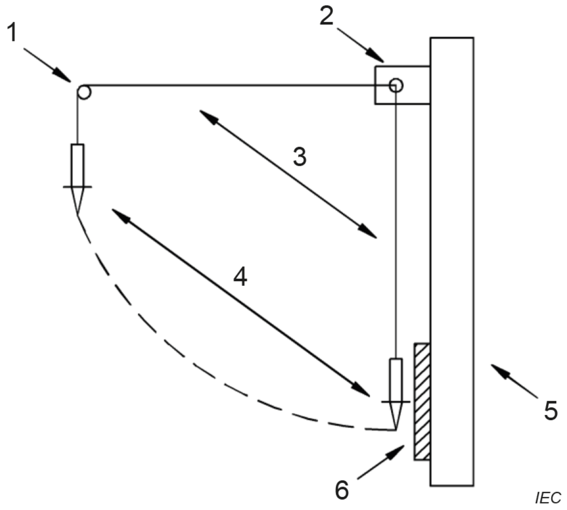
*Non-metallic* ENCLOSURES *of a probe assembly with a minimum* RATED *ambient temperature below 2 °C are cooled to the minimum* RATED *ambient temperature, then tested within 2 min.*

*Three samples of the probe assembly are each dropped three times through a ~~distance~~ height of 1 m onto a 50 mm thick hardwood board having a density of more than 700 kg/m*$^3$*, lying flat on a rigid base such as concrete. For each sample, the three tests are carried out so as to apply the impact to different points on the probe body.*

## 9.4 Impact swing test

*Non-metallic probe bodies with a minimum* RATED *ambient temperature below 2 °C are cooled to the minimum* RATED *ambient temperature, then tested within 2 min.*

*The probe body is subjected to one impact against a 50 mm thick hardwood board having a density of more than 700 kg/m*$^3$ *fixed to a solid wall, when swinging as a pendulum by its* PROBE WIRE *(see Figure 23). The height of the drop is 2 m, or the* PROBE WIRE *length if shorter.*



**Key**

| | |
|---|---|
| 1 | start point |
| 2 | suspension point |
| 3 | PROBE WIRE |
| 4 | probe body |
| 5 | wall |
| 6 | hardwood board |

**Figure 23 – Impact swing test**

## 10 Temperature limits ~~and protection against the spread of fire~~

### ~~9.1 General~~

~~Any heating shall not cause a HAZARD in NORMAL CONDITION or in SINGLE FAULT CONDITION, nor shall it cause spread of fire outside the probe assembly.~~

The temperature of easily touched surfaces shall not exceed the values of Table 14 in NORMAL CONDITION, and 105 °C in SINGLE FAULT CONDITION, at an ambient temperature of 40 °C.

Easily touched surfaces of probe assemblies RATED for a maximum ambient temperature above 40 °C are permitted to exceed the values of Table 14 in NORMAL CONDITION, and to exceed 105 °C in SINGLE FAULT CONDITION, by not more than the amount by which the maximum RATED temperature exceeds 40 °C.

If easily touched heated surfaces are necessary for functional reasons, they are permitted to exceed the values of Table 14, but shall be recognizable as such by appearance or function, or shall be marked with symbol 6 of Table 1 (see 6.2).

**Table 14 – Surface temperature limits in NORMAL CONDITION**

| Part | Limit<br>°C |
|---|---|
| Metal | 55 |
| Non-metallic materials | 70 |
| PROBE WIRES | 75 |

*Conformity is checked by inspection of the probe assembly under reference test conditions and in the position of NORMAL USE (see 5.3.2). Temperatures are measured when steady state has* *been attained. The maximum temperature of a part is determined by adding the measured temperature rise of the part to the maximum ambient temperature (40 °C or the maximum RATED ambient temperature if higher, see 4.4).*

~~If protection against fire depends on separation of circuits, they shall be separated at least by BASIC INSULATION.~~

~~The maximum temperature of a part is determined by measuring the temperature rise of the part under the conditions of 9.2 and adding it to the maximum ambient temperature (40 °C or the maximum RATED ambient temperature if higher, see 1.4).~~

~~*Conformity is checked by inspection, by the tests of 9.2 and by tests in the SINGLE FAULT CONDITIONS of 4.4. Alternatively, if protection is assured by separation of circuits, conformity is checked by measurement of SPACINGS, and by making the voltage tests of 6.6 (without humidity preconditioning) using the applicable test voltage of Table 10.*~~

### ~~9.2 Temperature tests~~

~~*A probe assembly is tested under reference test conditions and in the position of NORMAL USE (see 4.3.2). The tests of 6.7.4.2 to 6.7.4.4 are performed before performing these temperature tests. Temperatures are measured when steady state has been attained.*~~

## ~~10 Resistance to heat~~

### ~~10.1 Integrity of SPACINGS~~

~~SPACINGS shall meet the requirements of 6.5 when the probe assembly is operated at an ambient temperature of 40 °C or the maximum RATED ambient temperature if higher (see 1.4).~~

~~*Conformity in cases of doubt, if the probe assembly produces an appreciable amount of heat, is checked by operating the probe assembly under the reference test conditions of 4.3, except that the ambient temperature is 40 °C or the maximum RATED ambient temperature, if higher. After this test, SPACINGS shall not have been reduced below the requirements of 6.5.*~~

~~*If the ENCLOSURE is non-metallic, the temperature of parts of the ENCLOSURE is measured during the above test for the purpose of 10.2.*~~

### ~~10.2 Resistance to heat~~

~~ENCLOSURES of non-metallic material shall be resistant to elevated temperatures.~~

~~*Conformity is checked by the test of 8.2, applied after the following non-operative conditioning:*~~

~~*The probe assembly, not energized, is stored for 7 h at a temperature of 70 °C. However, if during the test of 10.1, a higher temperature is measured, the storage temperature is to be 10 °C above that measured temperature. If the probe assembly contains components which might be damaged by this treatment, an empty ENCLOSURE may be treated, followed by assembly of the probe at the end of the treatment.*~~

## 11 Protection against HAZARDS from fluids 38

### ~~11.1 General~~

~~Probe assemblies containing fluids, or to be used in measurements of processes on fluids, shall be designed to give protection to the OPERATOR and surrounding area against HAZARDS from fluids encountered in NORMAL USE.~~

~~NOTE Fluids likely to be encountered fall into three categories:~~

~~a) having continuous contact, for example, in vessels intended to contain them;~~
~~b) having occasional contact, for example, cleaning fluids;~~
~~c) having accidental (unexpected) contact. The manufacturer cannot safeguard against such cases.~~

~~*Conformity is checked by the treatment and tests of 11.2.*~~

### 11.1 Cleaning

If a cleaning or decontamination method is specified by the manufacturer, this shall not cause a direct safety HAZARD, an electric shock HAZARD, or a HAZARD resulting from corrosion or other weakening of structural parts associated with safety. The cleaning method and any decontamination method shall be described in the documentation (see 6.4.3).

*Conformity is checked by cleaning the probe assembly three times according to the manufacturer's instructions. If, immediately after this treatment, there are any signs of wetting of parts likely to cause a HAZARD, the probe assembly shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) (without humidity preconditioning) and ACCESSIBLE parts shall not exceed the levels of 7.3.2. If a decontamination method is specified, this method is applied once.*

### 11.2 Specially protected probe assemblies

If the probe assembly is RATED and marked by the manufacturer as having a protected ENCLOSURE according to the stated degrees of protection of IEC 60529, it shall adequately resist the ingress of solid foreign objects and water which could lead to a HAZARD.

*Conformity is checked by inspection and by subjecting the probe assembly to the appropriate treatment of IEC 60529, after which the probe assembly shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) (without humidity preconditioning) and ACCESSIBLE parts shall not exceed the levels of 7.3.2.*

## 12 Components

### 12.1 General

If safety ~~is involved~~ aspects are addressed by components, these components shall be used in accordance with their specified RATING unless a specific exception is made. They shall conform to one of the following a) to d).

a) All applicable safety requirements of relevant IEC International Standards. Conformity to other requirements of the component standard is not required. If necessary for the application, components shall be subjected to the tests of this document, except that it is not necessary to carry out identical or equivalent tests already performed to check conformity to the component standard.
b) The requirements of this document and, where necessary for the application, any additional applicable safety requirements of the relevant IEC component standard.
c) If there is no relevant IEC International Standard, the requirements of this document.
d) Applicable safety requirements of a non-IEC standard which are at least as ~~high~~ stringent as those of the relevant IEC International Standard, provided that the component has been approved to the non-IEC standard by a recognized testing authority.

   Tests performed by a recognized testing authority which confirm conformity with all applicable safety requirements need not be repeated, even if the tests were performed using a non-IEC standard.

*Conformity is checked by inspection, and if necessary, by test.*

### 12.2 Fuses

Fuses in probe assemblies may be used to provide protection to the user against arc explosions or burns, or they may be used to protect the equipment to which the probes are connected.

If a fuse is installed in a probe assembly, it shall have a voltage RATING at least as high as the highest RATED voltage of the probe assembly, and an appropriate breaking capacity and current RATING for the intended application of the probe assembly (see also 6.1.3). If the probe assembly is RATED for both AC and DC, the AC and DC breaking capacities shall be individually determined, and the fuse shall meet the RATED voltage and breaking capacity for each case.

*Conformity is checked by inspection.*

### 12.3 PROBE WIRE

### 12.3.1 General

PROBE WIRE shall be suitable for its intended use in NORMAL CONDITION and in SINGLE FAULT CONDITION.

*Conformity is checked as specified in 12.3.2 to 12.3.6.*

### 12.3.2 RATING of PROBE WIRE

PROBE WIRES shall be RATED for the maximum voltage and current of NORMAL USE and shall withstand the voltage test for the highest RATED voltage ~~to earth~~. Conductors shall be separated from ACCESSIBLE surfaces by DOUBLE INSULATION or REINFORCED INSULATION, based on the voltage values from a), b) or c).

a) For Type A, Type E and Type F probe assemblies, 125 V or the highest RATED voltage ~~to earth~~ of the probe assembly, whichever is greater.

b) For Type B probe assemblies, ~~500 V or the highest RATED voltage to earth of the probe assembly divided by the divider ratio, whichever is greater;~~

   1) RATED for voltages up to 1 000 V AC RMS or 1 500 V DC, 125 V or the highest RATED voltage of the probe assembly, whichever is greater;

   2) RATED for voltages above 1 000 V AC RMS or 1 500 V DC, 500 V or the highest RATED voltage of the probe assembly divided by the divider ratio, whichever is greater.

   For Type B probe assemblies under this b) 2), symbol 7 of Table 1 shall be marked on the probe assembly and a warning shall be provided in the documentation of the possibility that the PROBE WIRE ~~may~~ will not provide adequate protection if it comes into contact with the circuit under test (see 6.4.3 l)).

~~c) for type C probe assemblies, 125 V or the highest RATED voltage to earth of the probe assembly, whichever is greater;~~

c) For Type D probe assemblies, 125 V.

A wear indicator is highly recommended (see also 6.4.3 j)). Insulation of PROBE WIRES which have a wear indicator shall meet the requirements for BASIC INSULATION when the wear indicator has become visible.

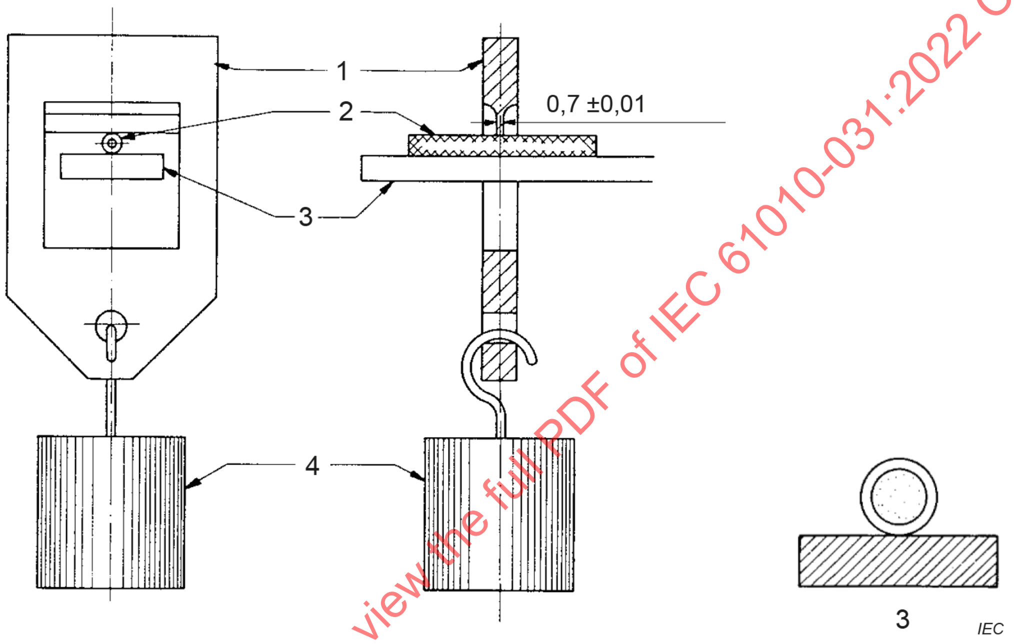
*Conformity is checked by inspection, and by the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for REINFORCED INSULATION. If the insulation includes a wear indicator, then the voltage test is repeated with the test voltage value for BASIC INSULATION after sufficient insulation has been removed from the cable to make the wear indicator just visible (see also 6.2 and 6.4.3 l)).*

*NOTE For the purposes of this test, the wear indicator can be made visible by slicing thin layers from the insulation, by abrasion, or by manufacturing special samples of the cable without the outer insulating layer.*

### 12.3.3 Pressure test at high temperature for insulations

*For each PROBE WIRE to be tested, three adjacent samples are taken from a PROBE WIRE having a length of 150 mm to 300 mm. The length of each sample is 50 mm to 100 mm. The conductors of flat PROBE WIRES without sheaths are not separated.*

*The indentation device is shown in Figure 24, and consists of a rectangular blade with an edge 0,70 mm ± 0,01 mm wide, which can be pressed against the sample. Each sample is placed in the position shown in Figure 24. A flat cord without a sheath is laid on its flat side. Samples are fixed on the support in such a manner that they do not curve under the pressure of the blade. The force is applied in a direction perpendicular to the axis of the sample; the blade is also perpendicular to the axis of the sample.*



**Key**

1 Testing frame

2 Sample

3 Supports

4 Weight

Figure 24 – Indentation device

*The compressing force which is exerted by the blade upon the sample is given by the formula:*

$$F = 0{,}6 \times \sqrt{(2 \times d \times e - e^{2})}$$

*where*

$F$ *is the compressing force in newtons;*

$e$ *is the mean value of the thickness of the insulation of the sample;*

$d$ *is the mean value of the outer diameter of the sample.*

*e and d are both expressed in millimetres, to one decimal place, and measured on a thin slice cut from the end of the test piece.*

*The test is carried out in air (i.e. in an air oven). The temperature of the air is maintained continuously at a temperature of 100 °C ± 3 °C. The loaded samples are kept in the test position for 4 h. Following this, the samples are rapidly cooled which may be carried out by spraying the* *sample with cold water on the spot where the blade is pressing. The sample is removed from the apparatus when it has cooled to a temperature where recovery of the insulation no longer occurs. The sample is then cooled further by immersion in cold water.*

*Conformity is checked by the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for* REINFORCED INSULATION *(without humidity preconditioning).*

### 12.3.4 Tests for resistance of insulation to cracking

*Four samples of suitable length are cut from two sections of the* PROBE WIRE *separated by at least 1 m.*

*~~Each sample is~~ Two samples are tautly wound and fixed, at ambient temperature, on ~~a mandrel~~ individual mandrels to form a close helix. The diameter of the mandrel and the number of turns are given in Table 15.*

**Table 15 – Diameter of mandrel and numbers of turns**

| Outer diameter of the PROBE WIRE *(d)* mm | Mandrel diameter mm | Number of turns |
|---|---|---|
| $d \leq 2{,}5$ | 5 | 6 |
| $2{,}5 < d \leq 4{,}5$ | 9 | 6 |
| $4{,}5 < d \leq 6{,}5$ | 13 | 6 |
| $6{,}5 < d \leq 9{,}5$ | 19 | 4 |
| $9{,}5 < d \leq 12{,}5$ | 40 | 2 |

*These two samples, on their mandrels, are placed in an air oven pre-heated to a temperature of 100 °C ± 3 °C. The samples are maintained at the specified temperature for 1 h. After the samples have been allowed to return to approximately ambient temperature, they are examined while still on the mandrel.*

*The other two samples are conditioned in a cold chamber for 4 h at −10 °C ± 2 °C. The test is to be performed in the cold chamber where space and mounting means are available in the chamber. Where this is not practical, it is appropriate to remove a sample and a mandrel from the test chamber and perform the test outside the chamber. In either case, the winding is to be completed within 30 s of the time that the cold chamber is opened. The winding is to be done at a rate of about 3 s per turn (18 s ± 3 s for six turns), and successive turns are to be in contact with one another.*

*Flat* PROBE WIRES *are to be wrapped in a U-bend in which the sample is in contact with a mandrel having a diameter of twice the minor axis diameter of the sample for minimum 180°.*

*Insulated conductors as well as the finished* PROBE WIRE *are to be tested separately.*

*Circumferential depressions in the outer surface indicate cracks on the inside surface of the insulation or jacket of most materials. Circumferential depressions in a fluoropolymer surface are yield marks (locally stronger points) rather than indicators of cracking.*

*After this conditioning, the samples shall show no cracks when examined with normal or corrected vision without magnification, and shall meet the requirements for solid insulation.*

*Conformity is checked by inspection and by the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for* REINFORCED INSULATION *(without humidity preconditioning).*

### 12.3.5 Voltage test

*Six lengths of insulated PROBE WIRE or insulated conductors removed from a jacketed wire are to be tested for each specimen of wire to be evaluated. Each sample is 600 mm in length. Three of the samples are to be tested in an unaged condition. The other three samples are to be tested after air oven conditioning.*

*The three straight samples intended for oven ageing are to be conditioned in a circulating air oven pre-heated to a temperature 100 °C ± 3 °C. The test piece shall be maintained at the specified temperature for 1 h.*

*After air oven conditioning, the three specimens are to be cooled to room temperature in still air for a period of 16 h to 96 h before testing. After the cooling period, both the unaged and oven-conditioned samples are to be tested. The centre 300 mm of each sample is to be wrapped with metal foil.*

*Except for flat PROBE WIRES, the foil-wrapped centre section of each sample is to then be wrapped closely for six complete turns around a metal mandrel having a diameter of two times the outside diameter of the specimen or 5 mm, whichever is larger. The end of each resulting helix is to be twisted loosely together or fastened together with tape to prevent unwinding. Specimens of flat wires are to be wrapped in a U-bend in which the specimen is in contact with a mandrel having a diameter of twice the minor axis diameter of the specimen for 180° minimum.*

*The applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for REINFORCED INSULATION (without humidity preconditioning) is then performed. The test voltage is applied between the conductor of the test specimen and the metal mandrel. After 1 min at the specified test voltage, the test voltage is increased at a rate not exceeding 500 V/s until dielectric breakdown occurs. If dielectric breakdown does not occur, breakdown voltage can be considered as twice the value in 7.5.4.2.1 b) or 7.5.4.3.1 b) (or 10 kV). The dielectric breakdown voltage values are recorded separately for unaged specimens and oven-aged specimens. The average of the dielectric breakdown voltage values is calculated and recorded separately for unaged specimens and oven-aged specimens.*

*Samples of both unaged and oven-aged specimens shall comply with the following:*

*a) unaged and oven-aged samples shall withstand the test voltage without breakdown for 1 min, and*

*b) the average dielectric breakdown value of oven-aged samples shall not be less than 50 % of the average breakdown value of unaged samples.*

*Conformity is checked by inspection and test.*

### 12.3.6 Tensile test

#### 12.3.6.1 General

These tests are to determine the tensile strength and elongation at break of the insulating material (exclusive of any semi-conducting layers) of the PROBE WIRE in the condition as manufactured (i.e., without any ageing treatment) and after an accelerated ageing treatment.

For the unaged samples, the median value of the tensile strengths shall be at least 7 N/mm$^2$ and the samples shall exhibit a median value of elongation of at least 100 % before they break. For the aged samples, the median value of the tensile strengths shall be at least 70 % of the result for unaged samples, and the samples shall exhibit a median value of elongation of at least 45 % of the result of the unaged samples before they break.

*After the test conditioning and procedure of 12.3.6.2 to 12.3.6.6, conformity is checked by calculation of the tensile strength and the elongation at break respectively and the median value of the result is determined.*

#### 12.3.6.2 Sampling

*The samples selected for the ageing treatment are from positions adjacent to the samples used for the test without ageing and the tensile tests on the aged and unaged test pieces are made in immediate succession.*

*One section of each core to be tested is taken of sufficient size to provide a minimum of ten samples, five each for the tensile tests without ageing and five each for the tensile tests after the ageing treatment, bearing in mind that a 100 mm length is needed for the preparation of each sample. The cores of flat cords are not separated. Any sample that shows signs of mechanical damage is not used for the test.*

#### 12.3.6.3 Preparation and conditioning of samples

*The section of core is cut into ten samples, each approximately 100 mm long and the conductor is removed, care being taken not to damage the insulation. The samples are marked to identify the section from which they were prepared and their relative positions in the section.*

*The centre 20 mm shall be marked immediately before the tensile test.*

#### 12.3.6.4 Determination of cross-sectional area

*At the middle of the section being used to prepare the samples, a piece is taken to determine the cross-sectional area A by the following method (for samples with a round shape).*

$$A = \pi \times (d - e) \times e$$

*where*

$e$ *is the mean value of the thickness of the insulation;*

$d$ *is the mean value of the outer diameter of the test piece.*

*For samples which are to be aged, the cross-sectional area is determined before the ageing treatment.*

#### 12.3.6.5 Ageing treatment

*The five samples intended for oven ageing are to be conditioned in a circulating air oven pre-heated to a temperature of 100 °C ± 3 °C. The test piece is maintained at the specified temperature for 1 h, and then allowed to cool to the temperature specified in 12.3.6.6.*

#### 12.3.6.6 Tensile testing procedure

*The test is carried out at a temperature of 23 °C ± 5 °C.*

*The grips of the tensile testing machine may be either of a self-tightening type or not. The distance between the grips is:*

*a) 50 mm for tubes, if tested with self-tightening grips;*

*b) 85 mm for tubes, if tested with non-self-tightening grips.*

*The rate of separation shall be 250 mm/min ± 50 mm/min and, in case of doubt, 25 mm/min ± 5 mm/min.*

*NOTE Many failures when tested at 250 mm/min can create a doubt.*

*For each sample, the maximum tensile force during the test is measured and recorded, and the distance between the two reference marks at the breaking point is measured and recorded.*

*One test result from the five aged samples and one test result from the five unaged samples may be ignored.*

## 13 Prevention of HAZARD from arc flash and short-circuits

### 13.1 General

When a PROBE TIP or SPRING-LOADED CLIP temporarily bridges two high-energy conductors at different potentials, it could cause a high current to flow through the PROBE TIP or SPRING-LOADED CLIP which could become hot and melt. This could cause burns to an OPERATOR or a bystander.

If the bridge is opened (by OPERATOR action, melting, or other event) while the high current is flowing through the PROBE TIP or SPRING-LOADED CLIP, arcing could occur. The arcing will ionize the air, permitting continued current flow in the vicinity of the PROBE TIP or SPRING-LOADED CLIP. If there is sufficient available energy, then the ionization of the air will continue to spread and the flow of current through the air will continue to increase. The result is an arc flash, which is similar to an explosion, and can cause injury or death to an OPERATOR or a bystander.

PROBE TIPS and SPRING-LOADED CLIPS shall be constructed to reduce the risk of short-circuits and arc flashes.

*Conformity is checked as specified in 13.2.*

### 13.2 Exposed conductive parts

The exposed conductive part of a PROBE TIP or jaws shall be constructed as follows:

a) For probe assemblies except for SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY III or IV:

   1) ~~for probe assemblies~~ when RATED for MEASUREMENT CATEGORY III or IV, the exposed conductive part of a PROBE TIP shall not exceed 4 mm in length;

   2) ~~for probe assemblies not~~ when RATED for~~ MEASUREMENT CATEGORY II, III or IV, and for~~ use in special applications where the energy levels will not support arc flash or fire but not RATED for any MEASUREMENT CATEGORY, the exposed conductive part of a PROBE TIP shall not exceed 80 mm;

   3) ~~for probe assemblies~~ when RATED for MEASUREMENT CATEGORY II, and for other probe assemblies not covered by items 1) and 2), above, the exposed conductive part of a PROBE TIP or jaw shall not exceed 19 mm.

b) For SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY III or IV:

   1) in closed position, the exposed ACCESSIBLE conductive parts shall not exceed 4 mm in all directions;

   2) in open position,

      i) the length of the exposed ACCESSIBLE conductive parts of SPRING-LOADED CLIPS with one hook shall not exceed 10 mm,

      ii) the outer surfaces of SPRING-LOADED CLIPS with more than one hook or jaw shall not be conductive.

Requirements of 13.2 a) and 13.2 b) do not apply to Type E probes assemblies, provided the two conductors of the probe assembly are separated from each other by high impedance. **39**

*Conformity is checked by inspection and measurement of the exposed conductive parts of the PROBE TIP or jaws as follows:*

*a) spring-loaded parts covering the conductive part of a PROBE TIP are retracted before the measurements are made;*

b) *PROBE TIPS with moving parts other than spring-loaded parts which change the RATING and the markings of the probe assembly are evaluated in each position;*

c) *PROBE TIPS with removable parts which change the RATING and the markings of the probe assembly are evaluated when the part is removed, partially removed and not removed (see also 6.1.1).*

# Annex A
(normative)

## Measuring circuits for touch current
(see 7.3)

NOTE Annex A is based on IEC 60990:2016, which specifies procedures for measuring touch-current, and also specifies the characteristics for test voltmeters.

## A.1 Measuring circuits for AC with frequencies up to 1 MHz and for DC

The current is measured with the circuit of Figure A.1. The current is calculated from:

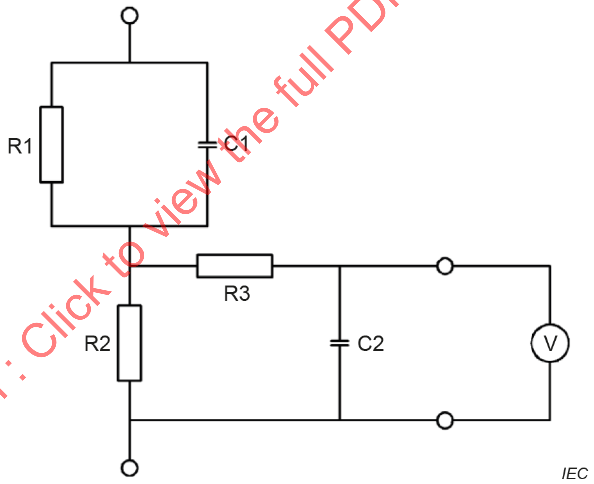
$$I = \frac{U}{500}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.

This circuit represents the impedance of the human body and compensates for the change of physiological response of the human body with frequency.



R1 = 1 500 Ω ±5 %

R2 = 500 Ω ±5 %

R3 = 10 kΩ ±5 %

C1 = 0,22 µF ±10 %

C2 = 0,022 µF ±10 %

Figure A.1 – Measuring circuit for AC with frequencies up to 1 MHz and for DC

## A.2 Measuring circuits for AC with sinusoidal frequencies up to 100 Hz and for DC

If the frequency does not exceed 100 Hz, the current may be measured with the alternative circuit of Figure A.2. When using the voltmeter, the current shall be calculated from:

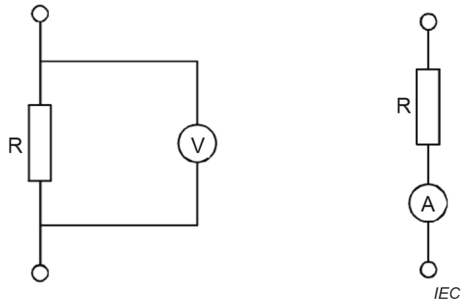
$$I = \frac{U}{2\ 000}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.

The circuit represents the impedance of the human body for frequencies not exceeding 100 Hz.



R = 2 000 Ω ±5 %

NOTE The value 2 000 Ω includes the impedance of the measuring instrument.

**Figure A.2 – Measuring circuits for AC with sinusoidal frequencies up to 100 Hz and for DC**

## A.3 Current measuring circuit for electrical burns at frequencies above 100 kHz

The current is measured with the circuit of Figure A.3 or Figure A.4 as specified in 7.3.2, 7.3.3, or 7.3.4.3. The current is calculated from:

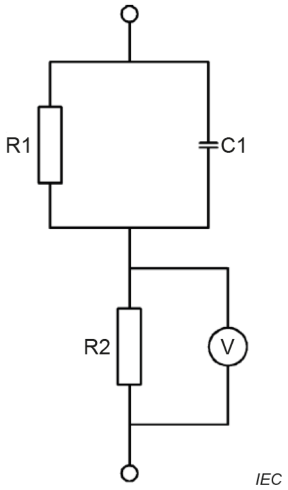
$$I = \frac{U}{500}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.

These circuits compensate for the physiological response of the human body to high frequencies.

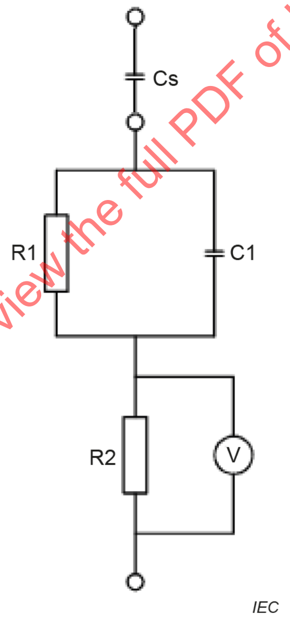


R1 = 1 500 Ω ±5 %

R2 = 500 Ω ±5 %

C1 = 0,22 µF ±10 %

**Figure A.3 – Current measuring circuit for electrical burns**



R1 = 1 500 Ω ±5 %

R2 = 500 Ω ±5 %

C1 = 0,22 µF ±10 %

Cs = Capacitance between the shield and the foil (see Figure 11)

**Figure A.4 – Current measuring circuit for high frequency test probes**

## A.4 Current measuring circuit for WET LOCATIONS

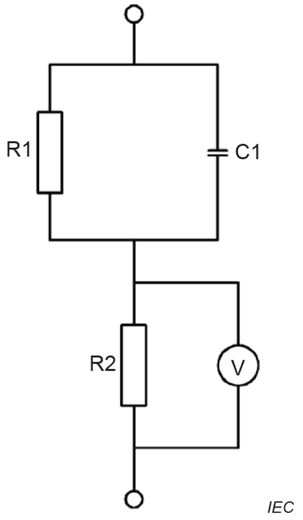
For WET LOCATIONS the current is measured using the circuit of Figure A.5. The current is calculated from:

$$I = \frac{U}{500}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.



R1 = 375 Ω ±5 %

R2 = 500 Ω ±5 %

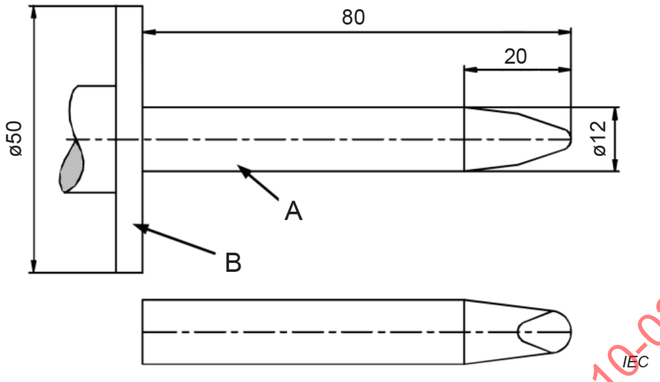
C1 = 0,22 µF ±10 %

**Figure A.5 – Current measuring circuit for WET LOCATIONS**

# Annex B
(normative)

## Standard test fingers

Dimensions in millimetres



**Key**

A metal

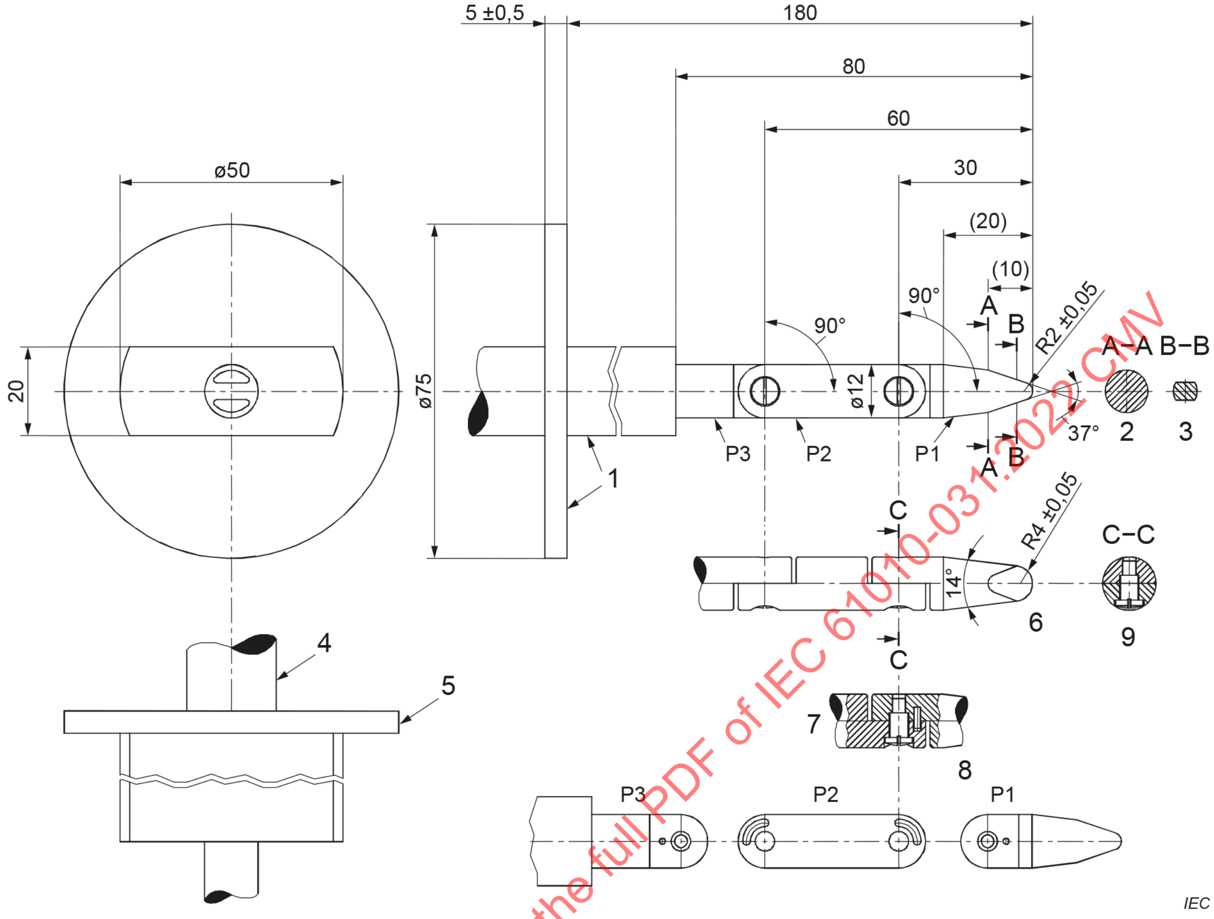
B insulating material

For tolerances and dimensions of the fingertip, see Figure B.2.

NOTE This test finger is identical to test probe 11 from IEC 61032:1997.

Figure B.1 – Rigid test finger

Dimensions in millimetres



**Key**

1 insulating material

2 section AA

3 section BB

4 handle

5 stop plate

6 spherical

7 detail × (example)

8 side view

9 chamfer all edges

Figure B.2 – Jointed test finger

Tolerances on dimensions without specific tolerance:

on angles: $^{0}_{-10'}$

on linear dimensions:

up to 25 mm: $^{0}_{-0,05}$ mm

over 25 mm: ±0,2 mm

Material of finger: heat-treated steel, etc.

Both joints of this finger may be bent through an angle of $(90^{+10}_{0})$° but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design shall ensure a $(90^{+10}_{0})°$ bending angle.

NOTE This test finger is identical to test probe B from Figure 2 of IEC 61032:1997.

# Annex C

(normative)

## Measurement of CLEARANCES and CREEPAGE DISTANCES

The methods of measuring CLEARANCES and CREEPAGE DISTANCES are indicated in Table C.2. These cases do not differentiate between gaps and grooves or between types of insulation.

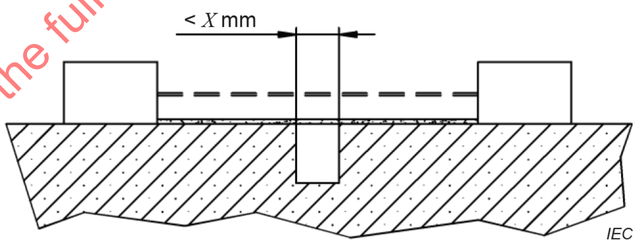
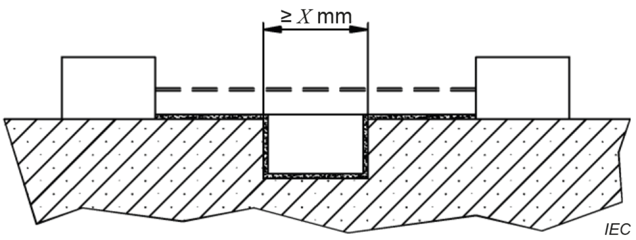
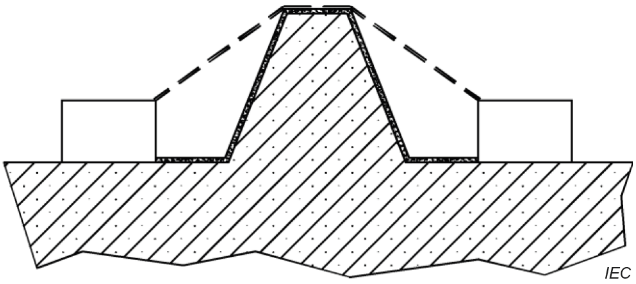
In the following examples dimension *X* has the value given in Table C.1 depending on the POLLUTION DEGREE.

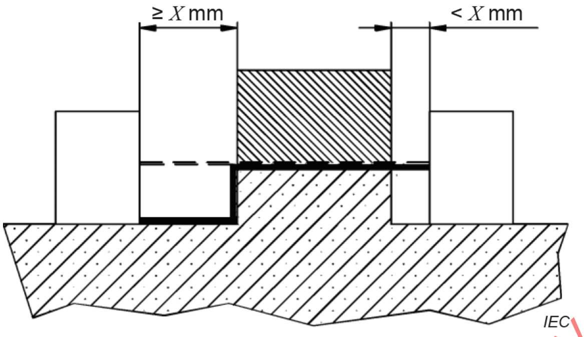
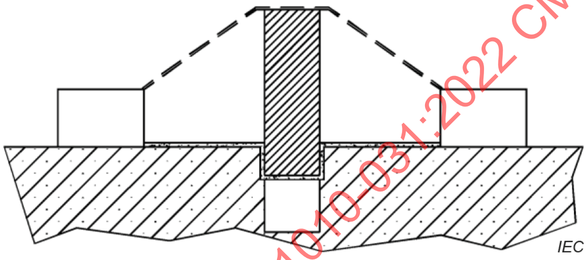
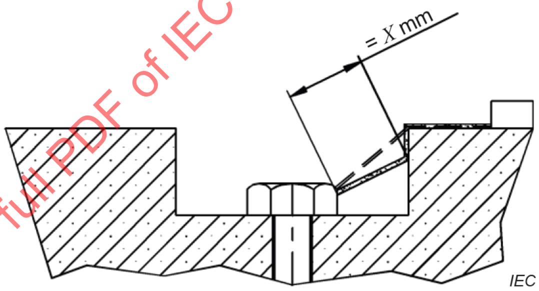
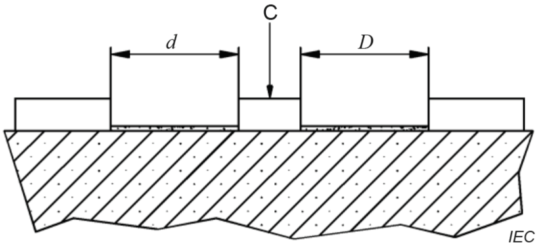
**Table C.1 – Dimension of *X***

| POLLUTION DEGREE | Dimension *X*<br>mm |
|---|---|
| 1 | 0,25 |
| 2 | 1,0 |
| 3 | 1,5 |

If the associated CLEARANCE is less than 3 mm, the dimension *X* in Table C.1 may be reduced to one-third of this CLEARANCE.

**Table C.2 – Methods of measuring CLEARANCES and CREEPAGE DISTANCES**

| | |
|---|---|
| **Example 1:**<br>The path includes a parallel- or converging-sided groove of any depth with a width less than *X* mm.<br>The CLEARANCE and CREEPAGE DISTANCE are measured directly across the groove as shown. |  |
| **Example 2:**<br>The path includes a parallel-sided groove of any depth and equal to, or greater than, *X* mm.<br>CLEARANCE is the "line-of-sight" distance. The CREEPAGE DISTANCE follows the contour of the groove. |  |
| **Example 3:**<br>The path includes a rib.<br>The CLEARANCE is the shortest direct air path over the top of the rib. The CREEPAGE DISTANCE follows the contour of the rib. |  |

| | |
|---|---|
| **Example 4:**<br>The path includes an uncemented joint with a groove on one side less than *X* wide and the groove on the other side equal to, or greater than, *X* wide.<br>The CLEARANCE and the CREEPAGE DISTANCE are as shown. |  |
| **Example 5:**<br>The CLEARANCE is the shortest direct air path over the top of the barrier.<br>The CREEPAGE DISTANCE through uncemented joint is less than the CREEPAGE DISTANCE over the barrier. |  |
| **Example 6:**<br>The gap between the head of screw and the wall of the recess is too narrow to be taken into account.<br>Measurement of the CREEPAGE DISTANCE is from screw to wall when the distance is equal to *X*. |  |
| **Example 7:**<br>C is a floating part.<br>The CLEARANCE is the distance *d* + *D*.<br>The CREEPAGE DISTANCE is also *d* + *D*.<br>Minimum CLEARANCE *d* or *D* is 0,2 mm in POLLUTION DEGREE 2, and 0,8 mm in POLLUTION DEGREE 3. |  |
| ———————<br>- - - - - - | CREEPAGE DISTANCE<br>CLEARANCE |

# Annex D
(normative)

# Routine spark tests on PROBE WIRE

## D.1 General

The spark test shall be performed by the manufacturer as a ROUTINE TEST on 100 % of the PROBE WIRE in accordance with the following spark test procedure and routine spark test method for PROBE WIRE.

## D.2 Spark test procedure

A DC or AC spark tester shall include a voltage source, an electrode, a voltmeter, a system for detecting and counting signalling faults, and the appropriate electrical connections.

The voltage source of a DC or AC spark tester shall maintain the following test voltage under all NORMAL CONDITIONS of leakage current:

a) a sinusoidal or nearly sinusoidal RMS voltage specified for an AC test of the wire type;

b) the voltage specified for a DC test of the wire type. The DC power supply output current capability shall not exceed 5 mA. Any ripple shall not exceed 1 %. After a fault, the DC test voltage shall recover to the specified level within 5 ms unless 610 mm or less of the product travels through the electrode in the time it takes for the full voltage recovery.

One TERMINAL of the DC power supply, the core of a transformer, and one end of the secondary winding in an AC power supply shall be solidly connected to earth. A voltage source shall not be connected to more than one electrode.

The electrode of a DC or AC spark tester shall be of the link- or bead-chain type or shall be of another evaluated and approved type. A link- or bead-chain electrode shall make intimate contact throughout its entire length with the surface of the insulated conductor being tested.

The bottom of a metal link- or bead-chain electrode enclosure shall be U- or V-shaped, the chains shall have a length appreciably greater than the depth of the enclosure, and the width of the trough shall be greater (typically 40 mm) than the diameter of the largest PROBE WIRE being tested.

For a bead-chain electrode, the longitudinal and transverse spacings of the chains and the diameter of each bead shall comply with Table D.1 (see also Figure D.1). The vertical spacing between beads in each chain shall not exceed the diameter of a bead.

**Table D.1 – Maximum centre-to-centre spacings of bead chains**

| Diameter of a bead [a] | Longitudinal spacing within each row [a] | Transverse spacing between rows [a] | |
|---|---|---|---|
| | | Chains staggered | Chains unstaggered |
| mm | mm | mm | mm |
| 5,0 | 13 | 13 | 10 |
| 2,5 | [b] | [b] | [b] |

[a] Other diameters and spacings are also acceptable if investigation shows that the chains contact an equal or greater area of the outer surface of the insulated conductor or initial assembly of conductors.

[b] The chains shall be staggered and shall touch one another in the longitudinal and transverse directions.

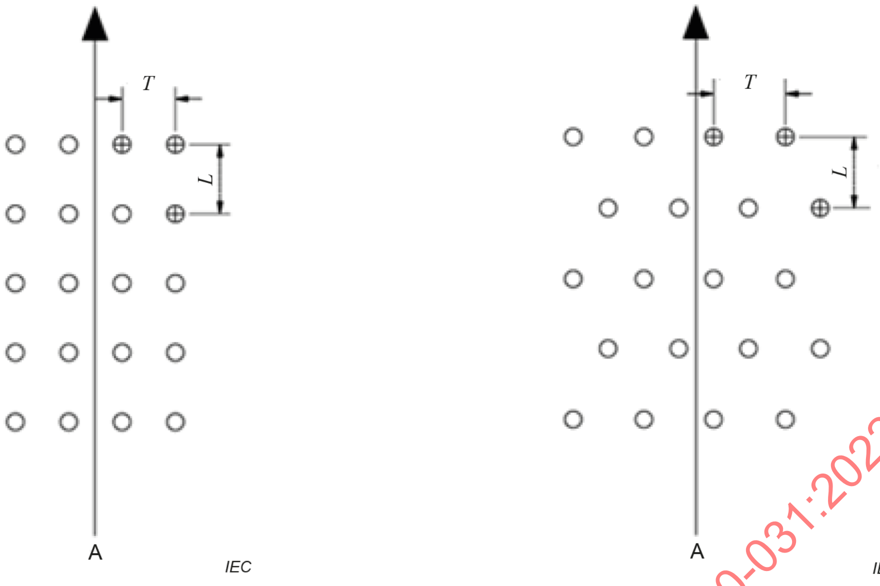


**Figure D.1 a) – Chains unstaggered**

**Figure D.1 b) – Chains staggered**

**Key**

| | |
|---|---|
| A | wire centre |
| T | transverse spacing |
| L | longitudinal spacing |

**Figure D.1 – Bead chain configuration (if applicable)**

The electrode shall have an earthed metal screen or an equivalent guard that protects operating personnel against electric shock from the electrode and associated live parts.

The voltmeter shall be connected in the circuit to indicate the actual test potential at all times.

The test equipment shall include a fault detector, fault counter, and a means of signalling each fault that occurs. When a fault is detected, the signal shall be maintained until the indicator is reset manually.

The fault detector shall detect a voltage breakdown of the insulation. A breakdown is characterized by arcing between the electrode and the earthed conductor(s) under test. A breakdown is defined as a decrease of 25 % or more from the test voltage applied between the electrode and the earthed conductor(s). The output current of the test equipment shall not exceed 5 mA.

The fault detector shall consist of a trigger circuit that converts an input pulse of short time duration to an output pulse of a magnitude and duration that reliably operates the fault-indicating circuit.

The fault counter shall accumulate the faults as a numerically increasing sequence and shall display the accumulated total. The response time of the fault counter shall result in the counter registering faults spaced no farther than 610 mm apart for any combination of product speed and counter response time. This distance is to be calculated as follows:

$$D = S \times t$$

where

$D$ is the distance between faults, in metres;

$S$ is the product speed, in metres per second;

$t$ is the counter response time, in seconds.

For a DC test using a link- or bead-chain electrode, the surface of the insulated conductor(s) shall be in intimate contact with the link or bead chains for a distance of 125 mm ± 25 mm.

The length of a link- or bead-chain electrode is not specified for an AC test; however, the rate of speed at which the insulated conductor travels through the electrode shall keep any point on the product in contact with the electrode for not less than a total of 18 positive and negative crests of the AC supply voltage (the equivalent of a full 9 cycles of the AC supply voltage). The maximum speed $V$ of the product is to be determined for an AC test by means of the following formula:

$$V = (F \times L) / 150$$

where

$V$ is the speed in metres per minutes;

$F$ is the frequency in hertz;

$L$ is the electrode length in millimetres.

For convenience, Table D.2 shows the formulas for seven frequencies.

**Table D.2 – Formula for maximum speed of wire in terms of electrode length *L* of link- or bead-chain electrode**

| **Nominal supply frequency** ***F*** (Hz) | **Speed *V*** (m/min) **with electrode length *L*** (mm) |
|---|---|
| 50 | 0,333 × *L* |
| 60 | 0,400 × *L* |
| 100 | 0,667 × *L* |
| 400 | 2,67 × *L* |
| 1 000 | 6,67 × *L* |
| 3 000 | 20,0 × *L* |
| 4 000 | 26,7 × *L* |

The conductor being tested shall be earthed during the spark test. Where the conductor coming from the pay-off reel is bare, the conductor shall be earthed at the pay-off reel or at another point at which continuous contact with the bare conductor, prior to the insulating process, is maintained and the conductor is not required to be tested for continuity or earthed at the take-up reel. Where the conductor coming from a pay-off reel is insulated, an earth connection shall be made at each pay-off reel and at the take-up reel. The earth connection shall be bonded to the protective earth TERMINAL in the spark tester.

## D.3 Routine spark test method for PROBE WIRE

For single-conductor wires with other than extruded insulation, the potential shall be 1 500 V if the wire is RATED for 300 V and shall be 2 000 V if the wire is RATED for 600 V.

For all other wires and insulations, the potential shall be 10 times the voltage RATING of the wire, up to 1 000 V, with a minimum potential of 1 500 V. If the RATED voltage is not specified, the potential shall be 3 000 V. For wire RATED more than 1 000 V, the potential shall be two times the RATED voltage with a minimum potential of 10 000 V. Insulated conductors or the insulated conductors of a jacketed wire shall be tested. In the case of a jacketed wire, the insulated conductors shall be tested prior to the application of the overall jacket or covering.

The spark test shall be performed at some point prior to the wire being cut to its final length or before being cut into shipping lengths.

Any faults shall be cut out or repaired. The insulation at points of repair shall be retested.

# Annex E
(informative)

# 4 mm CONNECTORS

## E.1 General

HAZARDS may arise from an OPERATOR's reliance on values displayed by the equipment when CONNECTORS appear to be in mated position but conductive parts are not in contact.

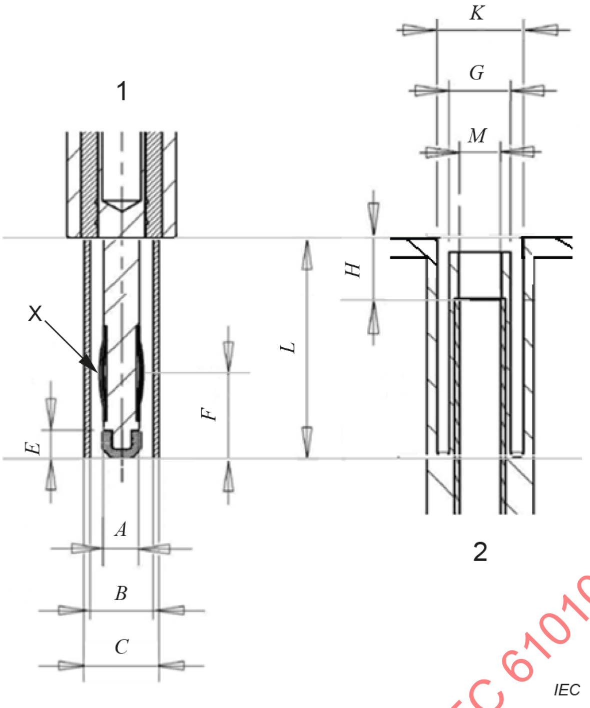
This annex gives the recommended dimensions for safety purposes of 4 mm CONNECTORS when used on probe assemblies and equipment to which probe assemblies can be connected. These 4 mm CONNECTORS are often called "banana connectors" or "banana plugs".

## E.2 Dimensions

The dimensions of Figure E.1 are compatible with 4 mm CONNECTORS RATED for MEASUREMENT CATEGORIES ~~II, III or IV~~ up to 1 000 V.

These dimensions ensure that SPACINGS values of 7.4.2 are met when the CONNECTORS and TERMINALS are mated, unmated or partially mated, and that conductive parts of mated CONNECTORS and TERMINALS are in contact.

NOTE Extraction or insertion forces and contact resistance values have not been considered.



**Key**

*A* = 3,90 mm ± 0,05 mm (compressed)

*B* ≥ 6,6 mm

*C* ≤ 7,9 mm

2,6 mm ≤ *E* ≤ 6 mm

*F* ≤ 12 mm

G ≤ 6,4 mm

*K* ≥ 8,1 mm

4 mm ≤ *H* ≤ 6 mm

*L* ≥ 20 mm

*M* = 4,00 mm + 0,05 mm

Tolerances on dimensions without specific tolerances: ± 0,1 mm

- 1 is a male CONNECTOR
- 2 is a female CONNECTOR
- X is the location where the best contact occurs and F is the distance to X
- A is the maximum diameter where the contact occurs
- The minimum value of *E* and *H* depends on whether or not plastic parts are present. ~~SPACINGS~~ CLEARANCES shall be at least 2,6 mm.

Figure E.1 – Recommended dimensions of 4 mm CONNECTORS

# Annex F
(normative)

# MEASUREMENT CATEGORIES

## F.1 General

For the purposes of this document, the following MEASUREMENT CATEGORIES are used. These MEASUREMENT CATEGORIES are not the same as the overvoltage categories according to ~~Annex K of IEC 61010-1:2010 and IEC 60664-1, or the impulse withstand categories (overvoltage categories) according to IEC 60364-4-44~~ IEC 61010-1:2010, K.1.1, IEC 60364-4-44:2007/AMD1:2015, 443.6 or IEC 60664-1:2020, 4.3.

~~NOTE~~ MEASUREMENT CATEGORIES are based on locations on the mains supply system where measurements can be made.

NOTE IEC 60364-4-44 and IEC 60664-1 overvoltage categories are created to achieve an insulation coordination of the components and equipment used within low-voltage mains supply systems.

## F.2 MEASUREMENT CATEGORIES

### F.2.1 MEASUREMENT CATEGORY II

MEASUREMENT CATEGORY II is applicable to test and measuring circuits connected directly to utilization points (socket outlets and similar points) of the low-voltage mains installation (see Table F.1 and Figure F.1).

EXAMPLE Measurements on mains circuits of household appliances, portable tools and similar equipment, and on the consumer side only of socket-outlets in fixed installations.

### F.2.2 MEASUREMENT CATEGORY III

MEASUREMENT CATEGORY III is applicable to test and measuring circuits connected to the distribution part of the building's low-voltage mains installation (see Table F.1 and Figure F.1).

To avoid risks caused by the HAZARDS arising from these higher short-circuit currents, additional insulation and other provisions are required.

~~NOTE~~ For equipment that is part of a fixed installation, the fuse or circuit breaker of the installation can be considered to provide adequate protection against short-circuit currents.

EXAMPLE Measurements on distribution boards (including secondary meters), photovoltaic panels, circuit-breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use and some other equipment such as stationary motors with permanent connection to the fixed installation.

### F.2.3 MEASUREMENT CATEGORY IV

MEASUREMENT CATEGORY IV is applicable to test and measuring circuits connected at the source of the building's low-voltage mains installation (see Table F.1 and Figure F.1).

~~Due to these high short-circuit currents which can be followed by a high energy level, measurements made within these locations are extremely dangerous. Great precautions shall be made to avoid any chance of a short circuit.~~

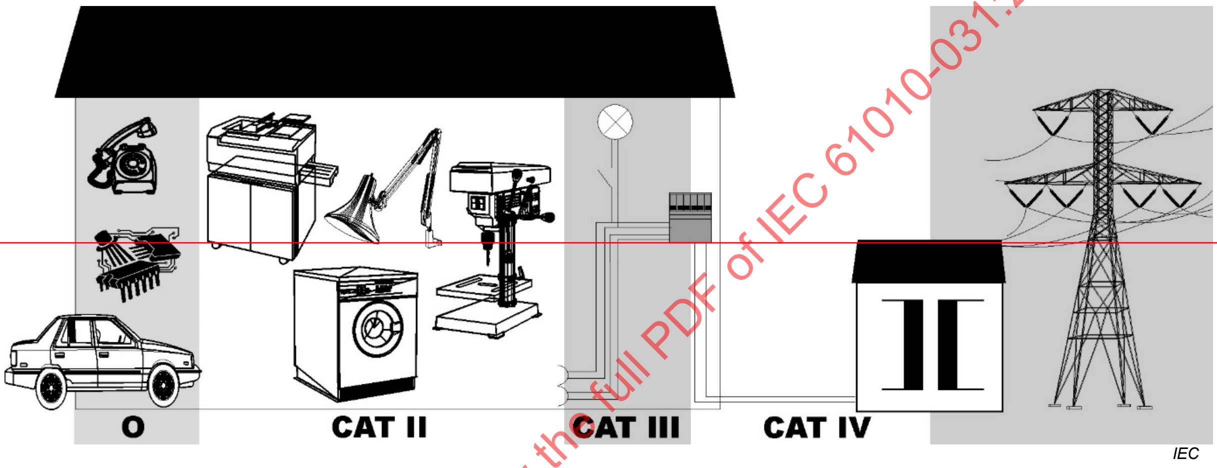
Owing to the high potential short-circuit currents existing in these circuits, any accidental short-circuit caused whilst making measurements can create a high-energy-level arc flash which is extremely dangerous to bystanders in the immediate vicinity. Great precautions must be taken to avoid any chance of a short circuit.

EXAMPLE Measurements on devices installed before the ~~main fuse or~~ mains circuit breaker or isolator switch in the building installation.

### F.2.4 Probe assemblies without a MEASUREMENT CATEGORY RATING

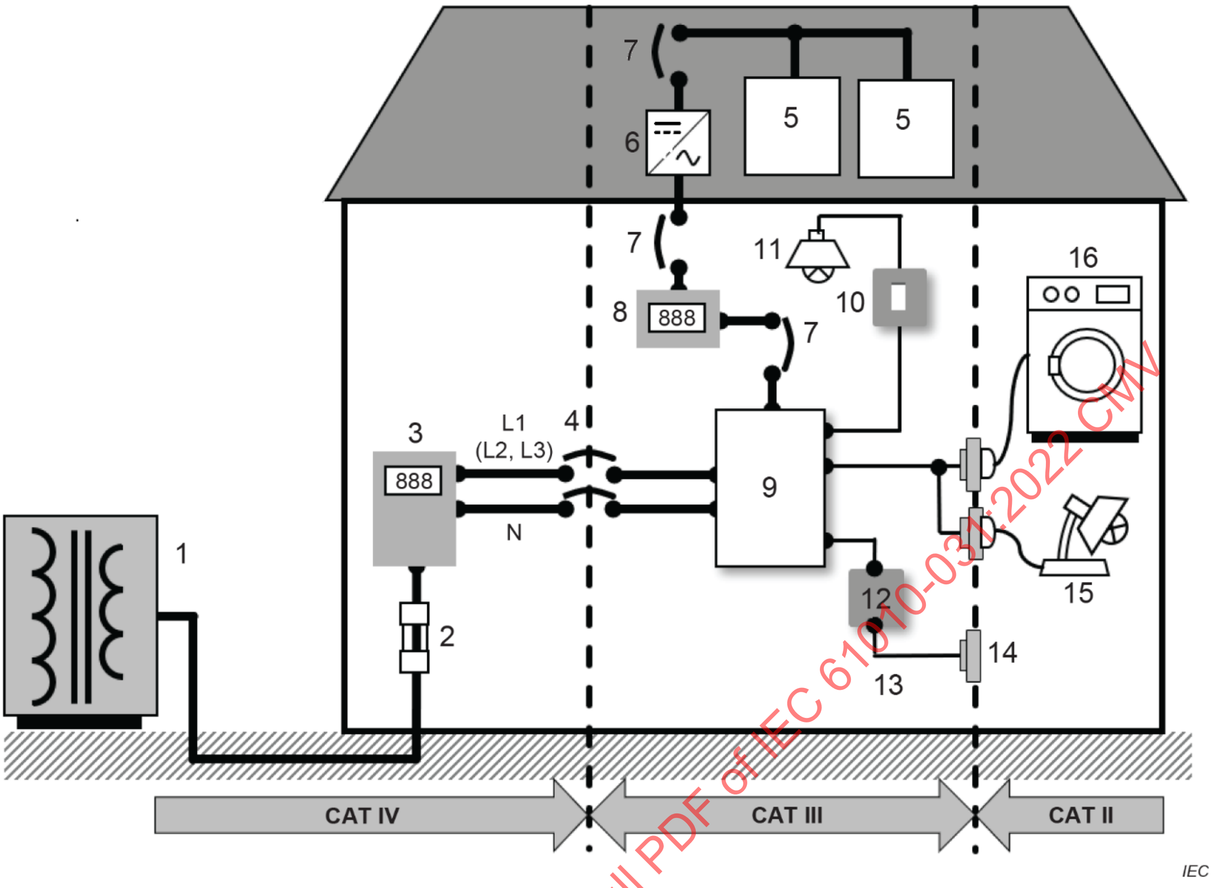
Many types of test and measuring circuits are not intended to be directly connected to the mains supply. Some of these measuring circuits are intended for very low energy applications, but others of these measuring circuits may experience very high amounts of available energy because of high short-circuit currents or high open-circuit voltages. There are no standard transient levels defined for these circuits. An analysis of the WORKING VOLTAGES, loop impedances, temporary overvoltages, and transient overvoltages in these circuits is necessary to determine the insulation requirements and short-circuit current requirements.

EXAMPLE Thermocouple measuring circuits, high-frequency measuring circuits, automotive testers, and testers used to characterize the mains installation before the installation is connected to the mains supply.



~~**Key**~~

~~O Other circuits that are not directly connected to mains~~
~~CAT II MEASUREMENT CATEGORY II~~
~~CAT III MEASUREMENT CATEGORY III~~
~~CAT IV MEASUREMENT CATEGORY IV~~



**Key**

| | | | |
|---|---|---|---|
| 1 | low-voltage supply source over or under ground | 9 | distribution board |
| 2 | service fuse | 10 | light switch |
| 3 | tariff meter | 11 | lighting |
| 4 | mains circuit breaker or isolator switch [a] | 12 | junction box |
| 5 | photovoltaic panel | 13 | socket wiring |
| 6 | DC to AC inverter | 14 | socket outlets |
| 7 | circuit breaker or isolator switch | 15 | plug-in lamps |
| 8 | generation meter | 16 | household appliances, portable tools |

[a] The mains circuit breaker or isolator switch may be installed by the service provider. If not, the demarcation point between CAT IV and CAT III is the first isolating switch in the distribution board.

CAT II MEASUREMENT CATEGORY II
CAT III MEASUREMENT CATEGORY III
CAT IV MEASUREMENT CATEGORY IV

**Figure F.1 – Example to identify the locations of MEASUREMENT CATEGORIES 40**

**Table F.1 – Characteristics of MEASUREMENT CATEGORIES**

| MEASUREMENT CATEGORY | Short-circuit current [a] (typical) kA | Location |
|---|---|---|
| II | < 10 | Circuits connected to mains socket outlets and similar points in the mains installation |
| III | < 50 | Mains distribution parts of the building |
| IV | > 50 | Source of the mains installation |

[a] The values of loop impedances (installation impedances) do not take into account the resistance of the test leads and impedances internal to the measuring equipment. These short-circuit currents vary, depending on the characteristics of the installation and the nominal voltage of the distribution system.

# Annex G
(informative)

## Determination of CLEARANCES for Table 2

$D_1$ values of Table 5 are interpolated values from Table F.2 of IEC 60664-1:2020. $D_2$ values of Table 5 below 100 mm are interpolated values from Table F.8 of IEC 60664-1:2020 and $D_2$ values of Table 5 above 100 mm are extrapolated values from Table F.8 of IEC 60664-1:2020.

CLEARANCES of Table G.1 have been calculated using linear interpolation of $D_2$ values from Table 5 for BASIC INSULATION (see 7.5.2.3.2) with a 25 % safety factor. Transient overvoltages have been disregarded.

**Table G.1 – CLEARANCES values for Table 2**

| [A] | [B] | [C] | [D] | [E] | [F] | [G] | [H] |
|---|---|---|---|---|---|---|---|
| **AC RMS or DC voltage** V | **Safety factor** × 1,25 V | **Peak value** | | **Exact CLEARANCE** | | **Final CLEARANCE** | |
| | | AC V | DC V | AC mm | DC mm | AC mm | DC mm |
| 300 | 375 | 530 | 375 | 0,046 | 0,016 | 0,8 | 0,8 |
| 600 | 750 | 1 061 | 750 | 0,31 | 0,11 | 0,8 | 0,8 |
| 1 000 | 1 250 | 1 768 | 1 250 | 1,03 | 0,48 | 1,0 | 0,8 |
| 1 500 | 1 875 | 2 652 | 1 875 | 2,00 | 1,14 | 2,0 | 1,1 |
| 2 000 | 2 500 | 3 536 | 2 500 | 3,20 | 1,80 | 3,2 | 1,8 |
| 3 000 | 3 750 | 5 303 | 3 750 | 6,40 | 3,45 | 6,4 | 3,5 |
| 5 000 | 6 250 | 8 839 | 6 250 | 13 | 8,3 | 13 | 8,3 |
| 10 000 | 12 500 | 17 678 | 12 500 | 30 | 20 | 30 | 20 |
| 15 000 | 18 750 | 26 517 | 18 750 | 48 | 32 | 48 | 32 |
| 20 000 | 25 000 | 35 355 | 25 000 | 67 | 44 | 67 | 44 |

Column [A]: Nominal AC RMS or DC voltage to which the CONNECTOR of the probe assembly is RATED

Column [B]: Values including a safety factor of +25 %

Column [C]: Peak values of the AC RMS voltage

Column [D]: Peak values of the DC voltage

Columns [E] and [F]: Exact values according to Table 5

Columns [G] and [H]: Final CLEARANCES values with the following

The 0,8 mm values are the minimum CLEARANCE values for POLLUTION DEGREE 3. Since CONNECTORS are external and exposed, POLLUTION DEGREE 3 has been used.

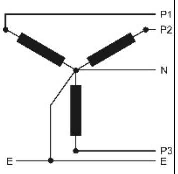
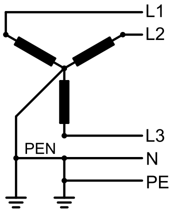
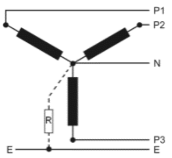
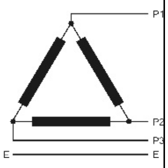
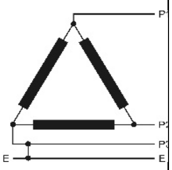
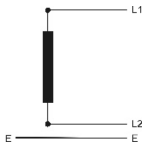
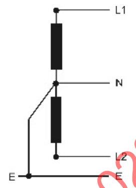
# Annex H 41
(informative)

## Line-to-neutral voltages for common mains supply systems

For the purposes of this document, Table H.1 gives the line-to-neutral voltage that should be used for determining CLEARANCE and solid insulation requirements of circuits connected to mains.

*Table H.1 is derived from Table B.1 of IEC 60664-1:2020. It is applicable to mains supply systems with inherent control (see IEC 60664-1:2020, 4.2.2.1).*

### Table H.1 – Line-to-neutral voltages for common mains supply systems

| Mains systems and nominal voltages | | | | | | Line-to-neutral voltage pertinent to mains system type and nominal voltage |
|---|---|---|---|---|---|---|
| **Three-phase four-wire systems [a]**<br>**with earthed neutral TT system**<br><br> <br>**TN-C-S System**<br><br> | **Three-phase four-wire systems [a]**<br>**with unearthed neutral (IT systems) [b, c]**<br><br> | **Three-phase three-wire systems**<br>**unearthed**<br><br> | **Three-phase three-wire systems**<br>**with earthed phase**<br><br> | **Single-phase two-wire systems**<br>**AC or DC**<br><br> | **Single-phase (split-phase) three-wire systems [a]**<br>**AC or DC**<br><br> | |
| V | V | V | V | V | V | V |
| | | | | 12,5 to 48 | 30/60 | 50 |
| 66/115 | | 66 | | 60 | | 100 |
| 120/208<br>127/220 | 120/208 | 110, 115<br>120, 127 | 100<br>120 | 100<br>110, 115<br>120, 127 | 100/200 [d]<br>110/220<br>115/230<br>120/240 | 150 |
| 220/380<br>230/400<br>240/415<br>260/440<br>277/480 | 230/400<br>277/480 | 200<br>220, 230, 240<br>260, 277, 347<br>380, 400, 415<br>440, 480 | 200<br>240 | 220<br>230<br>240 | 220/440<br>240/480 | 300 |
| 347/600<br>380/660<br>400/690<br>417/720<br>480/830 | 347/600<br>400/690 | 500<br>577<br>600 | 347<br>380, 400, 415<br>440, 480, 600 | 480 | 480/960 | 600 |
| | | 660<br>690, 720<br>830, 1 000 | | 1 000 | | 1 000 |
| | | | | 1 250, 1 500 | | 1 500 [e] |

[a] Voltages shown as two voltages separated by a "/" represent the phase-to-neutral (or line-to-neutral) voltage followed by the phase-to-phase (or line-to-line) voltage. For example, "120/208" indicates that the voltage from any phase to neutral is 120 V, and the voltage from any phase to another phase is 208 V. Likewise, "220/440" indicates that the voltage from either line-to-neutral is 220 V, and the voltage from line-to-line is 440 V.

[b] Z is an impedance which may connect neutral to earth (usually 1 500 Ω).

[c] When insulation is monitored, neutral of these systems is considered to be earthed.

[d] Practice in Japan.

[e] Only applicable for DC.

# Annex I
(informative)

## Index of defined terms

# Bibliography

IEC 60050-151~~:2001~~, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*

IEC 60050-195~~:1998~~, *International Electrotechnical Vocabulary – Part 195: Earthing and protection against electric shock*

~~IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*~~

~~IEC 60270, *High-voltage test techniques – Partial discharge measurements*~~

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*
IEC 60364-4-44:2007/AMD1:2015
IEC 60364-4-44:2007/AMD2:2018

IEC 60417, *Graphical symbols for use on equipment* (available at: http://www.graphical-symbols.info/equipment)

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

~~IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*~~
~~IEC 60664-3:2003/AMD1:2010~~

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

~~IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control and laboratory use*~~

IEC 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61010-2-032:2019, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-032: Particular requirements for hand-held and hand-manipulated current sensors for electrical test and measurement*

IEC 61010-2-033, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-033: Particular requirements for hand-held multimeters and other meters for domestic and professional use, capable of measuring mains voltage*

IEC 61010-2-034, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-034: Particular requirements for measurement equipment for insulation resistance and test equipment for electric strength*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61557-17, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 17: Non-contact AC voltage indicators*

IEC TS 62993:2017, *Guidance for determination of clearances, creepage distances and requirements for solid insulation for equipment with a rated voltage above 1 000 V AC and 1 500 V DC, and up to 2 000 V AC and 3 000 V DC*

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* (available at: http://www.iso.org/obp)

# List of comments

1 Subclause 5.3.3 of IEC GUIDE 104:2019 states that a group safety publication shall include in its scope the essence of the text. Description of the types of probe assemblies within the scope is moved to a new Clause 4.

2 Scope is enlarged to cover non-contact probe assemblies. Previously, non-contact probes for voltage detection or measurement felt in the scope from IEC 61010-1. Part 1 was not covering specific HAZARDS of non-contact probes which can touch uninsulated HAZARDOUS LIVE conductors.

3 Subclause 5.2.3 of IEC GUIDE 104:2019 requires to include these two paragraphs in the scope of a basic safety publication (BSP).

4 The standards referenced in this clause are dated to prevent any unwanted modifications of the requirements.

5 PROBE TIP applies now also to non-contact probes. The previous wording "makes a connection" was no longer appropriate.

6 A definition for REFERENCE CONNECTOR is needed. The reference point is usually the earth (ground) of the equipment under test.

7 It is the same definition as in IEC 61010-1.

8 It is the same definition as in IEC 61010-2-03x.

9 Definition is modified to fit with IEC 60050 International Electrotechnical Vocabulary.

10 Definition is modified to fit with IEC 60050 International Electrotechnical Vocabulary.

11 Definition is modified to fit with IEC 60050 International Electrotechnical Vocabulary.

12 It is the same definition as in IEC 61010-1.

13 Type B and Type C probe assemblies differ only by the voltage range. It is considered being no longer appropriate. Voltage range is removed, and Type C is deleted.

14 IEC 61557-4 and IEC 61557-14 require the equipment to be rated for MEASUREMENT CATEGORY II or III, and require test leads and test probes used with the measuring equipment to fulfil the requirements of IEC 61010-031. Type E probe assemblies are added to cover the 4-pole probe assemblies used for accurate resistance measurements in these specific environments.

15 IEC 61557-17:2021 defines minimum performance requirements for non-contact AC voltage indicators to reduce the risk of electric shock for the testing person and bystanders caused by the wrong interpretation of the indication. IEC 61557-17:2021 refers to IEC 61010-031:2015 for electrical safety, but IEC 61010-031:2015 does not include non-contact probe assemblies in its scope. Addition of Type F in this new edition fixes this inconsistency.

16 No HAZARD relating to the spread of fire in probe assemblies has been identified. The text of Clause 9 of edition 2.0, renumbered Clause 10 in this edition 3.0, which covers temperature limits and protection against the spread of fire is modified to cover only temperature limits.

17 It is not a new requirement, just a better classification of the HAZARDS covered by this document.

18 For example, a probe assembly can be fixed to an equipment, or a probe assembly can have insulated or protected outputs (e.g. a differential probe). In these situations, IEC 61010-031 should be read in conjunction with Part 1, Part 2-030, Part 2-032, Part 2-033 or Part 2-034.

19 It is considered that there is no risk of spread of fire for probe assemblies when a BASIC INSULATION is bridged.

20 After application of a fault condition, inspection of protection by BASIC INSULATION plus impedance or PROTECTIVE IMPEDANCE is considered, in addition to DOUBLE INSULATION and REINFORCED INSULATION.

21 Since the spread of fire is not considered as relevant for probe assemblies, there is no conformity statement needed.

22 Conformity statement of Subclause 13.2 *3)* of IEC 61010-031:2015+AMD1:2018 for removable parts of PROBE TIPS is ambiguous. Removable parts of PROBE TIPS are allowed when they comply with the new 13.2 *c)*.

23 Marking the voltage to earth value is not consistent with the MEASUREMENT CATEGORIES voltages which are based on the nominal AC RMS line-to-neutral or DC voltage of mains being measured:

- CLEARANCES for MEASUREMENT CATEGORIES are defined in Table 4 for the nominal AC RMS line-to-neutral or DC voltage of mains being measured,
- test voltages for testing solid insulation are defined in Table 8 and 9 for the nominal AC RMS line-to-neutral or DC voltage of mains being measured.

24 This statement is used when checking conformity of CONNECTORS or TERMINALS with different RATINGS connected in fully mated position or in partially mated position.

25 CLEARANCES for CONNECTORS in unmated position are recalculated (see Annex G for details of the calculation) and extended to 20 kV, in particular for probe assemblies used with equipment in the scope of IEC 61010-2-034.

26 Checking CLEARANCES by voltage is always an alternative.

27 Actually, a CONNECTOR in unmated position is not subjected to a permanent voltage which constrains it. CREEPAGE DISTANCES are specified to the same values as CLEARANCES although it is not necessary, but to avoid any question from the reader.

28 Conformity of IP2X PROBE TIPS above 1 000 V AC and 1 500 V DC is different from conformity given by Subclause 12.3.2 of IEC 60529. Main protection is ensured by protective FINGERGUARD or distance.

29 Values of Table 5 are recalculated according to IEC 60664-1:2020, Table F.2 for $D_1$ and Table F.8 for $D_2$ with extrapolation above 50 kV, in condition of inhomogeneous fields.

30 For checking the effects of transient overvoltages, the impulse voltage test is recommended.

31 Tables 8 and 9, previously Tables 14 and 4 of edition 2.0, are swapped, but values have not changed.

32 For MEASUREMENT CATEGORIES, the voltage which stresses the insulation is the nominal AC RMS line-to-neutral or DC voltage.

33 The test procedure for partial discharge is under consideration by IEC TC 66/WG 2. The minimum value of 1 mm for thickness and distance applies by default.

34 CLEARANCES of unmated CONNECTORS are measured or tested. This d) proposes a method for testing, using a test finger. As the test finger can be held at a HAZARDOUS LIVE voltage, precaution should be taken when performing this test.

35 Humidity preconditioning impregnates solid insulation sensitive to water. It has no effect on the air in the reference test conditions, and the CLEARANCES.

36 Each insulation (basic or supplementary) of a DOUBLE INSULATION shall be tested separately. DOUBLE INSULATION cannot be tested as REINFORCED INSULATION.

37 A CLEARANCE can be checked by a voltage test.

38 It has been stated that a probe assembly could contain fluids. If a probe assembly contains fluids, Part 1 applies.

39 Type E probe assemblies are supposed to be applied on non HAZARDOUS LIVE installation in normal use. In situation of REASONABLY FORESEEABLE MISUSE, the risk of short circuiting two high-energy conductors at different potentials is considered as reasonable.

40 A new figure is designed to clarify the MEASUREMENT CATEGORIES locations.

41 This new Annex H specifies the line-to-neutral voltage pertinent to mains system used by CLEARANCES and solid insulation for MEASUREMENT CATEGORIES. It is similar to Annex I of IEC 61010-1.

# IEC 61010-031

Edition 3.0 2022-12

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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GROUP SAFETY PUBLICATION
PUBLICATION GROUPÉE DE SÉCURITÉ

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

## Exigences de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire –
## Partie 031: Exigences de sécurité pour sondes équipées tenues à la main et manipulées pour mesurage et essais électriques

IEC 61010-031:2022-12(en-fr)

## CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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

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

This third edition cancels and replaces the second edition published in 2015, and Amendment 1:2018. IEC 61010-031 is a stand-alone standard.

This edition includes the following significant technical changes with respect to the previous edition:

a) the scope has been made succinct. General information from the scope of Edition 2 has been moved to a new Clause 4. Consequently, Clause 4 to Clause 8 of Edition 2 have been renumbered. Clause 9 of Edition 2 has been deleted;

b) in Clause 2, normative references have been dated and new normative references have been added;

c) in 3.1.4, the definition of PROBE TIP has been modified;

d) in 4.1, there is no longer any differentiation between high voltage and low voltage probe assemblies. Type C probe assemblies have been merged with Type B probe assemblies;

e) in 4.1 d) "Kelvin" probes have been added to the list of probe assemblies as a new Type E and a new Figure 5;

f) in 4.1 e), probes for voltage measurement without electrical connection to conductors have been added to the list of probe assemblies as a new Type F and a new Figure 6;

g) in 4.2.1, spread of fire is no longer considered as a HAZARD;

h) Subclause 4.4.2.5 from Edition 2 has been deleted;

i) Subclause 4.4.4.3 from Edition 2 has been deleted;

j) in 5.4.4.1 consideration has been given to SPACINGS and impedance;

k) in 6.1.1, removable parts of PROBE TIPS which bear markings are allowed;

l) in 6.1.5, the voltage to be marked for MEASUREMENT CATEGORIES is the AC line-to-neutral or DC voltage;

m) in 7.4.2, requirements for unmated CONNECTORS have been modified as follows:

   1) Table 2 has been modified and expanded,

   2) a calculation method for CLEARANCES of CONNECTORS above 20 kV has been defined,

   3) CREEPAGE DISTANCES have been aligned with CLEARANCES;

n) in 7.4.3.1 and 7.4.3.5, requirements for IP2X PROBE TIPS with retractable sleeve have been added;

o) in 7.4.3.2, PROBE TIPS are now applicable to non-contact probe assemblies;

p) in 7.5.2.3.2, the values of Table 5 have been modified;

q) in 7.6.2, voltage tests of CLEARANCES are done without humidity preconditioning;

r) pre-treatments for rigidity test from Clause 10 of Edition 2 have been moved to 9.2;

s) Subclause 11.1 of Edition 2 has been deleted;

t) addition of an exception for Type E probe assembly in 13.2. Removable parts of PROBE TIPS which bear markings are allowed;

u) Figure F.1 has been modified;

v) Annex G has been added, for determination of CLEARANCES for Table 2**;**

w) Annex H has been added, covering line-to-neutral voltages for common mains supply systems.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 66/770/FDIS | 66/771/RVD |

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

In this document 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 document which have been defined in Clause 3: SMALL ROMAN CAPITALS.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

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

## 1 Scope

This part of IEC 61010 specifies safety requirements for hand-held and hand-manipulated probe assemblies for electrical test and measurement, and their related accessories. These probe assemblies are for non-contact or direct electrical connection between a part and electrical test and measurement equipment. They can be fixed to the equipment or be detachable accessories for the equipment.

This group safety publication focusing on safety essential requirements is primarily intended to be used as a product safety standard for the products mentioned in the scope, but is also intended to be used by technical committees in the preparation of publications for products similar to those mentioned in the scope of this group safety publication, in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications and/or group safety publications in the preparation of its publications.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*
IEC 60027-1:1992/AMD1:1997
IEC 60027-1:1992/AMD2:2005

IEC 60027-2:2019, *Letter symbols to be used in electrical technology – Part 2: Telecommunications and electronics*

IEC 60027-4:2006, *Letter symbols to be used in electrical technology – Part 4: Rotating electric machines*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*
IEC 61010-1:2010/AMD1:2016

IEC 61180:2016, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply (see Annex I for index of defined terms).

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

### 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, etc.

**3.1.2**
**ENCLOSURE**
part providing protection of a probe assembly against certain external influences and, in any direction, protection against direct contact

**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 can touch the point being measured or tested

**3.1.5**
**CONNECTOR**
component which is attached to the PROBE WIRE, to connect the probe assembly to a TERMINAL of the equipment or to another probe assembly

**3.1.6**
**REFERENCE CONNECTOR**
CONNECTOR for connection to a reference point

**3.1.7**
**TOOL**
external device, including a key or coin, used to aid a person performing a mechanical function

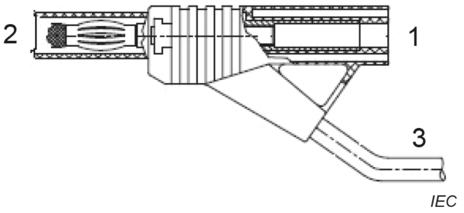
**3.1.8**
**PROBE WIRE**
flexible wire or cable used as part of the probe assembly or its accessories, consisting of one or more conductors and associated insulation

**3.1.9**
**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

### 3.1.10
**STACKABLE CONNECTOR**

CONNECTOR assembly which contains an additional TERMINAL

EXAMPLE Figure 1 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 1 – Example of a STACKABLE CONNECTOR with a male CONNECTOR and a female TERMINAL**

## 3.2 Quantities

### 3.2.1
**RATED**

RATED value

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

### 3.2.2
**RATING**

set of RATED values and operating conditions

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

### 3.2.3
**WORKING VOLTAGE**

highest RMS value of the AC or DC voltage across any particular insulation which can continuously appear during NORMAL USE

Note 1 to entry: 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 a probe assembly (or parts of a probe assembly) made to a particular design, to show that the design and construction meet the requirements of this document

Note 1 to entry: This is an enlargement of the IEC 60050-151:2001, 151-16-16 definition to cover design as well as construction.

### 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**

able to be touched with a standard test finger or test pin, when used as specified in 7.2

### 3.4.2

**HAZARDOUS LIVE**

capable of rendering an electric shock or electric burn

### 3.4.3

**HAZARD**

potential source of harm

### 3.4.4

**PROTECTIVE IMPEDANCE**

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

### 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 1 to entry: If a SINGLE FAULT CONDITION results unavoidably in one or more other fault conditions, all the failures are considered as one SINGLE FAULT CONDITION.

### 3.4.8

**OPERATOR**

person operating the probe assembly for its intended purpose

### 3.4.9

**RESPONSIBLE BODY**

individual or group responsible for the safe use and maintenance of 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 probe assembly, or wetting of the contact between the human body and the environment

### 3.4.11

**MEASUREMENT CATEGORY**

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

Note 1 to entry: MEASUREMENT CATEGORIES take into account overvoltage categories, short-circuit current levels, the location where the test or measurement is to be made and some forms of energy limitation or transient protection included in the building installation (see Annex F for more information).

### 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 which provides basic protection

Note 1 to entry: This concept does not apply to insulation used exclusively for functional purposes.

[SOURCE: IEC 60050-195:2021, 195-06-06]

### 3.5.2
**SUPPLEMENTARY INSULATION**
independent insulation applied in addition to BASIC INSULATION that provides fault protection

[SOURCE: IEC 60050-195:2021, 195-06-07]

### 3.5.3
**DOUBLE INSULATION**
insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

[SOURCE: IEC 60050-195:2021, 195-06-08]

### 3.5.4
**REINFORCED INSULATION**
insulation that provides a degree of protection against electric shock equivalent to DOUBLE INSULATION

Note 1 to entry: REINFORCED INSULATION can comprise several layers that cannot be tested singly as BASIC INSULATION or SUPPLEMENTARY INSULATION.

[SOURCE: IEC 60050-195:2021, 195-06-09]

### 3.5.5
**POLLUTION**
addition of foreign matter, solid, liquid or gaseous (ionized gases), that can produce a reduction of dielectric strength or surface resistivity

### 3.5.6
**POLLUTION DEGREE**
numeral indicating the level of POLLUTION that can be present in the environment

### 3.5.7
**POLLUTION DEGREE 1**
no POLLUTION or only dry, non-conductive POLLUTION occurs, which has no influence

### 3.5.8
**POLLUTION DEGREE 2**
only non-conductive POLLUTION 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

Note 1 to entry: In such conditions, probe assembly is normally protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity is controlled.

### 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

[SOURCE: IEC 60050-151:2001, 151-15-50]

### 3.5.12
**SPACING**

any combination of CLEARANCES and CREEPAGE DISTANCES

# 4 General

## 4.1 Type of probe assemblies

The safety of the following types of probe assemblies are covered by this document.

a) Type A: non-attenuating probe assemblies. Non-attenuating probe assemblies that are RATED for direct connection to voltages exceeding 30 V AC RMS, 42,4 V peak, or 60 V DC, but not exceeding 63 kV. They do not incorporate components which are intended to provide a voltage divider function or a signal conditioning function, but they can contain non-attenuating components such as fuses (see Figure 2).

b) Type B: attenuating or divider probe assemblies. Attenuating or divider probe assemblies that are RATED for direct connection to voltages exceeding 30 V AC RMS, 42,4 V peak, or 60 V DC but not exceeding 63 kV. The divider function can 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 3 a) and Figure 3 b)).

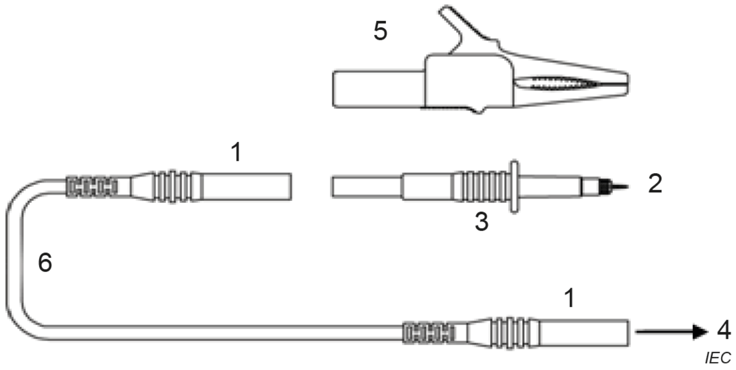
c) Type D: attenuating, non-attenuating or other signal conditioning probe assemblies that are RATED for direct connection only to voltages not exceeding 30 V AC RMS, 42,4 V peak, or 60 V DC, and are suitable for currents exceeding 8 A (see Figure 4).

d) Type E: non-attenuating probe assemblies for 4-pole precise resistance measurements (see Figure 5).

   EXAMPLE: Kelvin probes.

e) Type F: probe assemblies for non-contact AC voltage test and measurement. These probe assemblies are intended for use on insulated or non-insulated conductors without electrical contact (see Figure 6).

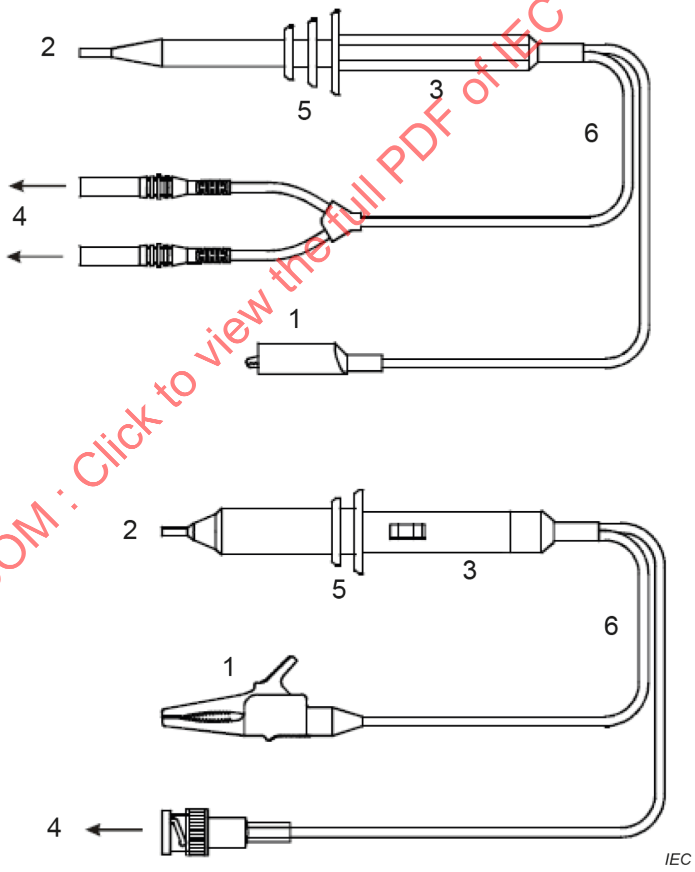
   NOTE Type F probe assemblies can be stand-alone probes or connected by a PROBE WIRE to equipment.



**Key**

| | | | |
|---|---|---|---|
| 1 | CONNECTOR (typical) | 4 | to equipment |
| 2 | PROBE TIP | 5 | SPRING-LOADED CLIP |
| 3 | hand-held area of probe body | 6 | PROBE WIRE |

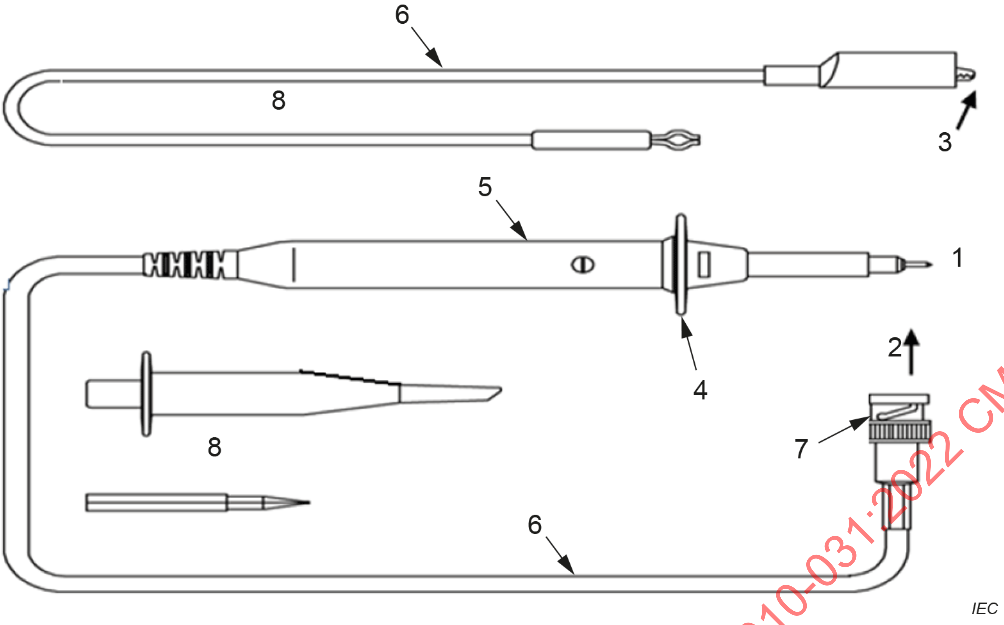
Figure 2 – Examples of Type A probe assemblies



**Key**

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

Figure 3 a) – High-voltage Type B probe assemblies

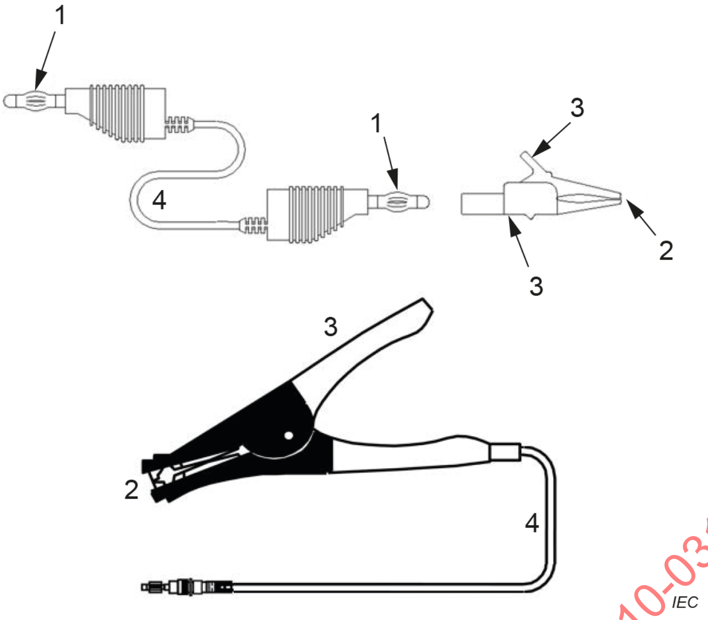


**Key**

| | | | |
|---|---|---|---|
| 1 | PROBE TIP | 5 | hand-held area of probe body |
| 2 | to equipment | 6 | PROBE WIRE |
| 3 | REFERENCE CONNECTOR | 7 | BNC CONNECTOR |
| 4 | PROTECTIVE FINGERGUARD | 8 | examples of accessories |

**Figure 3 b) – Low-voltage Type B probe assemblies**

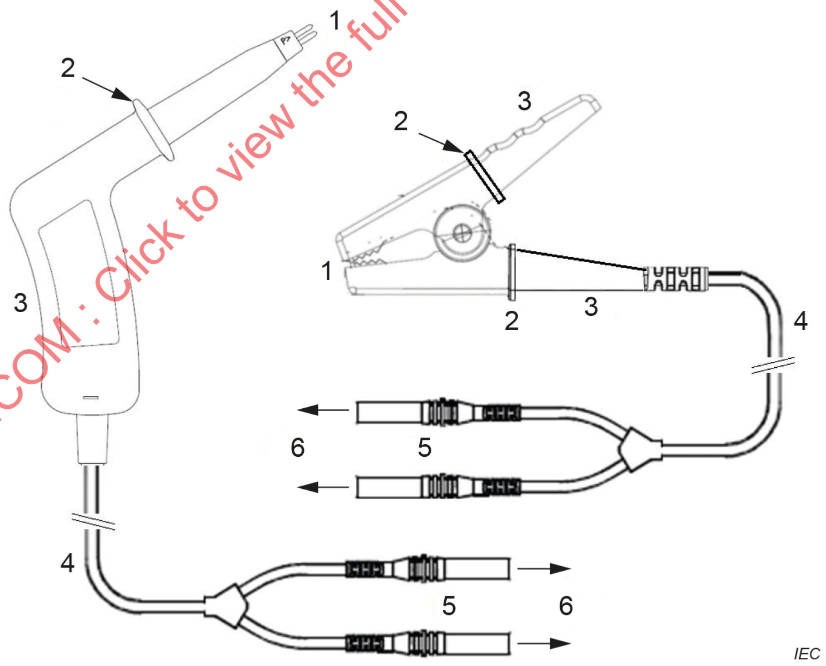
**Figure 3 – Example of Type B probe assemblies**



**Key**

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

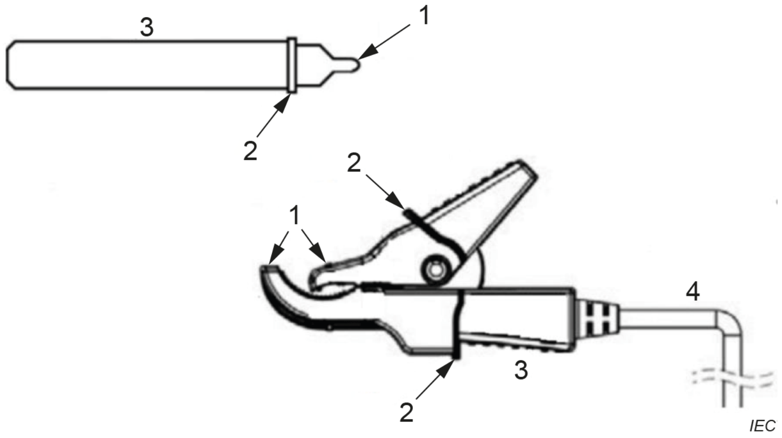
Figure 4 – Examples of Type D probe assemblies



**Key**

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

Figure 5 – Examples of Type E probe assemblies



**Key**

| | | | |
|---|---|---|---|
| 1 | PROBE TIP | 3 | hand-held area of probe body |
| 2 | PROTECTIVE FINGERGUARD | 4 | PROBE WIRE to equipment |

**Figure 6 – Examples of Type F probe assemblies**

This document does not apply to current sensors within the scope of IEC 61010-2-032:2019.

## 4.2 Safety aspects

### 4.2.1 Identified HAZARDS

The purpose of the requirements of this document is to ensure that HAZARDS to the OPERATOR and the surrounding area are reduced to a tolerable level.

Requirements for protection against particular types of HAZARDS are given in Clause 7 to Clause 11 and Clause 13, as follows:

a) electric shock or burn (see Clause 7);
b) mechanical HAZARDS (see Clause 8 and Clause 9);
c) excessive temperature (see Clause 10);
d) effects of fluids (see Clause 11);
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 document are in other parts of IEC 61010.

NOTE Attention is drawn to the possible existence of additional requirements regarding the health and safety of labour forces.

### 4.2.2 Aspects excluded

This document does not cover:

a) reliable function, performance, or other properties of the probe assembly;
b) effectiveness of transport packaging.

## 4.3 Verification

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

### 4.4 Environmental conditions

### 4.4.1 Normal environmental conditions

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

a) altitude up to 2 000 m;

b) ambient temperature of 5 °C to 40 °C;

c) maximum relative humidity of 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;

d) applicable POLLUTION DEGREE of the intended environment.

### 4.4.2 Extended environmental conditions

This document applies to probe assemblies designed to be safe not only in the environmental conditions specified in 4.4.1, but also in any of the following conditions as RATED by the manufacturer of the probe assembly:

a) outdoor use;

b) altitude above 2 000 m;

c) ambient temperatures below 5 °C or above 40 °C;

d) relative humidity above the levels specified in 4.4.1;

e) WET LOCATION.

## 5 Tests

### 5.1 General

Tests in this document 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 to this document. 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 document. It is permissible to exceed the requirements. If, in this document, 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 document, and used in accordance with them, need not be repeated during TYPE TESTS of the whole probe assembly.

If a probe assembly consists of more than one probe type (see 4.1), each type shall be tested in accordance with its applicable requirements.

*Conformity to the requirements of this document 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 5.3) and fault conditions (see 5.4).*

*Where conformity statements in this document 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.*

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

*a) manufacturers should ensure that at least the specified test value is applied;*

*b) test houses should ensure that no more than the specified test value is applied.*

If the RATED range of environmental conditions for probe assemblies is wider than that stated in 4.4.1, the manufacturer should make sure (for example, by suitable alteration of test requirements or additional tests) that the safety requirements of this document are still fulfilled.

Probe assemblies which have undergone TYPE TESTS may no longer be suitable for their intended function because of the residual effect of stresses resulting from tests. A probe assembly which has undergone TYPE TESTS shall not then be put into use.

### 5.2 Sequence of tests

The sequence of tests is optional unless otherwise specified. The probe assemblies under test shall be carefully inspected after each test. If the result of a test causes doubt as to whether any earlier tests would have passed if the sequence had been reversed, these earlier tests shall be repeated.

### 5.3 Reference test conditions

#### 5.3.1 Environmental conditions

Unless otherwise specified in this document, the following environmental conditions (but not conflicting with those of 4.4.1) 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.

#### 5.3.2 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 5.3.3 to 5.3.9.

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 document.

#### 5.3.3 Position of the probe assembly

All possible orientations of the probe assembly are considered to be positions of NORMAL USE.

#### 5.3.4 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.

#### 5.3.5 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.

### 5.3.6 Input and output voltages

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

### 5.3.7 Controls

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

### 5.3.8 Connections

The probe assembly shall be connected for NORMAL USE or not connected whichever is the worst condition.

### 5.3.9 Short-term or intermittent operation

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.

## 5.4 Testing in SINGLE FAULT CONDITION

### 5.4.1 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 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 5.3). These combinations may be different for different faults and they shall be recorded for each test.

### 5.4.2 Application of fault conditions

#### 5.4.2.1 General

Fault conditions shall include those specified in 5.4.2.2 to 5.4.2.4. 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 5.4.4.

#### 5.4.2.2 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 7.4.5, it need not be short-circuited or disconnected.

#### 5.4.2.3 Probe assemblies or parts for short-term or intermittent operation

Probe assemblies or parts for short-term or intermittent operation shall be operated continuously if continuous operation could occur in a SINGLE FAULT CONDITION.

#### 5.4.2.4 Outputs

Outputs of Type B probe assemblies shall be short-circuited.

### 5.4.3 Duration of tests

The probe assembly shall be operated until the point when it is unlikely that further change as a result of the applied fault will occur. 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 there is an indication that a HAZARD of electric shock or injury to persons may eventually occur, the test shall be continued for a maximum period of 4 h.

### 5.4.4 Conformity after application of fault conditions

#### 5.4.4.1 Electric shock

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

a) *by making the measurements of 7.3.3 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE, except as permitted by 7.1;*

b) *by performing a voltage test on DOUBLE INSULATION, REINFORCED INSULATION or BASIC INSULATION plus impedance when the impedance is short-circuited to check that the protection is still at least at the level of BASIC INSULATION. The voltage tests are made as specified in 7.6 (without humidity preconditioning) with the test voltage for BASIC INSULATION;*

c) *by inspection and measurements of the SPACINGS for the levels of BASIC INSULATION. This also applies to impedance or PROTECTIVE IMPEDANCE.*

#### 5.4.4.2 Temperature

*Conformity with requirements for temperature protection is checked by determining the temperature of the outer surface of the probe assembly (see Clause 10).*

*This temperature is determined by measuring the temperature rise of the surface or part and adding it to the ambient temperature of 40 °C, or to the maximum RATED ambient temperature, if higher.*

#### 5.4.4.3 Other HAZARDS

*Conformity with the requirements for protection against other HAZARDS is checked as specified in Clause 8 to Clause 13.*

## 5.5 Tests in REASONABLY FORESEEABLE MISUSE

### 5.5.1 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.

### 5.5.2 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 flash.

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 the 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.*

# 6 Marking and documentation

## 6.1 Marking

### 6.1.1 General

Probe assemblies shall bear markings in accordance with 6.1.2 to 6.2. 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, except for removable parts of PROBE TIPS if they comply with 13.2.

Letter symbols for quantities and units shall be in accordance with IEC 60027-1:1992, IEC 60027-1:1992:AMD1:1997, and IEC 60027-1:1992/AMD2:2005, IEC 60027-2:2019 and IEC 60027-4:2006. Graphical 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 graphical symbol may be used on a probe assembly provided the symbol is explained in the accompanying documentation (see 6.4.1).

If it is not possible to put all of the required markings on the part, the necessary information shall be included in the documentation specified in 6.4.1. Symbol 7 of Table 1 shall also be used.

*Conformity is checked by inspection.*

### 6.1.2 Identification

Each probe assembly and, when possible, its accessories shall be marked with:

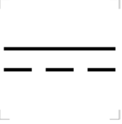
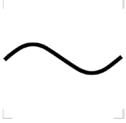
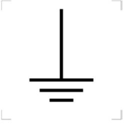
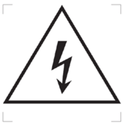
a) the name or registered trademark of the manufacturer or supplier;

b) in addition for Type B 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 |  | IEC 60417-5017 (2006-08) | Earth (ground) TERMINAL |
| 5 |  | IEC 60417-6042 (2010-11) | Caution, risk of electric shock |
| 6 |  | IEC 60417-5041 (2002-10) | Caution, hot surface |
| 7 |  | ISO 7000-0434A (2004-01) or<br>ISO 7000-0434B (2004-01) | Caution [a] |

[a] See 6.4.1 which requires manufacturers to state that documentation must be consulted in all cases where this symbol is marked.

### 6.1.3 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 there is not sufficient space to mark these details, 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.*

### 6.1.4 CONNECTORS and operating devices

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

*Conformity is checked by inspection.*

### 6.1.5 RATING

The RATING of probe assemblies shall be marked as follows:

a) probe assemblies which do not have a RATING for MEASUREMENT CATEGORIES shall be marked with the RATED voltage to earth and with symbol 7 of Table 1 (see also 6.4.3 k));

b) probe assemblies for measurements within MEASUREMENT CATEGORIES II, III and IV shall be marked with the RATED AC RMS line-to-neutral or DC voltage and the relevant MEASUREMENT CATEGORIES.

   The MEASUREMENT CATEGORY markings shall be "CAT II", "CAT III" or "CAT IV" as applicable.

   NOTE CLEARANCES and solid insulation are specified for nominal AC RMS line-to-neutral or DC voltages of mains being measured. Neutral is considered to be earthed (see Annex H).

If it is possible (see 6.1.1), marking on a probe assembly shall be on the probe body. The nature of the voltage (AC, DC, etc.) shall also be marked, unless the voltage marking applies to both AC RMS and DC. If a REFERENCE CONNECTOR is intended for connection to points at a voltage level exceeding the values of 7.3.2, the RATED voltage to earth shall be marked on the CONNECTOR or as close to the CONNECTOR as is practicable.

For Type A, Type D and Type E probe assemblies only, the RATED current of the probe assembly shall be marked together with the RATED voltage. The 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.*

## 6.2 Warning markings

Warning markings shall be 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 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 Clause 10 to exceed the temperature limits shall be marked with symbol 6 of Table 1.

*Conformity is checked by inspection.*

## 6.3 Durability of markings

Required markings shall remain clear and legible under conditions of NORMAL USE and shall resist the effects of cleaning agents specified by the manufacturer (see 11.1).

*Conformity is checked 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.*

## 6.4 Documentation

### 6.4.1 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 6.4.2 to 6.4.4.

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 must 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.*

### 6.4.2 Probe assembly RATING

Documentation shall include the 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 4.4).

*Conformity is checked by inspection.*

### 6.4.3 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 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 6.1.5);
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;
h) instructions for replacement of consumable materials;
i) for probe assemblies 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, a warning not to use the probe assemblies for measurements on mains circuits;

l) for Type B probe assemblies RATED for voltages above 1 000 V AC RMS or 1 500 V DC, if the RATED voltage of the PROBE WIRE is lower than the RATED voltage of the PROBE TIP, a warning that the PROBE WIRE will 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 lowest of the MEASUREMENT CATEGORIES of the probe assembly and of the accessory.

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.*

### 6.4.4 Probe assembly maintenance and service

Instructions shall be provided to the RESPONSIBLE BODY 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 its agent.

The RATING and characteristics of fuses used shall be stated (see 6.1.3).

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.*

## 7 Protection against electric shock

### 7.1 General

Protection against electric shock shall be maintained in NORMAL CONDITION and in SINGLE FAULT CONDITION. ACCESSIBLE parts of probe assemblies shall not be HAZARDOUS LIVE (see 7.3).

If it is not feasible for operating reasons to prevent the following parts from 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 6.2;

b) PROBE TIPS, provided that they meet the requirements of 7.4.3;

c) unmated CONNECTORS as specified in 7.4.2.4 1).

*Conformity is checked by the determination of 7.2 and the measurements of 7.3, followed by the inspection and tests of 7.4 to 7.7.*

## 7.2 Determination of ACCESSIBLE parts

### 7.2.1 General

*Unless obvious, determination of whether a part is ACCESSIBLE is made as specified in 7.2.2 and 7.2.3. Test fingers (see Figure B.1 and Figure B.2 of Annex B) and pins are applied without force. Parts are considered to be ACCESSIBLE if they can be touched with any part of a test finger or pin, or if they could be touched in the absence of a covering which is not considered to provide suitable insulation (see 7.7.2).*

*If in NORMAL USE an OPERATOR is intended to perform any actions (with or without a TOOL) that could increase the accessibility of parts, such actions are taken before performing the examinations of 7.2.2 and 7.2.3.*

*NOTE Examples of such actions include:*

*a) removing covers;*

*b) adjusting controls;*

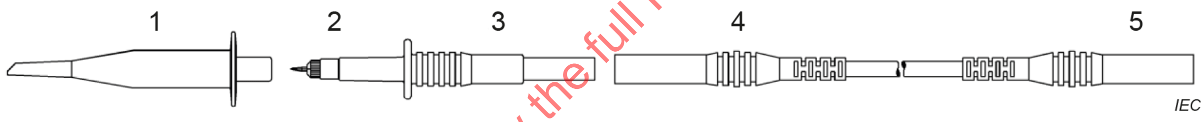
*c) replacing consumable materials;*

*d) removing or installing parts and supplied accessories.*

*Figure 7 gives methods for determination of ACCESSIBLE parts of probe assemblies.*

### 7.2.2 Examination

*The jointed test finger (see Figure B.2) is applied in every possible position without force. The test is applied to all outer surfaces.*



**Key**

1 accessory PROBE TIP

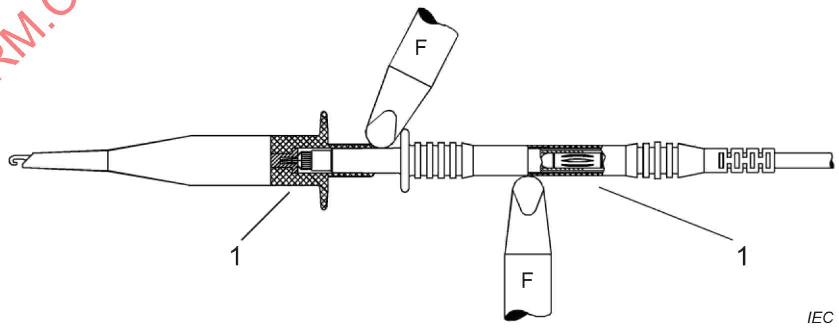
2 PROBE TIP

3 hand-held area of probe body

4 CONNECTOR

5 CONNECTOR to equipment

**Figure 7 a) – Parts of a probe assembly**

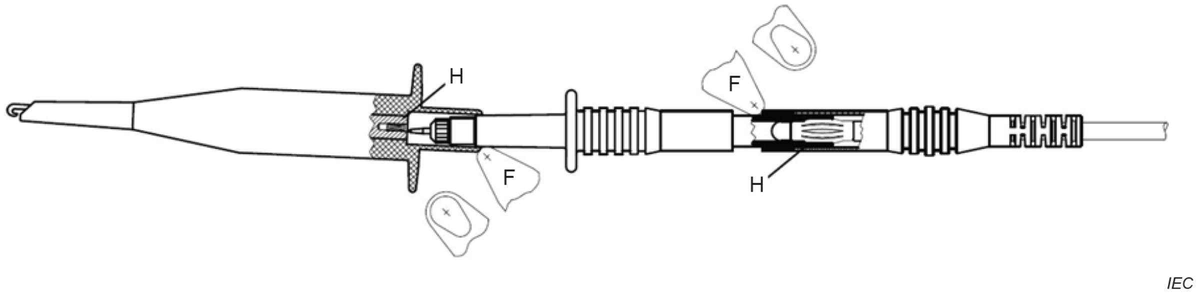


**Key**

1 CONNECTOR

F jointed test finger (see Figure B.2)

**Figure 7 b) – Fully mated probe assembly (see 7.4.2.2)**



**Key**

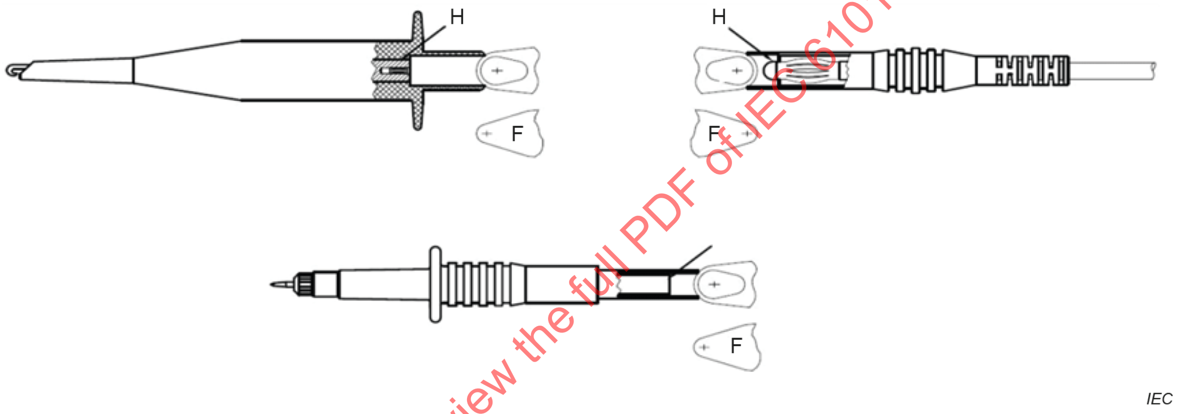
F jointed test finger (see Figure B.2)

H potentially HAZARDOUS LIVE part

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

Note the two possible positions of the test finger.

**Figure 7 c) – Partially mated probe assemblies (see 7.4.2.3)**



**Key**

F jointed test finger (see Figure B.2)

H potentially HAZARDOUS LIVE part

Note the two possible positions of the test finger.

**Figure 7 d) – Unmated parts of a probe assembly (see 7.4.2.4)**

**Figure 7 – Methods for determination of ACCESSIBLE parts**

### 7.2.3 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.*

## 7.3 Limit values for ACCESSIBLE parts

### 7.3.1 General

Except as permitted in 7.1, the voltage between an ACCESSIBLE part and earth, or between any two ACCESSIBLE parts on the same probe assembly, shall not exceed the levels of 7.3.2 in NORMAL CONDITION or of 7.3.3 in SINGLE FAULT CONDITION.

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 7.3.4). If the voltage is below the levels of 7.3.2 a) or 7.3.3 a) as applicable, the touch current and the capacitance need not be measured. If the voltage exceeds that level, the touch current and the capacitance shall be measured. For high frequencies test probes RATED for frequencies above 100 kHz, the alternative method of 7.3.4.3 can also be used.

*Conformity is checked by inspection and as specified in 7.3.2, 7.3.3 and 7.3.4.*

### 7.3.2 Levels in NORMAL CONDITION

Voltages above the levels of 7.3.2 a) are deemed to be HAZARDOUS LIVE if any of the levels of 7.3.2 b) or 7.3.2 c) are exceeded at the same time.

a) The AC voltage level is 30 V RMS or 42,4 V peak, and the DC voltage level is 60 V. For probe assemblies intended for use in WET LOCATIONS, the AC voltage level is 16 V RMS or 22,6 V peak, and the DC voltage level is 35 V.

b) The touch current levels are:

   1) 0,5 mA RMS for sinusoidal waveforms, 0,7 mA peak for non-sinusoidal waveforms or mixed frequencies, or 2 mA DC, 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 intended for use in WET LOCATIONS.

   2) 70 mA RMS when measured with measuring circuit of Figure A.3. This relates to possible burns at frequencies above 100 kHz.

c) The levels of capacitive charge or energy are:

   1) 45 µC charge for voltages up to 15 kV peak or 15 kV DC. Line A of Figure 8 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 15 kV DC.

### 7.3.3 Levels in SINGLE FAULT CONDITION

In SINGLE FAULT CONDITION, voltages above the levels of 7.3.3 a) are deemed to be HAZARDOUS LIVE if any of the levels of 7.3.3 b) or 7.3.3 c) are exceeded at the same time.

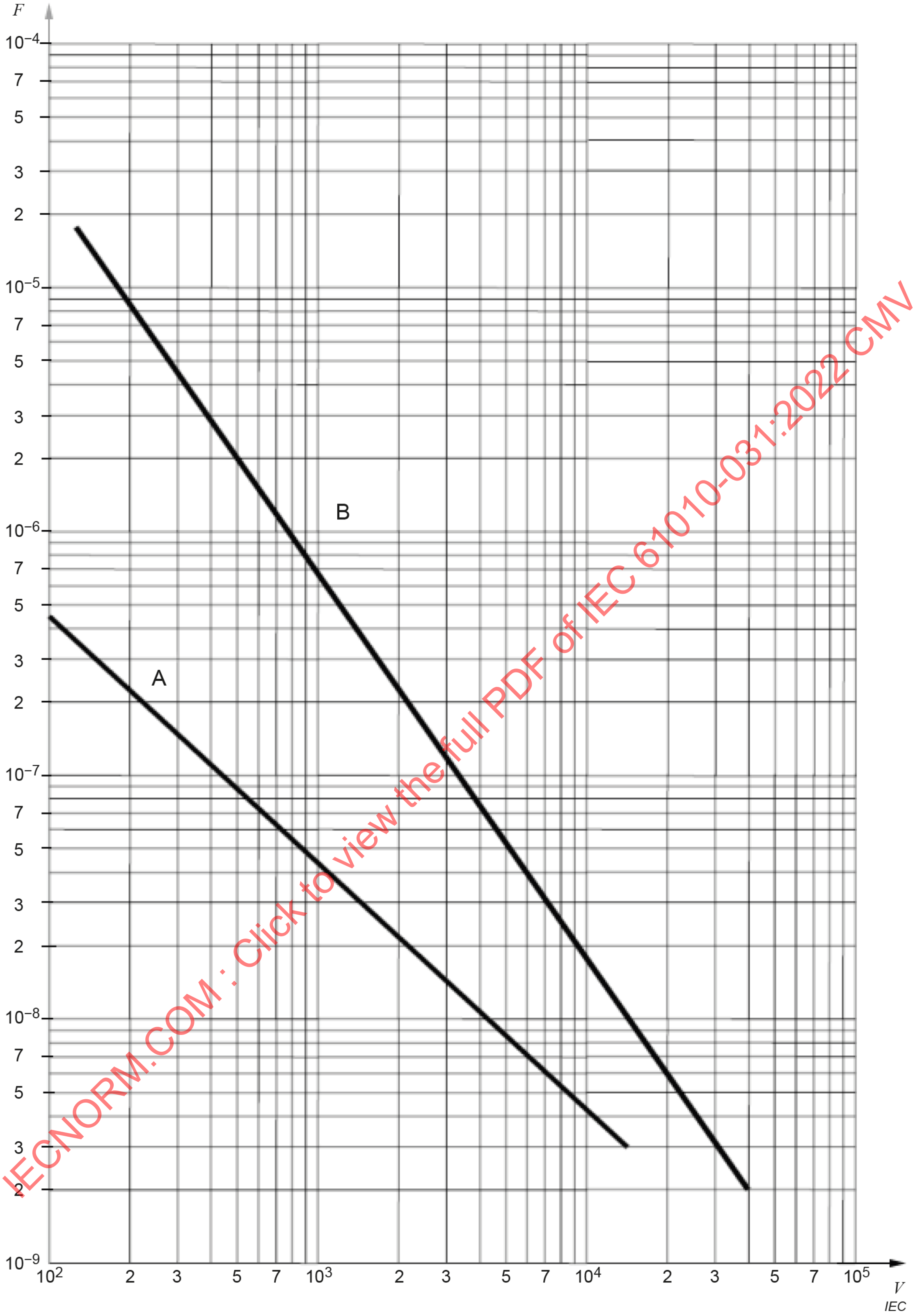
a) The AC voltage level is 50 V RMS or 70,7 V peak, and the DC voltage level is 120 V. For probe assemblies intended for use in WET LOCATIONS, the AC voltage level is 33 V RMS or 46,7 V peak, and the DC voltage level is 70 V.

b) The touch current levels are:

   1) 3,5 mA RMS for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA DC, 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 intended for use in WET LOCATIONS.

   2) 500 mA RMS when measured with the measuring circuit of Figure A.3. This relates to possible burns at frequencies above 100 kHz.

c) The capacitance level is line B of Figure 8.



**Key**

A = NORMAL CONDITION

B = SINGLE FAULT CONDITION

Figure 8 – Capacitance level versus voltage in NORMAL CONDITION and SINGLE FAULT CONDITION (see 7.3.2 c) and 7.3.3 c))

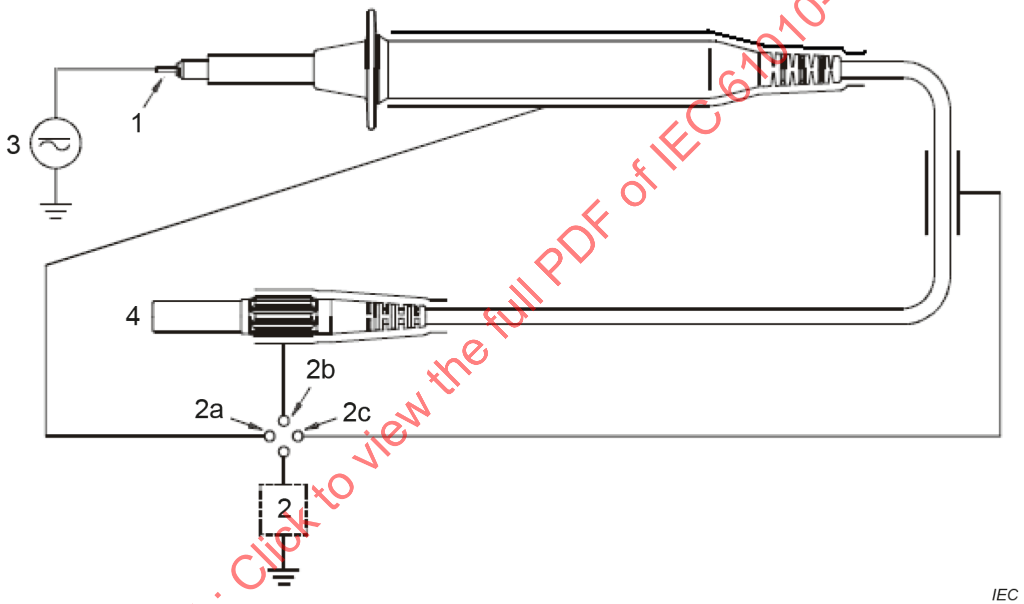
### 7.3.4 Measurement of voltage and touch current

#### 7.3.4.1 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) hand-held or hand-manipulated parts of each CONNECTOR;*
- *c) 150 mm ± 20 mm of the PROBE WIRE or the maximum length of the cable whichever is shorter;*
- *d) other hand-held or hand-manipulated parts.*

*The highest 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, then 2b, and then 2c of Figure 9) between each of the foil-wrapped items and the earth (see Figure 9 and Figure 10).*



**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

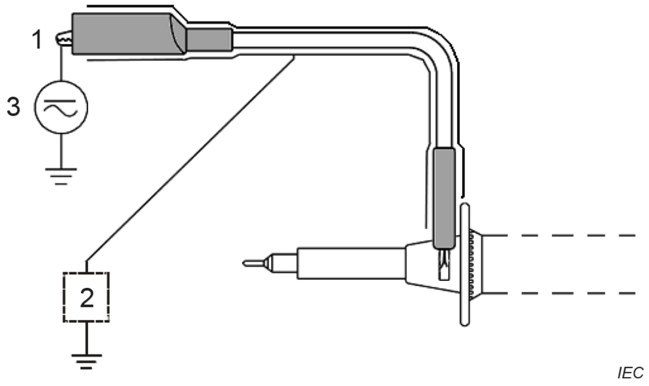
2b connection to metal foil tightly wrapped around the CONNECTOR

2c connection to metal foil tightly wrapped around the cable

3 highest RATED voltage with connection to internal conductor of the PROBE WIRE

4 not connected to test or measuring equipment

**Figure 9 – 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)

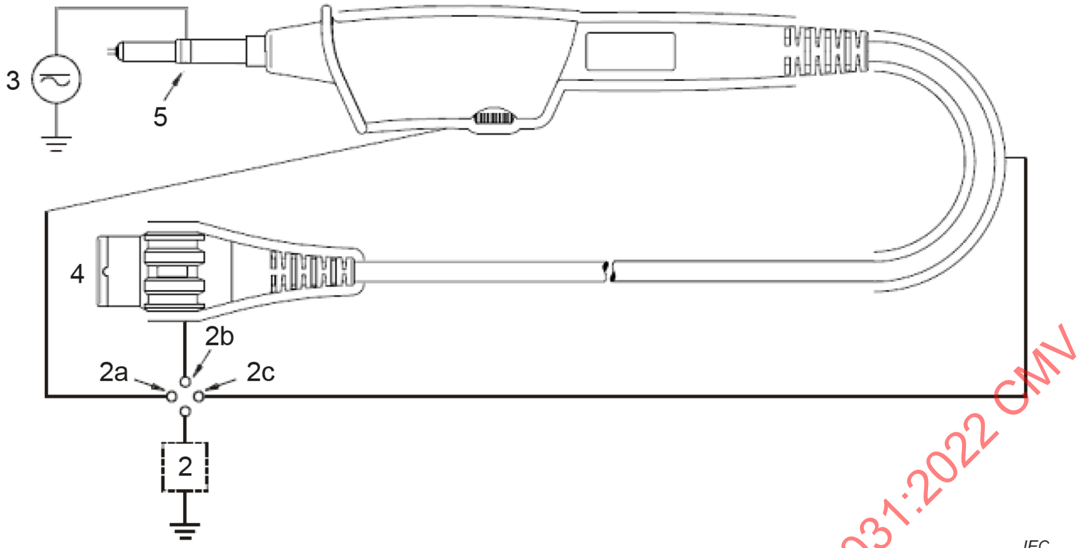
3 highest RATED voltage for the REFERENCE CONNECTOR

**Figure 10 – Voltage and touch current measurement for the REFERENCE CONNECTOR**

### 7.3.4.2 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 *(Figure 11, item 5) and the earth (see Figure 11).*

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



**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

3 highest 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 11 – Voltage and touch current measurement with shielded test probe**

### 7.3.4.3 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 is determined to avoid electrical burns. The touch current is measured in the whole frequency range and at maximum voltage in each frequency range.*

*The measurements are made (see Figure 11):*

*a) between the shield and the foil around the probe body (Figure 11, item 2a), and*

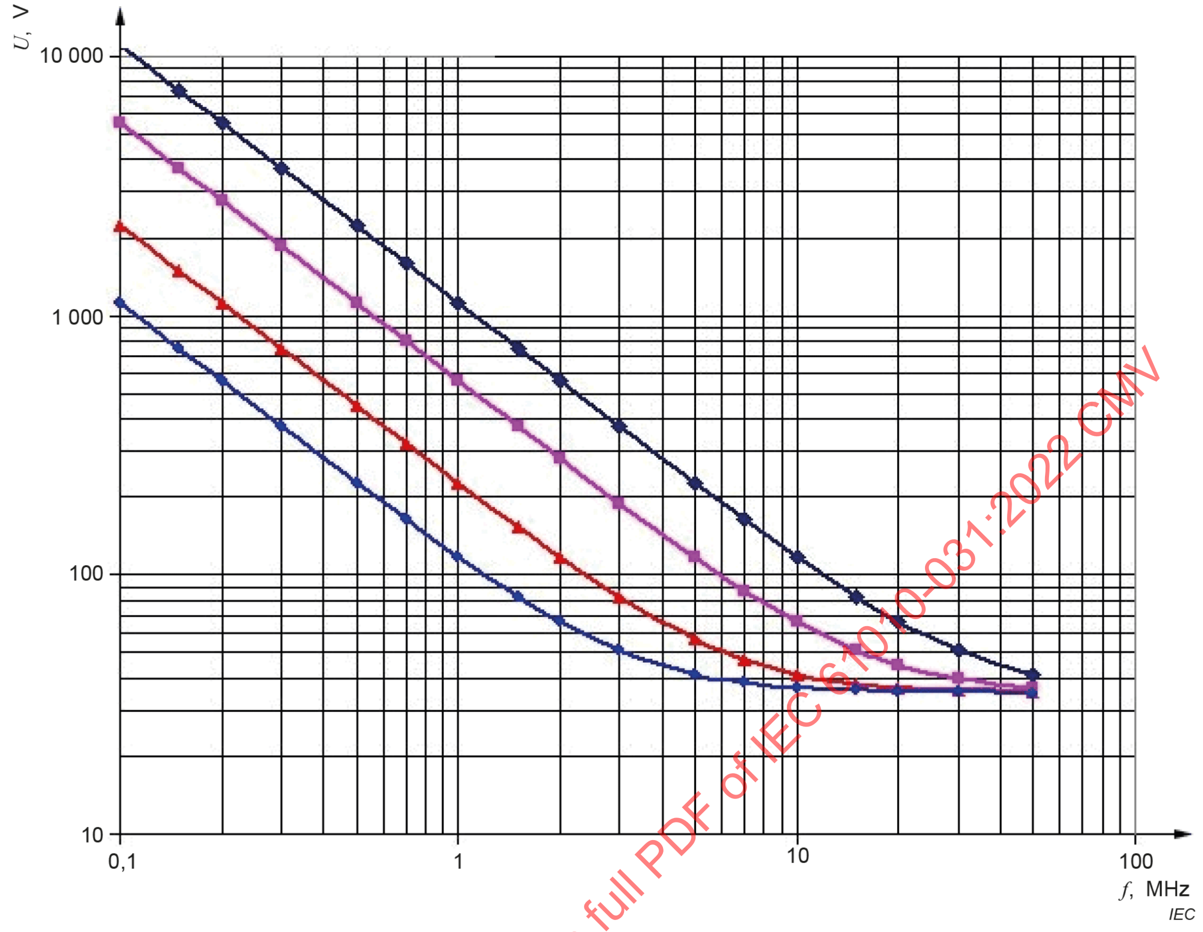
*b) between the shield and the foil around the coaxial CONNECTOR (Figure 11, item 2b), and*

*c) between the shield and the foil around the PROBE WIRE (Figure 11, item 2c).*

*As an 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 Cs (measured capacitance between the shield and the foil) together with the circuit from Figure A.3 creates the impedance shown in Figure A.4. The variable parameters of this impedance are the capacitance Cs and the frequency (R1, C1 and R2 are fixed). Through 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 R2) as shown in Figure 12 for some values of the capacitance Cs.*

*The maximum voltage for each frequency can then be calculated. In practice for the calculation with frequencies above 100 kHz, the values of R1 and C1 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 12 – Maximum test probe input voltage for 70 mA touch current

## 7.4 Means of protection against electric shock

### 7.4.1 General

CONNECTORS shall meet the requirements of 7.4.2.

PROBE TIPS shall meet the requirements of 7.4.3.

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) BASIC INSULATION plus impedance (see 7.4.4);

b) PROTECTIVE IMPEDANCE (see 7.4.5);

c) DOUBLE INSULATION, consisting of BASIC INSULATION plus SUPPLEMENTARY INSULATION (see 7.4.6);

d) REINFORCED INSULATION (see 7.4.6).

NOTE The PROBE WIRE is considered to be hand-held. See also Clause 12 for requirements pertaining to the PROBE WIRE.

*Conformity is checked by inspection and as specified in 7.4.2 to 7.4.6, as applicable.*

### 7.4.2 CONNECTORS

#### 7.4.2.1 General

Insulation, ACCESSIBLE parts and SPACINGS for CONNECTORS of probe assemblies shall meet the applicable requirements of 7.4.2.2 to 7.4.2.4. When a CONNECTOR is intended to mate with another CONNECTOR or a TERMINAL having different RATINGS, the lower RATING applies.

Insulation covers or sleeves over CONNECTORS which are intended to be hand-held or hand-manipulated by the OPERATOR during measurement or test, and which 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 except when they are needed for connection to test or measurement equipment that is equipped with TERMINALS which cannot accept fully shrouded CONNECTORS. For example, retractable insulation sleeves are not considered to provide adequate protection.

Annex E provides information regarding the recommended dimensions of 4 mm CONNECTORS up to 1 000 V.

*Conformity is checked by inspection.*

#### 7.4.2.2 CONNECTORS in fully mated position

a) 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 during the measurement operation shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

b) ACCESSIBLE parts of CONNECTORS which are used for any other purpose or which are intended to be hand-held during the measurement operation shall be insulated from HAZARDOUS LIVE parts by DOUBLE INSULATION or REINFORCED INSULATION.

*Conformity is checked by the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 b) and as specified in 7.4.6 for BASIC INSULATION and REINFORCED INSULATION.*

#### 7.4.2.3 CONNECTORS in partially mated position

ACCESSIBLE parts of CONNECTORS in partially mated position shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

*Conformity is checked by the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 c) and as specified in 7.4.6 for BASIC INSULATION.*

#### 7.4.2.4 CONNECTORS in unmated position

When RATED voltages are applied to other CONNECTORS or to PROBE TIPS of the probe assembly, the following requirements apply to CONNECTORS in unmated position.

1) ACCESSIBLE parts of locking-type or screw-held-type CONNECTORS in unmated position, including CONNECTORS which do not require the use of a TOOL for unlocking or unscrewing are permitted to be HAZARDOUS LIVE.

   *Conformity is checked by inspection.*

2) ACCESSIBLE parts of unmated integrated TERMINALS of STACKABLE CONNECTORS shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

   *Conformity is checked by the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 d) for the part defined by key 1 of Figure 1 and measurement of the CLEARANCES as specified in 7.5.2 for BASIC INSULATION.*

3) ACCESSIBLE parts of other unmated CONNECTORS shall be insulated from HAZARDOUS LIVE parts by PROTECTIVE IMPEDANCE (see 7.4.5) or SPACINGS meeting the requirements of a) and b) below.

   a) For CONNECTORS with a voltage RATING up to 20 kV, the CLEARANCE shall be at least the applicable value of Table 2.

**Table 2 – CLEARANCES for unmated CONNECTORS**

| **Maximum voltage applied to the conductive parts of the CONNECTORS** V | **CLEARANCE** AC RMS mm | DC mm |
|---|---|---|
| | **AC RMS** mm | **DC** mm |
| 600 | 0,8 | 0,8 |
| 1 000 | 1,0 | 0,8 |
| 1 500 | 2,0 | 1,1 |
| 2 000 | 3,2 | 1,8 |
| 3 000 | 6,4 | 3,5 |
| 5 000 | 13 | 8,3 |
| 10 000 | 30 | 20 |
| 15 000 | 48 | 32 |
| 20 000 | 67 | 44 |

For maximum voltages above 30 V AC RMS or 60 V DC up to 600 V, CLEARANCES are 0,8 mm.

Linear interpolation is allowed above 600 V.

NOTE See Annex G.

For CONNECTORS with a RATING above 20 kV, the CLEARANCE shall be at least the $D_2$ value of Table 5 with $U_m$ equal to 1,25 times the peak value of the RATED voltage (see 7.5.2.3.2).

If the probe assembly is RATED to operate at an altitude greater than 2 000 m, the value of the CLEARANCE shall be multiplied by the applicable factor of Table 3.

*Conformity is checked by one of the following tests:*

i) *the determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 d)) and the measurement of the CLEARANCE, or*

ii) *the AC voltage test of 7.6.5.1 or the DC voltage test of 7.6.5.2 for probe assemblies stressed only by DC with a duration of at least 5 s, or the impulse voltage test of 7.6.5.3, using the test voltage of Table 11 for the required CLEARANCE.*

   *Correction factors of Table 12 are applicable to the values of the test voltages for CLEARANCES given in Table 11.*

b) The CREEPAGE DISTANCE values shall be at least the applicable CLEARANCE values defined in a).

   *Conformity is checked by determination of ACCESSIBLE parts as specified in 7.2 (see Figure 7 d)) and measurement of the CREEPAGE DISTANCE.*

### 7.4.3 PROBE TIPS

#### 7.4.3.1 General

PROBE TIPS that can become HAZARDOUS LIVE during NORMAL USE (see also 7.1 b)) shall meet the requirements of one of the following subclauses, 7.4.3.2 (if protection by a PROTECTIVE FINGERGUARD), 7.4.3.3 (if protection by distance) or 7.4.3.4 (if protection by tactile indicator). In addition, IP 2X PROBE TIPS with retractable sleeve shall meet the requirements of 7.4.3.5.

PROBE TIPS that can be used as CONNECTORS shall also meet the requirements of 7.4.3.6.

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 7.3.2 a).

*Conformity is checked by inspection and measurement.*

#### 7.4.3.2 Protection by a PROTECTIVE FINGERGUARD

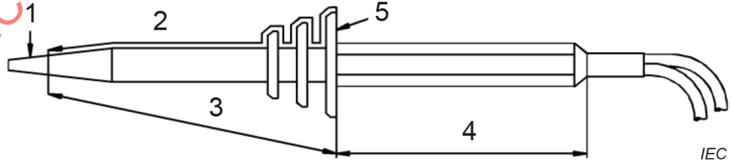
If a conductive part of a PROBE TIP can become HAZARDOUS LIVE, or if the end of a PROBE TIP can touch a HAZARDOUS LIVE conductor, a PROTECTIVE FINGERGUARD shall be fitted to reduce the risk of touching an exposed part of the PROBE TIP, and to provide an indication of the limit beyond which it may be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

SPACINGS between 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.

The PROTECTIVE FINGERGUARD of probe assemblies which have a voltage RATING above the levels of 7.3.2 a) shall extend across at least 80 % of the sides where the fingers are intended to be applied.

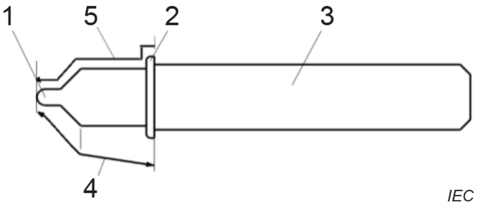
Figure 13 gives examples of probe assemblies with a PROTECTIVE FINGERGUARD and indicates applicable SPACINGS.



**Key**

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

**Figure 13 a) – Probe assembly for direct electrical connection**



**Key**

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

**Figure 13 b) – Type F probe assembly for non-contact measurement**

**Figure 13 – Protection by a PROTECTIVE FINGERGUARD**

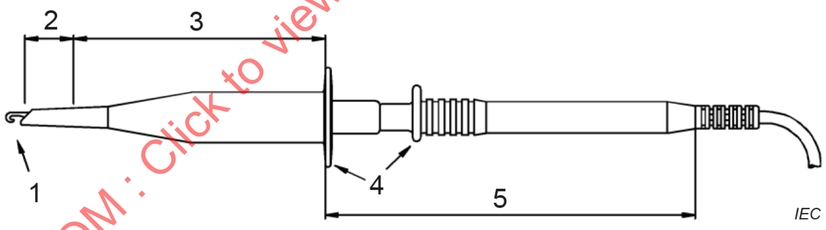
### 7.4.3.3 Protection by distance

SPRING-LOADED CLIPS RATED for voltages 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) the SPACINGS between the PROBE TIP and the nearest surface which the OPERATOR needs to touch to actuate the mechanism are increased by an additional protective distance of 45 mm.

Figure 14 gives an example of a probe assembly protected by distance and indicates applicable SPACINGS.



**Key**

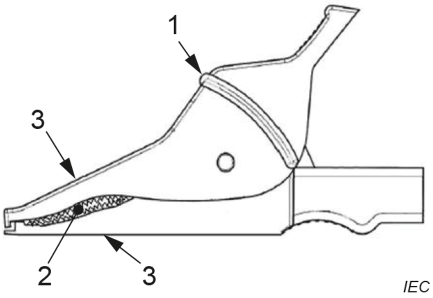
| | | | |
|---|---|---|---|
| 1 | PROBE TIP | 4 | actuating parts |
| 2 | SPACINGS as specified in 7.5 | 5 | hand-held area of the probe assembly |
| 3 | additional protective distance | | |

**Figure 14 – Protection by distance**

### 7.4.3.4 Protection by tactile indicator

SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY II or without MEASUREMENT CATEGORY for maximum 300 V 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.

EXAMPLE Figure 15 gives an example of a SPRING-LOADED CLIP with a tactile indicator.



**Key**

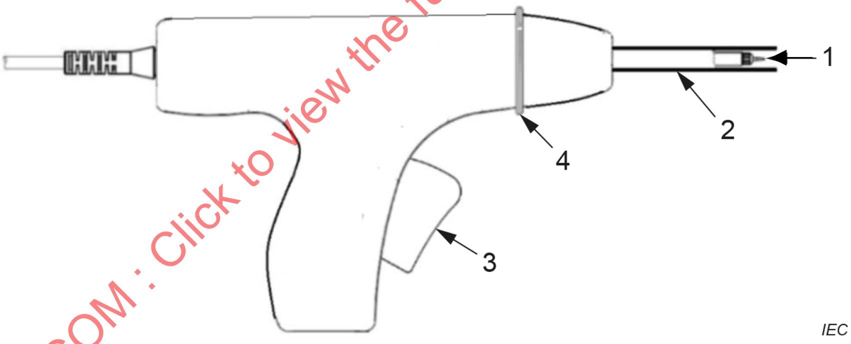
| | | | |
|---|---|---|---|
| 1 | tactile indicator | 3 | insulated metal jaws |
| 2 | metal jaws | | |

**Figure 15 – Protection by tactile indicator**

### 7.4.3.5 IP2X PROBE TIPS with retractable sleeve

IP2X probe assemblies are probe assemblies with an IP2X protection of the PROBE TIP. HAZARDOUS LIVE parts of the PROBE TIP with an IP2X degree of protection are prevented by a retractable sleeve from being ACCESSIBLE. In non-operative position, the sleeve covers the PROBE TIP. The sleeve can be retracted voluntarily by pressing on a trigger or by applying a strength force exceeding the value as set out in Table 6 of IEC 60529:1989. When the sleeve is retracted, the OPERATOR's hand holds onto the probe body.

EXAMPLE Figure 16 gives an example of probe assembly with an IP2X PROBE TIP.



**Key**

| | | | |
|---|---|---|---|
| 1 | PROBE TIP | 3 | trigger |
| 2 | retractable sleeve | 4 | PROTECTIVE FINGERGUARD |

**Figure 16 – Example of probe assembly with IP2X PROBE TIP**

IP2X PROBE TIPS with retractable sleeve do not provide particular protection against risk of short circuits.

The conductive parts of PROBE TIPS of IP2X probe assemblies shall not be ACCESSIBLE when the sleeve is in the non-operative position.

*Conformity is checked by determination of the ACCESSIBLE parts when performing the test from IEC 60529:1989, 12.2.*

#### 7.4.3.6 PROBE TIPS used as CONNECTORS

PROBE TIPS which can be used as CONNECTORS and are intended to be connected to specified accessories (for example to a SPRING-LOADED CLIP) shall, in combination with those accessories, also meet the requirements for CONNECTORS in fully mated position (see 7.4.2.2) and partially mated position (see 7.4.2.3).

### 7.4.4 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 7.3.3;

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 7.5 for BASIC INSULATION.

*Conformity is checked by inspection, by measuring the voltage or current to confirm that they do not exceed the levels of 7.3.3, and by measuring SPACINGS as specified in 7.5.*

### 7.4.5 PROTECTIVE IMPEDANCE

A PROTECTIVE IMPEDANCE shall limit the current or voltage to the levels of 7.3.2 in NORMAL CONDITION and to the levels of 7.3.3 in SINGLE FAULT CONDITION (see also 5.4.2.2).

Insulation between the terminations of the PROTECTIVE IMPEDANCE shall meet the requirements of 7.4.6 for 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 ensured. 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 7.3 and by measuring SPACINGS as specified in 7.5. Conformity of a single component is checked by inspection of its RATINGS.*

### 7.4.6 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 7.5.

DOUBLE INSULATION is composed of BASIC INSULATION and SUPPLEMENTARY INSULATION, each of which shall meet the applicable requirements of 7.5.

*Conformity is checked as specified in 7.5.*

## 7.5 Insulation requirements

### 7.5.1 The nature of insulation

Measuring circuits are subjected to WORKING VOLTAGES and transient stresses from the circuit to which they are connected during measurement or test. When the measuring circuit is used to measure mains supplies or circuits directly connected to them, the transient stresses can be estimated by the location within the installation at which the measurement is performed. When the measuring circuit is used to measure any other electrical signal, the transient stresses should be considered by the OPERATOR to ensure that they do not exceed the capabilities 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;
e) insulation between circuits and ACCESSIBLE parts (see 7.2) or between separate circuits consists of SPACINGS, solid insulation, or a combination of SPACINGS and solid insulation.

SPACINGS are a combination of CLEARANCES and CREEPAGE DISTANCES, which are specified in 7.5.2 and 7.5.3 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.

### 7.5.2 CLEARANCES

#### 7.5.2.1 General

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. If transient overvoltages cannot occur, CLEARANCES are based on the WORKING VOLTAGE.

The values for CLEARANCES given in Table 4 and Table 5 are based on absolute inhomogeneous field conditions. Reduced CLEARANCES may apply to 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.

No particular value can be specified for a reduced CLEARANCE for these more homogeneous constructions, but it can be tested by a voltage test (see 7.6). CLEARANCES which meet the values of Table 4 and Table 5 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 probe assembly is RATED to operate at an altitude greater than 2 000 m, the values for CLEARANCES are multiplied by the applicable factor of Table 3.

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

| RATED operating altitude<br>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 |

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, the minimum CLEARANCE value for POLLUTION DEGREE 2 is 0,2 mm and for POLLUTION DEGREE 3 is 0,8 mm.

See Annex C for details of how to measure CLEARANCES.

CLEARANCES for CONNECTORS are defined in 7.4.2; CLEARANCES for probe assemblies RATED for MEASUREMENT CATEGORIES are defined in 7.5.2.2; and CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES are defined in 7.5.2.3.

*Conformity is checked as specified in 7.4.2.4, 7.5.2.2 and 7.5.2.3.*

### 7.5.2.2 CLEARANCES for probe assemblies RATED for MEASUREMENT CATEGORIES

CLEARANCES for probe assemblies RATED for MEASUREMENT CATEGORIES are specified in Table 4.

**Table 4 – CLEARANCES for probe assemblies RATED for MEASUREMENT CATEGORIES**

| Nominal AC RMS line-to-neutral or DC voltage of mains being measured<br>V | CLEARANCE<br>mm | | | | | |
|---|---|---|---|---|---|---|
| | BASIC INSULATION and SUPPLEMENTARY INSULATION | | | REINFORCED INSULATION | | |
| | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV |
| ≤ 50 | 0,04 | 0,10 | 0,50 | 0,10 | 0,32 | 1,4 |
| > 50 ≤ 100 | 0,10 | 0,50 | 1,5 | 0,32 | 1,4 | 3,0 |
| > 100 ≤ 150 | 0,50 | 1,5 | 3,0 | 1,4 | 3,0 | 6,0 |
| > 150 ≤ 300 | 1,5 | 3,0 | 5,5 | 3,0 | 6,0 | 10,4 |
| > 300 ≤ 600 | 3,0 | 5,5 | 8,0 | 6,0 | 10,4 | 15,0 |
| > 600 ≤ 1 000 | 5,5 | 8,0 | 14,0 | 10,4 | 15,0 | 23,9 |
| > 1 000 ≤ 1 500 | 8,0 | 11,0 | 18,0 | 16,0 | 22 | 36 |
| > 1 500 ≤ 2 000 | 14,0 | 18,0 | 22,0 | 28,0 | 36 | 44 |
| > 2 000 ≤ 3 000 | 18,0 | 22,0 | 25,0 | 36 | 44 | 50 |

*Conformity is checked by inspection and measurement, or by the AC voltage test of 7.6.5.1 or the DC voltage test of 7.6.5.2 for probe assemblies stressed only by DC with a duration of at least 5 s, or the impulse voltage test of 7.6.5.3, using the test voltage of Table 11 for the required CLEARANCE.*

### 7.5.2.3 CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES

#### 7.5.2.3.1 General

CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES are calculated according to 7.5.2.3.2.

If they have either one of the following characteristics in a) or b), CLEARANCES are determined according to 7.5.2.3.3, and the larger of the two CLEARANCES is the required CLEARANCE:

a) the WORKING VOLTAGE includes a recurring peak voltage that may include a periodic non-sinusoidal waveform or a non-periodic waveform that occurs with some regularity;
b) the WORKING VOLTAGE has a frequency above 30 kHz.

#### 7.5.2.3.2 CLEARANCE calculation

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION are determined from the following formula:

$$D_{BI} = D_1 + F \times (D_2 - D_1)$$

where

$D_{BI}$ is the CLEARANCE to determine;

$F$ is a factor, determined from one of the equations:

$F = (1{,}25 \times U_w/U_m) - 0{,}25$ if $U_w/U_m > 0{,}2$;

$F = 0$ if $U_w/U_m \leq 0{,}2$;

where

$U_m = U_w + U_t$;

$U_w$ = the maximum peak value of the WORKING VOLTAGE;

$U_t$ = the maximum additional transient overvoltage;

$D_1$ and $D_2$ are values taken from Table 5 for $U_m$:

where

$D_1$ represents the CLEARANCE that would be applicable to a transient overvoltage with the shape of a 1,2 × 50 µs impulse;

$D_2$ represents the CLEARANCE that would be applicable to the peak WORKING VOLTAGE without any transient overvoltage.

CLEARANCES for REINFORCED INSULATION are twice the values for BASIC INSULATION.

*Conformity is checked by inspection and measurement, or by the AC voltage test of 7.6.5.1 with a duration of at least 5 s, or the DC voltage test of 7.6.5.2 for probe assemblies stressed only by DC with a duration of at least 5 s, or the impulse voltage test of 7.6.5.3, using the applicable test voltage from Table 11 for the required CLEARANCE.*

*Correction factors of Table 12 are applicable to the values of test voltages.*

### Table 5 – CLEARANCE values for the calculation of 7.5.2.3.2

| Maximum voltage<br>$U_m$<br>V | CLEARANCE<br>$D_1$<br>mm | <br>$D_2$<br>mm | Maximum voltage<br>$U_m$<br>V | CLEARANCE<br>$D_1$<br>mm | <br>$D_2$<br>mm |
|---|---|---|---|---|---|
| 14,1 to 266 | 0,010 | 0,010 | 4 000 | 3,00 | 3,80 |
| 283 | 0,010 | 0,010 | 4 530 | 3,53 | 4,80 |
| 330 | 0,010 | 0,010 | 5 660 | 4,99 | 7,15 |
| 354 | 0,012 | 0,013 | 6 000 | 5,50 | 7,90 |
| 453 | 0,030 | 0,030 | 7 070 | 6,84 | 9,55 |
| 500 | 0,040 | 0,040 | 8 000 | 8,00 | 11,0 |
| 566 | 0,053 | 0,053 | 8 910 | 9,37 | 12,9 |
| 707 | 0,081 | 0,097 | 11 300 | 13,0 | 17,7 |
| 800 | 0,10 | 0,13 | 14 100 | 16,8 | 23,2 |
| 891 | 0,12 | 0,19 | 17 700 | 21,8 | 29,9 |
| 1 130 | 0,22 | 0,36 | 22 600 | 29,2 | 39,2 |
| 1 410 | 0,43 | 0,66 | 28 300 | 37,6 | 51,3 |
| 1 500 | 0,50 | 0,76 | 35 400 | 50,8 | 66,9 |
| 1 770 | 0,77 | 1,04 | 45 300 | 68,0 | 89,2 |
| 2 260 | 1,26 | 1,55 | 56 600 | 85,0 | 115 |
| 2 500 | 1,50 | 1,80 | 70 700 | 111 | 148 |
| 2 830 | 1,83 | 2,2 | 89 100 | 148 | 190 |
| 3 540 | 2,54 | 3,16 | 100 000 | 170 | 215 |
| Linear interpolation is allowed | | | | | |

NOTE The following is an example calculation:

CLEARANCE $D_{RI}$ for REINFORCED INSULATION for a WORKING VOLTAGE with peak value of 3 500 V and an additional transient voltage of 4 500 V (this can be expected within an electronic switching-circuit):

Maximum voltage $U_m = U_w + U_t = 3\,500 + 4\,500 = 8\,000$ V

$U_w / U_m = 3\,500 / 8\,000 = 0{,}44 > 0{,}2$

thus $F = (1{,}25 \times U_w / U_m) - 0{,}25 = (1{,}25 \times 3\,500 / 8\,000) - 0{,}25 = 0{,}297$

Values derived from Table 5 at 8 000 V:

$D_1 = 8{,}00$ mm, $D_2 = 11{,}0$ mm

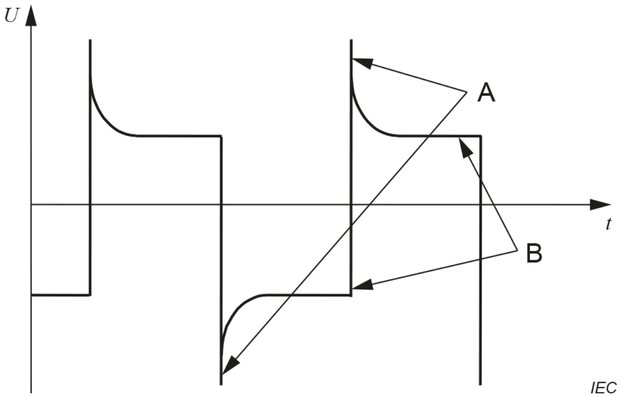
$D_{BI} = D_1 + F \times (D_2 - D_1) = 8{,}00 + 0{,}297 \times (11{,}0 - 8{,}00) = 8{,}00 + 0{,}89 = 8{,}89$ mm

For REINFORCED INSULATION the value is doubled: $D_{RI} = D_{BI} \times 2 = 17{,}8$ mm.

#### 7.5.2.3.3 CLEARANCES for probe assemblies subjected to recurring peak voltages, or WORKING VOLTAGES with frequencies above 30 kHz, or both

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for probe assemblies subjected to recurring peak voltages with frequencies not exceeding 30 kHz shall meet the values of the second column of Table 6, using the recurring peak voltage as the index (see Figure 17 for an example of a recurring peak voltage).

NOTE In most practical recurring waveforms, the fundamental frequency has a substantially higher amplitude than the harmonics. Therefore, the fundamental frequency is used for determining whether the frequency of the waveform exceeds 30 kHz. However, the peak amplitude of the waveform, and not the peak amplitude of the fundamental component of the waveform, is used for determining SPACINGS. For more information, see Clause E.2 of IEC 60664-4:2005.



**Key**

A peak value of recurring voltage

B WORKING VOLTAGE value

Figure 17 – Example of recurring peak voltage

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for probe assemblies that are subjected to WORKING VOLTAGES with frequencies above 30 kHz shall meet the values of the third column of Table 6, using the peak value of the WORKING VOLTAGE as the index.

CLEARANCES for BASIC INSULATION and SUPPLEMENTARY INSULATION for probe assemblies that may be subjected to both recurring peak voltages and WORKING VOLTAGES with frequencies above 30 kHz shall meet the higher of these requirements.

CLEARANCES for REINFORCED INSULATION are twice the values for BASIC INSULATION.

*Conformity is checked by inspection and measurement.*

**Table 6 – CLEARANCES for BASIC INSULATION in probe assemblies subjected to recurring peak voltages or WORKING VOLTAGES with frequencies above 30 kHz**

| Voltage peak value<br>V | CLEARANCE | |
|---|---|---|
| | Frequencies up to 30 kHz<br>mm | Frequencies above 30 kHz<br>mm |
| 0 to 330 | 0,01 | 0,02 |
| 400 | 0,02 | 0,04 |
| 500 | 0,04 | 0,07 |
| 600 | 0,06 | 0,11 |
| 800 | 0,13 | 0,26 |
| 1 000 | 0,26 | 0,48 |
| 1 200 | 0,42 | 0,76 |
| 1 500 | 0,76 | 1,1 |
| 2 000 | 1,27 | 1,8 |
| 2 500 | 1,8 | 2,6 |
| 3 000 | 2,4 | 3,5 |
| 4 000 | 3,8 | 5,7 |
| 5 000 | 5,7 | 8 |
| 6 000 | 7,9 | 10 |
| 8 000 | 11 | 15 |
| 10 000 | 15,2 | 20 |
| 12 000 | 19 | 25 |
| 15 000 | 25 | 32 |
| 20 000 | 34 | 44 |
| 25 000 | 44 | 58 |
| 30 000 | 55 | 72 |
| 40 000 | 77 | 100 |
| 50 000 | 100 | |
| Linear interpolation is allowed. | | |

### 7.5.3 CREEPAGE DISTANCES

CREEPAGE DISTANCES protect against tracking on the surface of an insulation, which is a long-term phenomenon. Therefore, they cannot be confirmed by voltage testing, but have to be measured as specified in Annex C.

CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION for probe assemblies shall meet the applicable values of Table 7, based on the WORKING VOLTAGE which stresses the insulation.

Values for REINFORCED INSULATION are twice the values for BASIC INSULATION.

Coatings that meet the requirements of IEC 61010-1:2010, Annex H and IEC 61010-1:2010/AMD1:2016, Annex H when applied to the outer surfaces of printed wiring boards reduce the POLLUTION DEGREE of the coated area to POLLUTION DEGREE 1.

*Conformity is checked by inspection and measurement.*

## Table 7 – CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION

| **WORKING VOLTAGE AC RMS or DC** | **CREEPAGE DISTANCE** | | | | |
|---|---|---|---|---|---|
| | **Printed wiring board material** | | **Other insulating material** | | |
| | **POLLUTION DEGREE** | | **POLLUTION DEGREE** | | |
| | **1** | **2** | **1** | **2** | **3** |
| V | mm | mm | mm | mm | mm |
| 10 | 0,025 | 0,04 | 0,08 | 0,40 | 1,00 |
| 12,5 | 0,025 | 0,04 | 0,09 | 0,42 | 1,05 |
| 16 | 0,025 | 0,04 | 0,10 | 0,45 | 1,10 |
| 20 | 0,025 | 0,04 | 0,11 | 0,48 | 1,20 |
| 25 | 0,025 | 0,04 | 0,125 | 0,50 | 1,25 |
| 32 | 0,025 | 0,04 | 0,14 | 0,53 | 1,3 |
| 40 | 0,025 | 0,04 | 0,16 | 0,56 | 1,4 |
| 50 | 0,025 | 0,04 | 0,18 | 0,60 | 1,5 |
| 63 | 0,040 | 0,063 | 0,20 | 0,63 | 1,6 |
| 80 | 0,063 | 0,10 | 0,22 | 0,67 | 1,7 |
| 100 | 0,10 | 0,16 | 0,25 | 0,71 | 1,8 |
| 125 | 0,16 | 0,25 | 0,28 | 0,75 | 1,9 |
| 160 | 0,25 | 0,40 | 0,32 | 0,80 | 2,0 |
| 200 | 0,40 | 0,63 | 0,42 | 1,00 | 2,5 |
| 250 | 0,56 | 1,0 | 0,56 | 1,25 | 3,2 |
| 320 | 0,75 | 1,6 | 0,75 | 1,60 | 4,0 |
| 400 | 1,0 | 2,0 | 1,0 | 2,0 | 5,0 |
| 500 | 1,3 | 2,5 | 1,3 | 2,5 | 6,3 |
| 630 | 1,8 | 3,2 | 1,8 | 3,2 | 8,0 |
| 800 | 2,4 | 4,0 | 2,4 | 4,0 | 10,0 |
| 1 000 | 3,2 | 5,0 | 3,2 | 5,0 | 12,5 |
| 1 250 | 4,2 | 6,3 | 4,2 | 6,3 | 16 |
| 1 600 | 5,6 | 8,0 | 5,6 | 8,0 | 20 |
| 2 000 | 7,5 | 10,0 | 7,5 | 10,0 | 25 |
| 2 500 | 10,0 | 12,5 | 10,0 | 12,5 | 32 |
| 3 200 | 12,5 | 16 | 12,5 | 16 | 40 |
| 4 000 | 16 | 20 | 16 | 20 | 50 |
| 5 000 | 20 | 25 | 20 | 25 | 63 |
| 6 300 | 25 | 32 | 25 | 32 | 80 |
| 8 000 | 32 | 40 | 32 | 40 | 100 |
| 10 000 | 40 | 50 | 40 | 50 | 125 |
| 12 500 | 50 | 63 | 50 | 63 | 156 |
| 16 000 | 63 | 80 | 63 | 80 | 200 |
| 20 000 | 80 | 100 | 80 | 100 | 250 |
| 25 000 | 100 | 125 | 100 | 125 | 315 |
| 32 000 | 125 | 160 | 125 | 160 | 400 |
| 40 000 | 160 | 200 | 160 | 200 | 500 |
| 50 000 | 200 | 250 | 200 | 250 | 625 |
| 63 000 | 250 | 320 | 250 | 320 | 790 |

Linear interpolation is allowed.

### 7.5.4 Solid insulation for probe assemblies

#### 7.5.4.1 General

The term "solid insulation" is used to describe many different types of construction, including monolithic blocks of insulating material and insulation subsystems composed of multiple insulating materials, organized in layers or otherwise.

The electric strength of a thickness of solid insulation is considerably greater than that of the same thickness of air. The insulating distances through solid insulation are therefore typically smaller than the distances through air. As a result, electric fields in solid insulation are typically higher, and often are less homogeneous.

Solid insulation material may contain gaps or voids. When a solid insulation system is constructed from layers of solid materials, there are also likely to be gaps or voids between layers. These voids will perturb the electric field so that a disproportionately large part of the electric field is located in the void, potentially causing ionization within the void, resulting in partial discharge. These partial discharges will influence the adjacent solid insulation and may reduce its service life.

Solid insulation is not a renewable medium: damage is cumulative over the life of the equipment. Solid insulation is also subject to ageing and to degradation from repeated high voltage testing.

*Conformity is checked as specified in 7.5.4.2 and 7.5.4.3.*

#### 7.5.4.2 Solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES

##### 7.5.4.2.1 General

Solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES shall withstand the electrical and mechanical stresses that may occur in NORMAL USE and in all RATED environmental conditions (see 4.4) during the intended life of the probe assembly.

*Conformity is checked by both of the following tests:*

a) *the impulse voltage test of 7.6.5.3 using the applicable test voltage of Table 8 or as an alternative, the AC voltage test of 7.6.5.1 using the applicable test voltage of Table 9 with a duration of at least 5 s;*

b) *for probe assemblies stressed by AC or AC plus DC, the AC voltage test of 7.6.5.1, or for probe assemblies stressed only by pure DC, the DC voltage test of 7.6.5.2 using the test voltage determined by 7.5.4.2.2 with a duration of at least 1 min.*

*NOTE Test a) checks the effects of transient overvoltages, while test b) checks the effects of long-term stress of solid insulation.*

**Table 8 – Impulse test voltages for testing electric strength of solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES**

| Nominal AC RMS line-to-neutral or DC voltage of mains being measured V | Impulse test voltage V peak | | | | | |
|---|---|---|---|---|---|---|
| | BASIC INSULATION and SUPPLEMENTARY INSULATION | | | REINFORCED INSULATION | | |
| | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV |
| ≤ 50 | 500 | 800 | 1 500 | 800 | 1 280 | 2 400 |
| > 50 ≤ 100 | 800 | 1 500 | 2 500 | 1 280 | 2 400 | 4 000 |
| > 100 ≤ 150 | 1 500 | 2 500 | 4 000 | 2 400 | 4 000 | 6 400 |
| > 150 ≤ 300 | 2 500 | 4 000 | 6 000 | 4 000 | 6 400 | 9 600 |
| > 300 ≤ 600 | 4 000 | 6 000 | 8 000 | 6 400 | 9 600 | 12 800 |
| > 600 ≤ 1 000 | 6 000 | 8 000 | 12 000 | 9 600 | 12 800 | 19 200 |
| > 1 000 ≤ 1 500 | 8 000 | 10 000 | 15 000 | 13 500 | 17 900 | 27 100 |
| > 1 500 ≤ 2 000 | 12 000 | 15 000 | 18 000 | 21 400 | 27 100 | 32 000 |
| > 2 000 ≤ 3 000 | 15 000 | 18 000 | 20 000 | 27 100 | 32 000 | 36 000 |

**Table 9 – AC test voltages for testing electric strength of solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES**

| Nominal AC RMS line-to-neutral or DC voltage of mains being measured V | AC test voltage V | | | | | |
|---|---|---|---|---|---|---|
| | BASIC INSULATION and SUPPLEMENTARY INSULATION | | | REINFORCED INSULATION | | |
| | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV | MEASUREMENT CATEGORY II | MEASUREMENT CATEGORY III | MEASUREMENT CATEGORY IV |
| ≤ 50 | 370 | 500 | 840 | 500 | 720 | 1 300 |
| > 50 ≤ 100 | 500 | 840 | 1 400 | 720 | 1 300 | 2 200 |
| > 100 ≤ 150 | 840 | 1 400 | 2 200 | 1 300 | 2 200 | 3 500 |
| > 150 ≤ 300 | 1 400 | 2 200 | 3 300 | 2 200 | 3 500 | 5 100 |
| > 300 ≤ 600 | 2 200 | 3 300 | 4 300 | 3 500 | 5 100 | 7 000 |
| > 600 ≤ 1 000 | 3 300 | 4 300 | 6 600 | 5 100 | 7 000 | 10 000 |
| > 1 000 ≤ 1 500 | 4 300 | 5 400 | 8 200 | 7 400 | 9 700 | 15 000 |
| > 1 500 ≤ 2 000 | 6 600 | 8 200 | 9 700 | 12 000 | 15 000 | 18 000 |
| > 2 000 ≤ 3 000 | 8 200 | 9 700 | 11 000 | 15 000 | 18 000 | 20 000 |

#### 7.5.4.2.2 Long term stress test voltage value calculation

Test voltage values for testing long term stress of solid insulation are determined as follows:

The test voltage value for BASIC INSULATION and SUPPLEMENTARY INSULATION is calculated with the following formula:

$$U_T = A \times U_N + B$$

where

$U_T$ is the AC or DC test voltage;

$U_N$ is the nominal AC RMS line-to-neutral or DC voltage of mains being measured;

$A$ and $B$ are parameters determined as follows:

when $U_N \leq 1\,000$ V $A = 1$ and $B = 1\,200$ V;

when $U_N > 1\,000$ V $A = 1{,}5$ and $B = 750$ V.

NOTE Parameter values up to 1 000 V are derived from 442.2.2 of IEC 60364-4-44:2007 and parameter values over 1 000 V are derived from 6.1.3.1 of IEC TS 62993:2017.

For REINFORCED INSULATION, the test voltage value is twice the value for BASIC INSULATION.

### 7.5.4.2.3 Constructional requirements

#### 7.5.4.2.3.1 General

Solid insulation shall also meet the following requirements, as applicable:

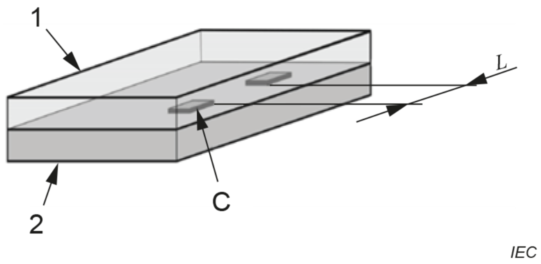
1) for solid insulation used as an ENCLOSURE or PROTECTIVE FINGERGUARD, the requirements of Clause 9;
2) for moulded and potted parts, the requirements of 7.5.4.2.3.2;
3) for insulating layers of printed wiring boards, the requirements of 7.5.4.2.3.3;
4) for thin-film insulation, the requirements of 7.5.4.2.3.4.

*Conformity is checked as specified in 7.5.4.2.3.2 to 7.5.4.2.3.4, and in Clause 9, as applicable.*

#### 7.5.4.2.3.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, conductors located between the same two layers moulded together (see Figure 18, item *L*) shall be separated by at least the applicable minimum distance of Table 10 after the moulding is completed.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*



**Key**

1 layer 1

2 layer 2

C conductor

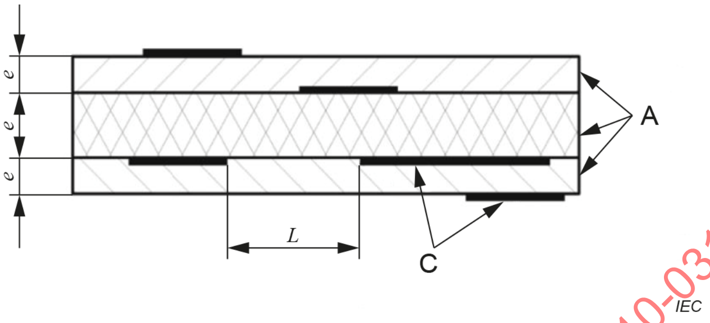
*L* distance between conductors

Figure 18 – Distance between conductors on an interface between two layers

### 7.5.4.2.3.3 Insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure 19, item *L*) shall be separated by at least the applicable minimum distance of Table 10.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*



**Key**

*L* distance between conductors on the same surface

*e* thickness

A layers

C conductors

Figure 19 – Distance between adjacent conductors along an interface of two layers

**Table 10 – Minimum values for distance or thickness of solid insulation for probe assemblies RATED for MEASUREMENT CATEGORIES**

| Nominal AC RMS line-to-neutral or DC voltage<br>V | Minimum thickness *e* [b]<br>mm | Minimum distance *L* (see Figure 18 and Figure 19) [a]<br>mm |
|---|---|---|
| ≤ 300 | 0,4 | 0,4 |
| > 300 ≤ 600 | 0,6 | 0,6 |
| > 600 ≤ 1 000 | 1,0 | 1,0 |

[a] These values apply for BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION.

[b] For voltages above 1 000 V, a partial discharge test should be used (see IEC 60664-1:2020, 6.4.6 for the test procedure).

REINFORCED INSULATION of insulating layers of printed wiring boards (see Figure 19, item A) shall also have adequate electric strength through the respective layers. One of the following methods shall be used.

a) The thickness of the insulation is at least the value set out in Table 10.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*

b) The insulation is assembled from at least two separate layers of printed wiring board materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the applicable values for BASIC INSULATION of the test voltages and durations of 7.5.4.2.1.

*Conformity is checked by inspection of the manufacturer's specifications.*

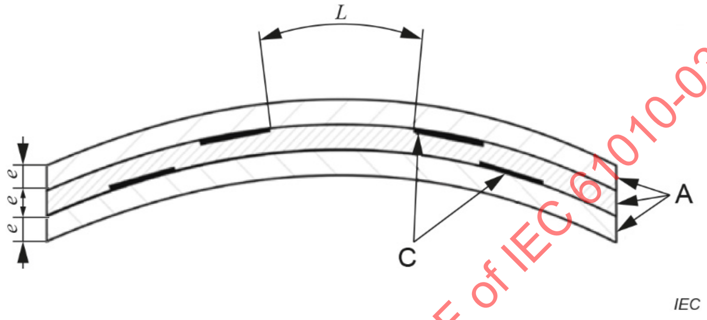
c) The insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength of at least the applicable values for REINFORCED INSULATION of the test voltages and durations of 7.5.4.2.1.

*Conformity is checked by inspection of the manufacturer's specifications.*

#### 7.5.4.2.3.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, conductors located between the same two layers (see Figure 20, item *L*) shall be separated by at least the applicable SPACINGS of 7.5.2.2 and 7.5.3.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*



**Key**

| | |
|---|---|
| *L* | distance between adjacent conductors |
| *e* | thickness |
| A | layers of thin-film material such as tape and polyester film |
| C | conductors |

NOTE There can be air present between the layers.

**Figure 20 – Distance between adjacent conductors located between the same two layers**

REINFORCED INSULATION through the layers of thin-film insulation shall also have adequate electric strength. One of the following methods shall be used.

a) The thickness through the insulation is at least the value set out in Table 10.

*Conformity is checked by inspection and either by measurement of the separation or by inspection of the manufacturer's specifications.*

b) The insulation consists of at least two separate layers of thin-film materials, each of which is RATED by the manufacturer of the material for an electric strength of at least the applicable values for BASIC INSULATION of the test voltages and durations of 7.5.4.2.1.

*Conformity is checked by inspection of the manufacturer's specifications.*

c) The insulation consists of at least three separate layers of thin-film materials, any two of which have been tested to exhibit adequate electric strength.

*Conformity is checked by the voltage tests of 7.5.4.2.1 a) and b) applied to two of the three layers for REINFORCED INSULATION.*

*For the purposes of these tests, a special sample can be assembled with only two layers of the material.*

### 7.5.4.3 Solid insulation for probe assemblies which are not RATED for MEASUREMENT CATEGORIES

#### 7.5.4.3.1 General

Solid insulation for probe assemblies which are not RATED for MEASUREMENT CATEGORIES shall withstand the electrical and mechanical stresses that may occur in NORMAL USE and in all RATED environmental conditions (see 4.4) during the intended life of the probe assembly.

*Conformity is checked by both of the following tests:*

a) *The impulse voltage test of 7.6.5.3 using the applicable test voltage of Table 11, or as an alternative, the AC voltage test of 7.6.5.1 using the applicable test voltage of Table 11 with a duration of at least 5 s.*

   *The required CLEARANCE for Table 11 is determined by the following procedure:*

   1) *the theoretically required CLEARANCE for BASIC INSULATION or SUPPLEMENTARY INSULATION is calculated according to 7.5.2.3;*
   2) *for REINFORCED INSULATION, CLEARANCE is twice the value for BASIC INSULATION.*

   *The minimum CLEARANCE for POLLUTION DEGREES 2 and 3 do not apply.*

b) *For probe assemblies stressed by AC or AC plus DC, the AC voltage test of 7.6.5.1 or for probe assemblies stressed only by pure DC, the DC voltage test of 7.6.5.2, using the test voltage determined as follows with a duration of at least 1 min:*

   1) *for BASIC INSULATION and SUPPLEMENTARY INSULATION, the test voltage is 1,5 times the WORKING VOLTAGE;*
   2) *for REINFORCED INSULATION, the test voltage is twice the value for BASIC INSULATION.*

*NOTE Test a) checks the effects of transient overvoltages, while test b) checks the effects of long-term stress of solid insulation.*

#### 7.5.4.3.2 Constructional requirements

Solid insulation shall also meet the following requirements, as applicable:

1) for solid insulation used as an ENCLOSURE or PROTECTIVE FINGERGUARD, the requirements of Clause 9;
2) for moulded and potted parts, the requirements of 7.5.4.2.3.2;
3) for insulating layers of printed wiring boards, the requirements of 7.5.4.2.3.3, except that the applicable test voltages are determined using the procedure of 7.5.4.3.1 a) and b);
4) for thin-film insulation, the requirements 7.5.4.2.3.4, except that the applicable SPACINGS are as set out in 7.5.2.3 and 7.5.3, and the applicable test voltages are determined using the procedure of 7.5.4.3.1 a) and b).

*Conformity is checked as specified in 7.5.4.2.3.2 to 7.5.4.2.3.4 with the test voltages of 7.5.4.3.1 a) and b), and Clause 9 as applicable.*

## 7.6 Procedure for voltage tests

### 7.6.1 General

*The following test procedures apply when carrying out TYPE TESTS, and deterioration of the test specimen may occur. It is possible that further use of the test specimen will not be appropriate.*

*Test equipment for the voltage tests is specified in IEC 61180:2016.*

*The reference point for the voltage tests is one or more of the following items a) to d), bonded together if more than one.*

*a) Any ACCESSIBLE conductive part, except for any live parts permitted to be ACCESSIBLE because they do not exceed the values of 7.3.2 and any ACCESSIBLE conductive parts which are allowed to be HAZARDOUS LIVE by the exceptions given in 7.1 a) to 7.1 c).*

*b) Any ACCESSIBLE insulating part of the ENCLOSURE, covered with metal foil everywhere except around CONNECTORS. For test voltages up to 10 kV AC peak or 10 kV DC, the distance from foil to CONNECTOR is not more than 20 mm. For higher voltages, the distance is the minimum to prevent flashover.*

*c) ACCESSIBLE parts of controls with parts made of insulating material being wrapped in metal foil or having soft conductive material pressed against them.*

*d) For testing CONNECTORS in unmated position, the test finger is applied to the external parts of the CONNECTOR in the least favourable position with the closest approach (see Figure 7 d)).*

### 7.6.2 Humidity preconditioning

*To ensure that the probe assembly does not become hazardous in the humidity conditions of 4.4, it is subjected to humidity preconditioning before the voltage tests of solid insulation. There is no humidity preconditioning before the voltage tests of CLEARANCES. The probe assembly is not operated during preconditioning.*

*If wrapping in foil is required by 7.6.1, the foil is applied after humidity preconditioning and recovery.*

*Electrical components, covers, and other parts which can be removed by hand are removed and subjected to the humidity preconditioning together with the main part.*

*Preconditioning is carried out in a humidity chamber containing air with a humidity of 93 % RH ± 3 % RH. The temperature of the air in the chamber is maintained at 40 °C ± 2 °C.*

*Before applying humidity, the probe assembly is brought to a temperature of 42 °C ± 2 °C, normally by keeping it at this temperature for at least 4 h before the humidity preconditioning.*

*The air in the chamber is stirred and the chamber is designed so that condensation will not precipitate on the probe assembly.*

*The probe assembly remains in the chamber for 48 h, after which it is removed and allowed a recovery period of 2 h under the environmental conditions of 5.3.1, after which parts removed (see third paragraph of this Subclause 7.6.2) are re-installed.*

### 7.6.3 Conduct of tests

*The tests are performed and completed within 1 h of the end of the recovery period after humidity preconditioning. The probe assembly is not operated during the tests.*

*Voltage tests are not made between two circuits, or between a circuit and an ACCESSIBLE conductive part, if they are connected to each other or not separated from each other.*

*PROTECTIVE IMPEDANCE in parallel with the insulation to be tested is disconnected.*

*When testing REINFORCED INSULATION, the test voltages specified can be applied to parts of circuits where two or more protective means are used in combination (see 7.4) and which are not required to withstand these test voltages. To avoid this, such parts may be disconnected during the tests, or the parts of circuits where REINFORCED INSULATION is required may be tested separately.*

### 7.6.4 Test voltages

*Voltage tests for solid insulation are applied using the values specified in 7.5.4.2 and 7.5.4.3.*

*Voltage tests for CLEARANCES are applied using the test voltage values of Table 11. The values of Table 11 are for test sites located at 2 000 m altitude. For other test site altitudes, the correction factors of Table 12 are applied to the values of Table 11 when testing CLEARANCES but not when testing solid insulation.*

*NOTE The electric testing of CLEARANCES will also stress the associated solid insulation.*

### Table 11 – Test voltages based on CLEARANCES

| Required CLEARANCE<br>mm | Impulse 1,2/50 µs<br>V peak | AC RMS 50/60 Hz<br>V | AC peak 50/60 Hz or DC<br>V | Required CLEARANCE<br>mm | Impulse 1,2/50 µs<br>V peak | AC RMS 50/60 Hz<br>V | AC peak 50/60 Hz or DC<br>V |
|---|---|---|---|---|---|---|---|
| 0,010 | 330 | 230 | 330 | 16,5 | 14 000 | 7 600 | 10 700 |
| 0,025 | 440 | 310 | 440 | 17,0 | 14 300 | 7 800 | 11 000 |
| 0,040 | 520 | 370 | 520 | 17,5 | 14 700 | 8 000 | 11 300 |
| 0,063 | 600 | 420 | 600 | 18,0 | 15 000 | 8 200 | 11 600 |
| 0,1 | 806 | 500 | 700 | 19 | 15 800 | 8 600 | 12 100 |
| 0,2 | 1 140 | 620 | 880 | 20 | 16 400 | 9 000 | 12 700 |
| 0,3 | 1 310 | 710 | 1 010 | 25 | 19 900 | 10 800 | 15 300 |
| 0,5 | 1 550 | 840 | 1 200 | 30 | 23 300 | 12 600 | 17 900 |
| 1,0 | 1 950 | 1 060 | 1 500 | 35 | 26 500 | 14 400 | 20 400 |
| 1,4 | 2 440 | 1 330 | 1 880 | 40 | 29 700 | 16 200 | 22 900 |
| 2,0 | 3 100 | 1 690 | 2 400 | 45 | 32 900 | 17 900 | 25 300 |
| 2,5 | 3 600 | 1 960 | 2 770 | 50 | 36 000 | 19 600 | 27 700 |
| 3,0 | 4 070 | 2 210 | 3 130 | 55 | 39 000 | 21 200 | 30 000 |
| 3,5 | 4 510 | 2 450 | 3 470 | 60 | 42 000 | 22 900 | 32 300 |
| 4,0 | 4 930 | 2 680 | 3 790 | 65 | 45 000 | 24 500 | 34 600 |
| 4,5 | 5 330 | 2 900 | 4 100 | 70 | 47 900 | 26 100 | 36 900 |
| 5,0 | 5 720 | 3 110 | 4 400 | 75 | 50 900 | 27 700 | 39 100 |
| 5,5 | 6 100 | 3 320 | 4 690 | 80 | 53 700 | 29 200 | 41 300 |
| 6,0 | 6 500 | 3 520 | 4 970 | 85 | 56 610 | 30 800 | 43 500 |
| 6,5 | 6 800 | 3 710 | 5 250 | 90 | 59 400 | 32 300 | 45 700 |
| 7,0 | 7 200 | 3 900 | 5 510 | 95 | 62 200 | 33 800 | 47 900 |
| 7,5 | 7 500 | 4 080 | 5 780 | 100 | 65 000 | 35 400 | 50 000 |
| 8,0 | 7 800 | 4 300 | 6 030 | 110 | 70 500 | 38 400 | 54 200 |
| 8,5 | 8 200 | 4 400 | 6 300 | 120 | 76 000 | 41 300 | 58 400 |
| 9,0 | 8 500 | 4 600 | 6 500 | 130 | 81 300 | 44 200 | 62 600 |
| 9,5 | 8 800 | 4 800 | 6 800 | 140 | 86 600 | 47 100 | 66 700 |
| 10,0 | 9 100 | 4 950 | 7 000 | 150 | 91 900 | 50 000 | 70 700 |
| 10,5 | 9 500 | 5 200 | 7 300 | 160 | 97 100 | 52 800 | 74 700 |
| 11,0 | 9 900 | 5 400 | 7 600 | 170 | 102 300 | 55 600 | 78 700 |
| 11,5 | 10 300 | 5 600 | 7 900 | 180 | 107 400 | 58 400 | 82 600 |
| 12,0 | 10 600 | 5 800 | 8 200 | 190 | 112 500 | 61 200 | 86 500 |
| 12,5 | 11 000 | 6 000 | 8 500 | 200 | 117 500 | 63 900 | 90 400 |
| 13,0 | 11 400 | 6 200 | 8 800 | 210 | 122 500 | 66 600 | 94 200 |
| 13,5 | 11 800 | 6 400 | 9 000 | 220 | 127 500 | 69 300 | 98 000 |
| 14,0 | 12 100 | 6 600 | 9 300 | 230 | 132 500 | 72 000 | 102 000 |
| 14,5 | 12 500 | 6 800 | 9 600 | 240 | 137 300 | 74 700 | 106 000 |
| 15,0 | 12 900 | 7 000 | 9 900 | 250 | 142 200 | 77 300 | 109 400 |
| 15,5 | 13 200 | 7 200 | 10 200 | 264 | 149 000 | 81 100 | 115 000 |
| 16,0 | 13 600 | 7 400 | 10 500 | | | | |
| Linear interpolation is allowed. | | | | | | | |

**Table 12 – Correction factors according to test site altitude for test voltages for CLEARANCES**

| | Correction factor | | | |
|---|---|---|---|---|
| **Test voltage** peak | **≥ 327 V < 600 V** | **≥ 600 V < 3 500 V** | **≥ 3 500 V < 25 kV** | **≥ 25 kV** |
| **Test voltage** RMS | **≥ 231 V < 424 V** | **≥ 424 V < 2 475 V** | **≥ 2 475 V < 17,7 kV** | **≥ 17,7 kV** |
| **Test site altitude** m | | | | |
| 0 | 1,08 | 1,16 | 1,22 | 1,24 |
| 500 | 1,06 | 1,12 | 1,16 | 1,17 |
| 1 000 | 1,04 | 1,08 | 1,11 | 1,12 |
| 2 000 | 1,00 | 1,00 | 1,00 | 1,00 |
| 3 000 | 0,96 | 0,92 | 0,89 | 0,88 |
| 4 000 | 0,92 | 0,85 | 0,80 | 0,79 |
| 5 000 | 0,88 | 0,78 | 0,71 | 0,70 |
| Linear interpolation is allowed. | | | | |

### 7.6.5 Test procedures

### 7.6.5.1 The AC voltage test

*The voltage tester shall have a regulated output capable of maintaining the test voltage throughout the test within ±3 % of the specified value. The waveform of the power frequency test voltage shall be substantially sinusoidal. This requirement is fulfilled if the ratio between the peak value and the RMS value is √2 ± 3 %.*

*The test voltage is raised uniformly from 0 V to the specified value within 5 s and held at that value for at least the specified time.*

*No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test.*

### 7.6.5.2 The DC voltage test

*The voltage tester shall have a regulated output capable of maintaining the test voltage throughout the test within ±3 % of the specified value. The DC test voltage shall be substantially free of ripple. This requirement is fulfilled if the ratio between the peak value of the voltage and the average value is 1,0 ± 3 %.*

*The DC test voltage is raised uniformly from 0 V to the specified value within 5 s and held at that value for at least the specified time.*

*No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test.*

### 7.6.5.3 The impulse voltage test

*The test shall be conducted for five impulses of each polarity with an interval of at least 1 s between impulses. The impulse voltage test is carried out with a 1,2/50 µs waveform (see IEC 61180:2016, Figure 1). The wave shape of each impulse shall be observed.*

*When verifying CLEARANCES within the probe assembly by an impulse voltage test, it is necessary to ensure that the specified impulse voltage appears at the CLEARANCE.*

*No flashover of CLEARANCES or breakdown of solid insulation shall occur during the test, but partial discharges are allowed.*

## 7.7 Constructional requirements for protection against electric shock

### 7.7.1 General

If a failure could cause a HAZARD,

a) the security of wiring connections subject to mechanical stresses shall not depend on soldering;

b) screws securing removable covers shall be captive if their length determines a SPACING between ACCESSIBLE conductive parts and HAZARDOUS LIVE parts;

c) accidental loosening or freeing of the wiring, screws, etc., shall not cause ACCESSIBLE parts to become HAZARDOUS LIVE.

NOTE Screws or nuts with lock washers are not regarded as likely to become loose, nor are wires which are mechanically secured by more than soldering alone.

*Conformity is checked by inspection and by measurement of SPACINGS.*

### 7.7.2 Insulating materials

The following shall not be used as insulation for safety purposes:

a) materials which can easily be damaged (for example, lacquer, enamel, oxides, anodic films);

b) non-impregnated hygroscopic materials (for example, paper, fibres, fibrous materials).

*Conformity is checked by inspection.*

### 7.7.3 ENCLOSURES of probe assemblies with DOUBLE INSULATION or REINFORCED INSULATION

A probe assembly which relies on DOUBLE INSULATION or REINFORCED INSULATION throughout for protection against electric shock shall have an ENCLOSURE which surrounds all metal parts. This requirement does not apply to small metal parts such as nameplates, screws or rivets, if they are separated from parts which are HAZARDOUS LIVE by REINFORCED INSULATION or its equivalent.

ENCLOSURES or parts of ENCLOSURES made of insulating material shall meet the requirements for DOUBLE INSULATION or REINFORCED INSULATION.

Protection for ENCLOSURES or parts of ENCLOSURES made of metal shall be provided by one of the means from a) or b), except for parts where PROTECTIVE IMPEDANCE is used:

a) an insulating coating or a barrier on the inside of the ENCLOSURE which shall surround all metal parts and all places where loosening of a part which is HAZARDOUS LIVE can cause it to touch a metal part of the ENCLOSURE;

b) SPACINGS between the ENCLOSURE and parts which are HAZARDOUS LIVE that cannot be reduced below the values specified in 7.5 by loosening of parts or wires.

*Conformity is checked by inspection and measurement and as specified in 7.5.*

### 7.7.4 PROBE WIRE attachment

#### 7.7.4.1 General

The attachment of the PROBE WIRE to the probe body and to the equipment (or to the CONNECTORS if the attachment is not fixed) shall withstand forces likely to be encountered in NORMAL USE without damage which could cause a HAZARD. Solder alone, without mechanical gripping, shall not be used for strain relief. The insulation of the PROBE WIRE shall be mechanically secured to avoid retraction.

*Conformity is checked by inspection and by applying the tests of 7.7.4.2 to 7.7.4.4. After the tests,*

*a) the insulation of the PROBE WIRE shall not have been cut or torn, and shall not have moved more than 2 mm in the bushing;*

*b) SPACINGS shall not have been reduced below the applicable values of 7.5.2 and 7.5.3;*

*c) the PROBE WIRE shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b);*

*d) no more than 75 % of the copper strands of the PROBE WIRE shall be broken.*

NOTE For test purposes, it can be useful to prepare a special sample of the probe, manufactured in all respects like the probe being investigated but in which no solder has been applied.

#### 7.7.4.2 Pull test

*With the probe body or equipment or CONNECTOR clamped so that it cannot move and any soldered connection is severed, the PROBE WIRE is subjected for 1 min to a steady axial pull at the values shown in a) or b) below:*

*a) for probe bodies and for locking CONNECTORS, twice the pull force value from Table 13;*

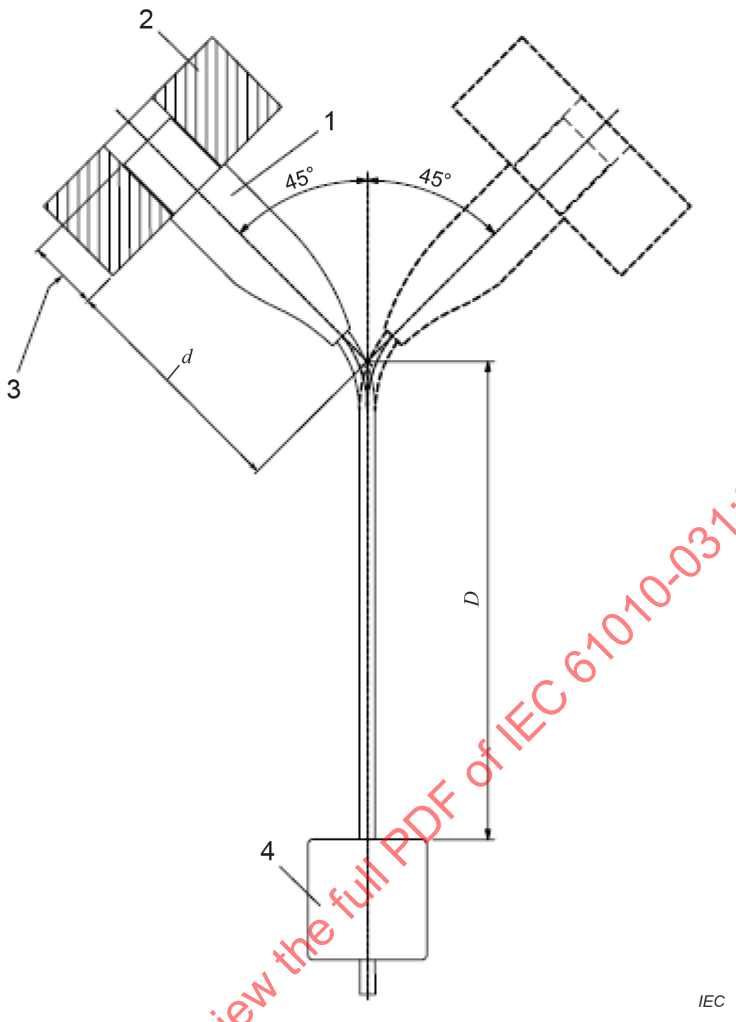
*b) for non-locking CONNECTORS, twice the pull force value from Table 13 or four times the axial pull force required to disconnect the CONNECTOR, whichever is less.*

#### 7.7.4.3 Flexing test

*CONNECTORS shall be subjected to a flexing test in an apparatus similar to that shown in Figure 21.*

*The CONNECTOR is fixed to the oscillating member of the apparatus so that, when this is at the midpoint of its travel, the axis of the flexible PROBE WIRE, where it enters the CONNECTOR, is vertical and passes through the axis of oscillation.*

*The oscillating member is, by variation of distance d shown in Figure 21, so positioned that the flexible PROBE WIRE makes a minimum lateral movement when the oscillating member of the test apparatus is moved over its full travel.*



**Key**

| | |
|---|---|
| *D* | > 300 mm |
| 1 | CONNECTOR |
| 2 | part of oscillating member for fixing the CONNECTOR |
| 3 | depth specified for the shroud of corresponding equipment TERMINAL |
| 4 | weight |

**Figure 21 – Flexing test**

*The PROBE WIRE is loaded with a weight such that the force from Table 13 is applied.*

*The oscillating member is moved to each side of vertical through a total angle of 90° (45° on each side of vertical). The total number of flexings is 5 000. The rate of flexing is 60 per minute. A complete cycle is two flexings.*

*CONNECTORS with PROBE WIRE of nominally circular cross-sectional area are rotated approximately 90° around the vertical axis within the oscillating member after 2 500 flexings; CONNECTORS with flat flexible PROBE WIRE are not so rotated, and are only flexed in a direction perpendicular to the thinner dimension of the cross-section.*

*If a HAZARD can result from the breaking of a conductor or a short-circuit between conductors, a current equal to the RATED current of the probe assembly is passed through each conductor, the voltage between them being the RATED voltage. During the test, there shall be no interruption of the test current and no short-circuit between the conductors.*

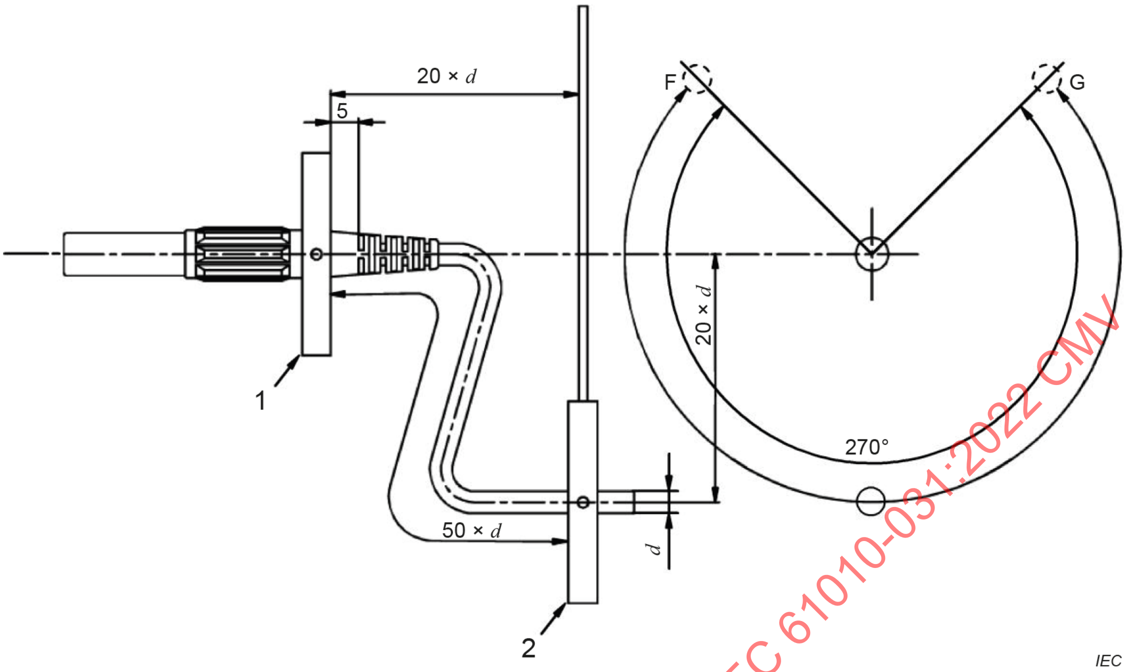
**Table 13 – Pull forces for PROBE WIRE attachment tests**

| **Cross sectional area of the conductor *(a)*** mm$^2$ | **Pull force** N |
|---|---|
| 0,25 | 2,5 |
| 0,50 | 5 |
| 1,0 | 10 |
| 2,5 | 18 |
| 4 | 25 |
| 6 | 30 |
| 10 | 40 |
| 16 | 45 |
| Linear interpolation is allowed.<br>For PROBE WIRES with multiple conductors, the cross-sectional area (*a*) is calculated as the sum of the cross-sectional areas of the individual conductors.<br>For the purpose of this calculation, the cross-sectional area of any shield is ignored. | |

### 7.7.4.4 Rotational flexing test

*The probe assembly is mounted in the test fixture as shown in Figure 22, so that the fixed clamp holds the probe body, CONNECTOR, or equipment with at least 5 mm of the solid portion protruding through the clamp. The rotating clamp is attached to the PROBE WIRE at a point 50 times the diameter of the PROBE WIRE, measured along the surface of the PROBE WIRE from the fixed clamp. The rotating clamp rotates in a plane at a distance equal to 20 times the diameter of the PROBE WIRE from the fixed clamp. The rotating clamp is rotated from point F to point G and back to point F (one complete oscillation) at a rate of 20 oscillations per minute for a total of 250 swings. The probe body or CONNECTOR is turned 90° about its axis and the test continued for a further 250 oscillations.*

Dimensions in millimetres



**Key**

*d* diameter of PROBE WIRE

F start point, end point

G middle point (F + 270°)

1 fixed clamp

2 rotating clamp

**Figure 22 – Rotational flexing test**

## 8 Protection against mechanical HAZARDS

Handling of a probe assembly or an accessory during NORMAL USE shall not lead to a HAZARD.

Easily touched edges, projections, etc. should be smooth and rounded so as not to cause injury. This does not apply to PROBE TIPS.

*Conformity is checked by inspection.*

## 9 Resistance to mechanical stresses

### 9.1 General

Probe assemblies shall not cause a HAZARD when subjected to mechanical stresses likely to occur in NORMAL USE. To achieve this requirement, probe assemblies shall have adequate mechanical strength, components shall be reliably secured and electrical connections shall be secure.

*Conformity is checked by performing the tests of 9.2 to 9.4. The probe assembly is not operated during the tests.*

*After completion of the tests, the probe assembly shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) without humidity preconditioning and is inspected to check that:*

a) *parts which are* HAZARDOUS LIVE *have not become* ACCESSIBLE*;*
b) ENCLOSURES *show no cracks which could cause a* HAZARD*;*
c) SPACINGS *are not less than their permitted values and the insulation of internal wiring remains undamaged;*
d) PROTECTIVE FINGERGUARDS *have not been damaged or loosened.*

*Damage to the finish, small dents which do not reduce* SPACINGS *below the applicable values of 7.5.2 and 7.5.3, and small chips which do not adversely affect the protection against electric shock or moisture, are ignored.*

## 9.2 Rigidity test

*If the probe assembly produces an appreciable amount of heat, the probe assembly is operated under the reference test conditions of 5.3, except that the ambient temperature is 40 °C or the maximum* RATED *ambient temperature if higher. The temperature of parts of the* ENCLOSURE *is measured during this treatment.*

*The probe assembly, not energized, is stored for 7 h at a temperature of 70 °C. However, if during the previous operative treatment, a higher temperature is measured, the storage temperature is to be 10 °C above that measured temperature. If the probe assembly contains components which can be damaged by this treatment, an empty* ENCLOSURE *may be treated, followed by assembly of the probe at the end of the treatment.*

*Within 2 min of the end of the non-operative treatment, the probe assembly is held firmly against a rigid support and subjected to a force of 20 N applied by the hemispherical end of a hard rod of 12 mm diameter. The rod is applied three times to any part of the probe assembly which is* ACCESSIBLE *when the probe assembly is ready for use, and which could cause a* HAZARD *if distorted.*

## 9.3 Drop test

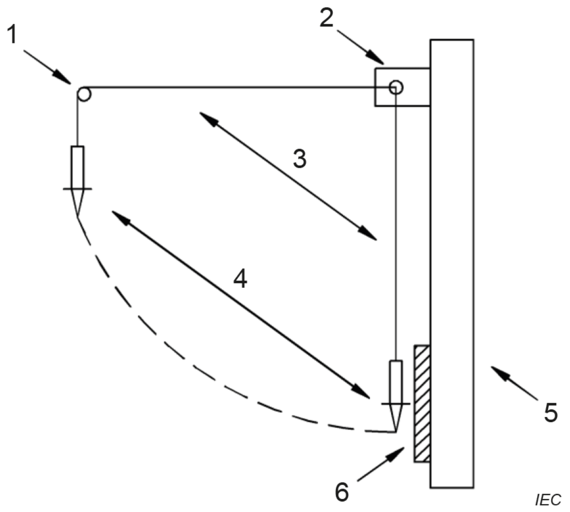
*Non-metallic* ENCLOSURES *of a probe assembly with a minimum* RATED *ambient temperature below 2 °C are cooled to the minimum* RATED *ambient temperature, then tested within 2 min.*

*Three samples of the probe assembly are each dropped three times through a height of 1 m onto a 50 mm thick hardwood board having a density of more than 700 kg/m$^3$, lying flat on a rigid base such as concrete. For each sample, the three tests are carried out so as to apply the impact to different points on the probe body.*

## 9.4 Impact swing test

*Non-metallic probe bodies with a minimum* RATED *ambient temperature below 2 °C are cooled to the minimum* RATED *ambient temperature, then tested within 2 min.*

*The probe body is subjected to one impact against a 50 mm thick hardwood board having a density of more than 700 kg/m$^3$ fixed to a solid wall, when swinging as a pendulum by its* PROBE WIRE *(see Figure 23). The height of the drop is 2 m, or the* PROBE WIRE *length if shorter.*



**Key**

| | | | |
|---|---|---|---|
| 1 | start point | 4 | probe body |
| 2 | suspension point | 5 | wall |
| 3 | PROBE WIRE | 6 | hardwood board |

**Figure 23 – Impact swing test**

## 10 Temperature limits

The temperature of easily touched surfaces shall not exceed the values of Table 14 in NORMAL CONDITION, and 105 °C in SINGLE FAULT CONDITION, at an ambient temperature of 40 °C.

Easily touched surfaces of probe assemblies RATED for a maximum ambient temperature above 40 °C are permitted to exceed the values of Table 14 in NORMAL CONDITION, and to exceed 105 °C in SINGLE FAULT CONDITION, by not more than the amount by which the maximum RATED temperature exceeds 40 °C.

If easily touched heated surfaces are necessary for functional reasons, they are permitted to exceed the values of Table 14, but shall be recognizable as such by appearance or function, or shall be marked with symbol 6 of Table 1 (see 6.2).

**Table 14 – Surface temperature limits in NORMAL CONDITION**

| **Part** | **Limit**<br>°C |
|---|---|
| Metal | 55 |
| Non-metallic materials | 70 |
| PROBE WIRES | 75 |

*Conformity is checked by inspection of the probe assembly under reference test conditions and in the position of NORMAL USE (see 5.3.2). Temperatures are measured when steady state has been attained. The maximum temperature of a part is determined by adding the measured temperature rise of the part to the maximum ambient temperature (40 °C or the maximum RATED ambient temperature if higher, see 4.4).*

## 11 Protection against HAZARDS from fluids

### 11.1 Cleaning

If a cleaning or decontamination method is specified by the manufacturer, this shall not cause a direct safety HAZARD, an electric shock HAZARD, or a HAZARD resulting from corrosion or other weakening of structural parts associated with safety. The cleaning method and any decontamination method shall be described in the documentation (see 6.4.3).

*Conformity is checked by cleaning the probe assembly three times according to the manufacturer's instructions. If, immediately after this treatment, there are any signs of wetting of parts likely to cause a HAZARD, the probe assembly shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) (without humidity preconditioning) and ACCESSIBLE parts shall not exceed the levels of 7.3.2. If a decontamination method is specified, this method is applied once.*

### 11.2 Specially protected probe assemblies

If the probe assembly is RATED and marked by the manufacturer as having a protected ENCLOSURE according to the stated degrees of protection of IEC 60529, it shall adequately resist the ingress of solid foreign objects and water which could lead to a HAZARD.

*Conformity is checked by inspection and by subjecting the probe assembly to the appropriate treatment of IEC 60529, after which the probe assembly shall pass the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) (without humidity preconditioning) and ACCESSIBLE parts shall not exceed the levels of 7.3.2.*

## 12 Components

### 12.1 General

If safety aspects are addressed by components, these components shall be used in accordance with their specified RATING unless a specific exception is made. They shall conform to one of the following a) to d).

a) All applicable safety requirements of relevant IEC International Standards. Conformity to other requirements of the component standard is not required. If necessary for the application, components shall be subjected to the tests of this document, except that it is not necessary to carry out identical or equivalent tests already performed to check conformity to the component standard.

b) The requirements of this document and, where necessary for the application, any additional applicable safety requirements of the relevant IEC component standard.

c) If there is no relevant IEC International Standard, the requirements of this document.

d) Applicable safety requirements of a non-IEC standard which are at least as stringent as those of the relevant IEC International Standard, provided that the component has been approved to the non-IEC standard by a recognized testing authority.

   Tests performed by a recognized testing authority which confirm conformity with all applicable safety requirements need not be repeated, even if the tests were performed using a non-IEC standard.

*Conformity is checked by inspection, and if necessary, by test.*

### 12.2 Fuses

Fuses in probe assemblies may be used to provide protection to the user against arc explosions or burns, or they may be used to protect the equipment to which the probes are connected.

If a fuse is installed in a probe assembly, it shall have a voltage RATING at least as high as the highest RATED voltage of the probe assembly, and an appropriate breaking capacity and current RATING for the intended application of the probe assembly (see also 6.1.3). If the probe assembly is RATED for both AC and DC, the AC and DC breaking capacities shall be individually determined, and the fuse shall meet the RATED voltage and breaking capacity for each case.

*Conformity is checked by inspection.*

## 12.3 PROBE WIRE

### 12.3.1 General

PROBE WIRE shall be suitable for its intended use in NORMAL CONDITION and in SINGLE FAULT CONDITION.

*Conformity is checked as specified in 12.3.2 to 12.3.6.*

### 12.3.2 RATING of PROBE WIRE

PROBE WIRES shall be RATED for the maximum voltage and current of NORMAL USE and shall withstand the voltage test for the highest RATED voltage. Conductors shall be separated from ACCESSIBLE surfaces by DOUBLE INSULATION or REINFORCED INSULATION, based on the voltage values from a), b) or c).

a) For Type A, Type E and Type F probe assemblies, 125 V or the highest RATED voltage of the probe assembly, whichever is greater.

b) For Type B probe assemblies,

   1) RATED for voltages up to 1 000 V AC RMS or 1 500 V DC, 125 V or the highest RATED voltage of the probe assembly, whichever is greater;

   2) RATED for voltages above 1 000 V AC RMS or 1 500 V DC, 500 V or the highest RATED voltage of the probe assembly divided by the divider ratio, whichever is greater.

      For Type B probe assemblies under this b) 2), symbol 7 of Table 1 shall be marked on the probe assembly and a warning shall be provided in the documentation of the possibility that the PROBE WIRE will not provide adequate protection if it comes into contact with the circuit under test (see 6.4.3 l)).

c) For Type D probe assemblies, 125 V.

A wear indicator is highly recommended (see also 6.4.3 j)). Insulation of PROBE WIRES which have a wear indicator shall meet the requirements for BASIC INSULATION when the wear indicator has become visible.

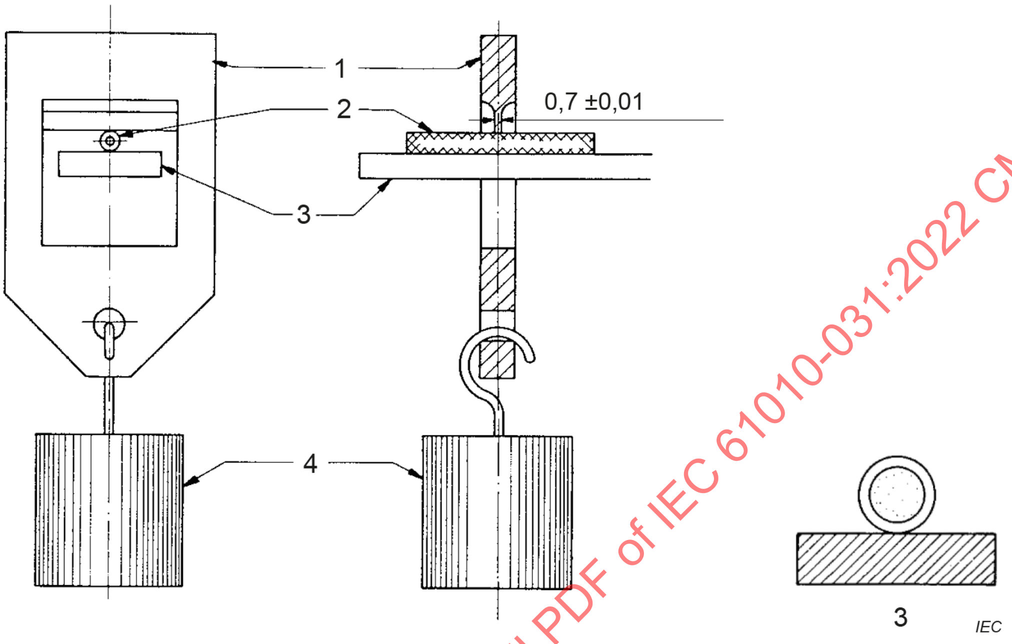
*Conformity is checked by inspection, and by the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for REINFORCED INSULATION. If the insulation includes a wear indicator, then the voltage test is repeated with the test voltage value for BASIC INSULATION after sufficient insulation has been removed from the cable to make the wear indicator just visible (see also 6.2 and 6.4.3 l)).*

*NOTE For the purposes of this test, the wear indicator can be made visible by slicing thin layers from the insulation, by abrasion, or by manufacturing special samples of the cable without the outer insulating layer.*

### 12.3.3 Pressure test at high temperature for insulations

*For each PROBE WIRE to be tested, three adjacent samples are taken from a PROBE WIRE having a length of 150 mm to 300 mm. The length of each sample is 50 mm to 100 mm. The conductors of flat PROBE WIRES without sheaths are not separated.*

*The indentation device is shown in Figure 24, and consists of a rectangular blade with an edge 0,70 mm ± 0,01 mm wide, which can be pressed against the sample. Each sample is placed in the position shown in Figure 24. A flat cord without a sheath is laid on its flat side. Samples are fixed on the support in such a manner that they do not curve under the pressure of the blade. The force is applied in a direction perpendicular to the axis of the sample; the blade is also perpendicular to the axis of the sample.*



**Key**

1 Testing frame

2 Sample

3 Supports

4 Weight

**Figure 24 – Indentation device**

*The compressing force which is exerted by the blade upon the sample is given by the formula:*

$$F = 0{,}6 \times \sqrt{(2 \times d \times e - e^{2})}$$

*where*

$F$ *is the compressing force in newtons*;

$e$ *is the mean value of the thickness of the insulation of the sample*;

$d$ *is the mean value of the outer diameter of the sample.*

*$e$ and $d$ are both expressed in millimetres, to one decimal place, and measured on a thin slice cut from the end of the test piece.*

*The test is carried out in air (i.e. in an air oven). The temperature of the air is maintained continuously at a temperature of 100 °C ± 3 °C. The loaded samples are kept in the test position for 4 h. Following this, the samples are rapidly cooled which may be carried out by spraying the sample with cold water on the spot where the blade is pressing. The sample is removed from the apparatus when it has cooled to a temperature where recovery of the insulation no longer occurs. The sample is then cooled further by immersion in cold water.*

*Conformity is checked by the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for* REINFORCED INSULATION *(without humidity preconditioning).*

### 12.3.4 Tests for resistance of insulation to cracking

*Four samples of suitable length are cut from two sections of the* PROBE WIRE *separated by at least 1 m.*

*Two samples are tautly wound and fixed, at ambient temperature, on individual mandrels to form a close helix. The diameter of the mandrel and the number of turns are given in Table 15.*

**Table 15 – Diameter of mandrel and numbers of turns**

| Outer diameter of the PROBE WIRE (*d*) mm | Mandrel diameter mm | Number of turns |
|---|---|---|
| *d* ≤ 2,5 | 5 | 6 |
| 2,5 < *d* ≤ 4,5 | 9 | 6 |
| 4,5 < *d* ≤ 6,5 | 13 | 6 |
| 6,5 < *d* ≤ 9,5 | 19 | 4 |
| 9,5 < *d* ≤ 12,5 | 40 | 2 |

*These two samples, on their mandrels, are placed in an air oven pre-heated to a temperature of 100 °C ± 3 °C. The samples are maintained at the specified temperature for 1 h. After the samples have been allowed to return to approximately ambient temperature, they are examined while still on the mandrel.*

*The other two samples are conditioned in a cold chamber for 4 h at −10 °C ± 2 °C. The test is to be performed in the cold chamber where space and mounting means are available in the chamber. Where this is not practical, it is appropriate to remove a sample and a mandrel from the test chamber and perform the test outside the chamber. In either case, the winding is to be completed within 30 s of the time that the cold chamber is opened. The winding is to be done at a rate of about 3 s per turn (18 s ± 3 s for six turns), and successive turns are to be in contact with one another.*

*Flat* PROBE WIRES *are to be wrapped in a U-bend in which the sample is in contact with a mandrel having a diameter of twice the minor axis diameter of the sample for minimum 180°.*

*Insulated conductors as well as the finished* PROBE WIRE *are to be tested separately.*

*Circumferential depressions in the outer surface indicate cracks on the inside surface of the insulation or jacket of most materials. Circumferential depressions in a fluoropolymer surface are yield marks (locally stronger points) rather than indicators of cracking.*

*After this conditioning, the samples shall show no cracks when examined with normal or corrected vision without magnification, and shall meet the requirements for solid insulation.*

*Conformity is checked by inspection and by the applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for* REINFORCED INSULATION *(without humidity preconditioning).*

### 12.3.5 Voltage test

*Six lengths of insulated* PROBE WIRE *or insulated conductors removed from a jacketed wire are to be tested for each specimen of wire to be evaluated. Each sample is 600 mm in length. Three of the samples are to be tested in an unaged condition. The other three samples are to be tested after air oven conditioning.*

*The three straight samples intended for oven ageing are to be conditioned in a circulating air oven pre-heated to a temperature 100 °C ± 3 °C. The test piece shall be maintained at the specified temperature for 1 h.*

*After air oven conditioning, the three specimens are to be cooled to room temperature in still air for a period of 16 h to 96 h before testing. After the cooling period, both the unaged and oven-conditioned samples are to be tested. The centre 300 mm of each sample is to be wrapped with metal foil.*

*Except for flat* PROBE WIRES*, the foil-wrapped centre section of each sample is to then be wrapped closely for six complete turns around a metal mandrel having a diameter of two times the outside diameter of the specimen or 5 mm, whichever is larger. The end of each resulting helix is to be twisted loosely together or fastened together with tape to prevent unwinding. Specimens of flat wires are to be wrapped in a U-bend in which the specimen is in contact with a mandrel having a diameter of twice the minor axis diameter of the specimen for 180° minimum.*

*The applicable test of 7.5.4.2.1 b) or 7.5.4.3.1 b) for* REINFORCED INSULATION *(without humidity preconditioning) is then performed. The test voltage is applied between the conductor of the test specimen and the metal mandrel. After 1 min at the specified test voltage, the test voltage is increased at a rate not exceeding 500 V/s until dielectric breakdown occurs. If dielectric breakdown does not occur, breakdown voltage can be considered as twice the value in 7.5.4.2.1 b) or 7.5.4.3.1 b) (or 10 kV). The dielectric breakdown voltage values are recorded separately for unaged specimens and oven-aged specimens. The average of the dielectric breakdown voltage values is calculated and recorded separately for unaged specimens and oven-aged specimens.*

*Samples of both unaged and oven-aged specimens shall comply with the following:*

*a) unaged and oven-aged samples shall withstand the test voltage without breakdown for 1 min, and*

*b) the average dielectric breakdown value of oven-aged samples shall not be less than 50 % of the average breakdown value of unaged samples.*

*Conformity is checked by inspection and test.*

### 12.3.6 Tensile test

#### 12.3.6.1 General

These tests are to determine the tensile strength and elongation at break of the insulating material (exclusive of any semi-conducting layers) of the PROBE WIRE in the condition as manufactured (i.e., without any ageing treatment) and after an accelerated ageing treatment.

For the unaged samples, the median value of the tensile strengths shall be at least 7 N/mm$^2$ and the samples shall exhibit a median value of elongation of at least 100 % before they break. For the aged samples, the median value of the tensile strengths shall be at least 70 % of the result for unaged samples, and the samples shall exhibit a median value of elongation of at least 45 % of the result of the unaged samples before they break.

*After the test conditioning and procedure of 12.3.6.2 to 12.3.6.6, conformity is checked by calculation of the tensile strength and the elongation at break respectively and the median value of the result is determined.*

#### 12.3.6.2 Sampling

*The samples selected for the ageing treatment are from positions adjacent to the samples used for the test without ageing and the tensile tests on the aged and unaged test pieces are made in immediate succession.*

*One section of each core to be tested is taken of sufficient size to provide a minimum of ten samples, five each for the tensile tests without ageing and five each for the tensile tests after the ageing treatment, bearing in mind that a 100 mm length is needed for the preparation of each sample. The cores of flat cords are not separated. Any sample that shows signs of mechanical damage is not used for the test.*

### 12.3.6.3 Preparation and conditioning of samples

*The section of core is cut into ten samples, each approximately 100 mm long and the conductor is removed, care being taken not to damage the insulation. The samples are marked to identify the section from which they were prepared and their relative positions in the section.*

*The centre 20 mm shall be marked immediately before the tensile test.*

### 12.3.6.4 Determination of cross-sectional area

*At the middle of the section being used to prepare the samples, a piece is taken to determine the cross-sectional area A by the following method (for samples with a round shape).*

$$A = \pi \times (d - e) \times e$$

*where*

*e is the mean value of the thickness of the insulation;*

*d is the mean value of the outer diameter of the test piece.*

*For samples which are to be aged, the cross-sectional area is determined before the ageing treatment.*

### 12.3.6.5 Ageing treatment

*The five samples intended for oven ageing are to be conditioned in a circulating air oven pre-heated to a temperature of 100 °C ± 3 °C. The test piece is maintained at the specified temperature for 1 h, and then allowed to cool to the temperature specified in 12.3.6.6.*

### 12.3.6.6 Tensile testing procedure

*The test is carried out at a temperature of 23 °C ± 5 °C.*

*The grips of the tensile testing machine may be either of a self-tightening type or not. The distance between the grips is:*

*a) 50 mm for tubes, if tested with self-tightening grips;*

*b) 85 mm for tubes, if tested with non-self-tightening grips.*

*The rate of separation shall be 250 mm/min ± 50 mm/min and, in case of doubt, 25 mm/min ± 5 mm/min.*

*NOTE Many failures when tested at 250 mm/min can create a doubt.*

*For each sample, the maximum tensile force during the test is measured and recorded, and the distance between the two reference marks at the breaking point is measured and recorded.*

*One test result from the five aged samples and one test result from the five unaged samples may be ignored.*

## 13 Prevention of HAZARD from arc flash and short-circuits

### 13.1 General

When a PROBE TIP or SPRING-LOADED CLIP temporarily bridges two high-energy conductors at different potentials, it could cause a high current to flow through the PROBE TIP or SPRING-LOADED CLIP which could become hot and melt. This could cause burns to an OPERATOR or a bystander.

If the bridge is opened (by OPERATOR action, melting, or other event) while the high current is flowing through the PROBE TIP or SPRING-LOADED CLIP, arcing could occur. The arcing will ionize the air, permitting continued current flow in the vicinity of the PROBE TIP or SPRING-LOADED CLIP. If there is sufficient available energy, then the ionization of the air will continue to spread and the flow of current through the air will continue to increase. The result is an arc flash, which is similar to an explosion, and can cause injury or death to an OPERATOR or a bystander.

PROBE TIPS and SPRING-LOADED CLIPS shall be constructed to reduce the risk of short-circuits and arc flashes.

*Conformity is checked as specified in 13.2.*

### 13.2 Exposed conductive parts

The exposed conductive part of a PROBE TIP or jaws shall be constructed as follows:

a) For probe assemblies except for SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY III or IV:
   1) when RATED for MEASUREMENT CATEGORY III or IV, the exposed conductive part of a PROBE TIP shall not exceed 4 mm in length;
   2) when RATED for use in special applications where the energy levels will not support arc flash or fire but not RATED for any MEASUREMENT CATEGORY, the exposed conductive part of a PROBE TIP shall not exceed 80 mm;
   3) when RATED for MEASUREMENT CATEGORY II, and for other probe assemblies not covered by items 1) and 2), above, the exposed conductive part of a PROBE TIP or jaw shall not exceed 19 mm.

b) For SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY III or IV:
   1) in closed position, the exposed ACCESSIBLE conductive parts shall not exceed 4 mm in all directions;
   2) in open position,
      i) the length of the exposed ACCESSIBLE conductive parts of SPRING-LOADED CLIPS with one hook shall not exceed 10 mm,
      ii) the outer surfaces of SPRING-LOADED CLIPS with more than one hook or jaw shall not be conductive.

Requirements of 13.2 a) and 13.2 b) do not apply to Type E probes assemblies, provided the two conductors of the probe assembly are separated from each other by high impedance.

*Conformity is checked by inspection and measurement of the exposed conductive parts of the PROBE TIP or jaws as follows:*

*a) spring-loaded parts covering the conductive part of a PROBE TIP are retracted before the measurements are made;*

*b) PROBE TIPS with moving parts other than spring-loaded parts which change the RATING and the markings of the probe assembly are evaluated in each position;*

*c) PROBE TIPS with removable parts which change the RATING and the markings of the probe assembly are evaluated when the part is removed, partially removed and not removed (see also 6.1.1).*

# Annex A
(normative)

## Measuring circuits for touch current
(see 7.3)

NOTE Annex A is based on IEC 60990:2016, which specifies procedures for measuring touch-current, and also specifies the characteristics for test voltmeters.

### A.1 Measuring circuits for AC with frequencies up to 1 MHz and for DC

The current is measured with the circuit of Figure A.1. The current is calculated from:

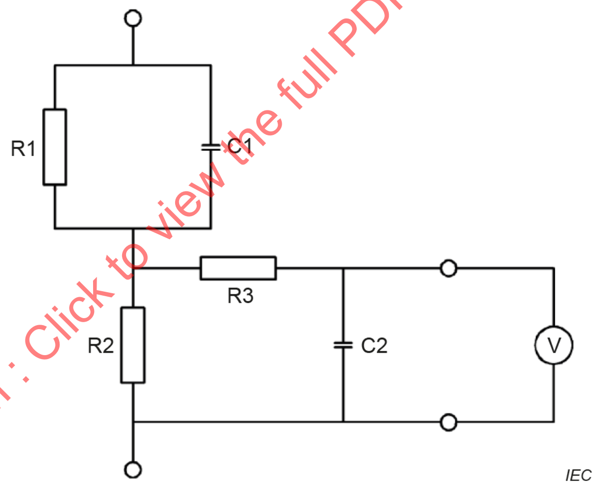
$$I = \frac{U}{500}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.

This circuit represents the impedance of the human body and compensates for the change of physiological response of the human body with frequency.



R1 = 1 500 Ω ±5 %

R2 = 500 Ω ±5 %

R3 = 10 kΩ ±5 %

C1 = 0,22 µF ±10 %

C2 = 0,022 µF ±10 %

**Figure A.1 – Measuring circuit for AC with frequencies up to 1 MHz and for DC**

### A.2 Measuring circuits for AC with sinusoidal frequencies up to 100 Hz and for DC

If the frequency does not exceed 100 Hz, the current may be measured with the alternative circuit of Figure A.2. When using the voltmeter, the current shall be calculated from:

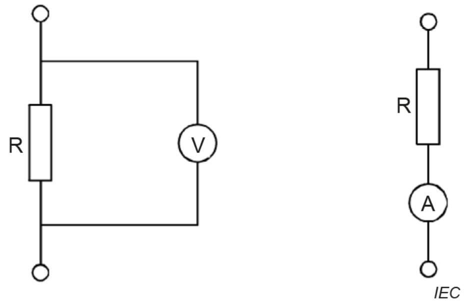
$$I = \frac{U}{2\ 000}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.

The circuit represents the impedance of the human body for frequencies not exceeding 100 Hz.



R = 2 000 Ω ±5 %

NOTE The value 2 000 Ω includes the impedance of the measuring instrument.

**Figure A.2 – Measuring circuits for AC with sinusoidal frequencies up to 100 Hz and for DC**

## A.3 Current measuring circuit for electrical burns at frequencies above 100 kHz

The current is measured with the circuit of Figure A.3 or Figure A.4 as specified in 7.3.2, 7.3.3, or 7.3.4.3. The current is calculated from:

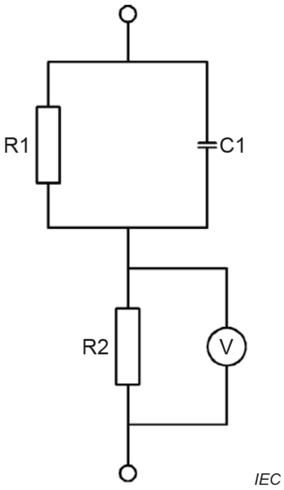
$$I = \frac{U}{500}$$

where

$I$ is the current, in amperes;

$U$ is the voltage, in volts, indicated by the voltmeter.

These circuits compensate for the physiological response of the human body to high frequencies.

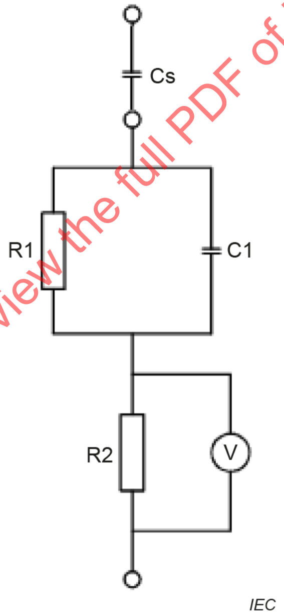


R1 = 1 500 Ω ±5 %

R2 = 500 Ω ±5 %

C1 = 0,22 µF ±10 %

**Figure A.3 – Current measuring circuit for electrical burns**



R1 = 1 500 Ω ±5 %

R2 = 500 Ω ±5 %

C1 = 0,22 µF ±10 %

Cs = Capacitance between the shield and the foil (see Figure 11)

**Figure A.4 – Current measuring circuit for high frequency test probes**

## A.4 Current measuring circuit for WET LOCATIONS

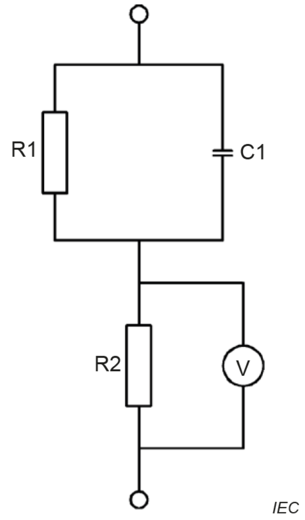
For WET LOCATIONS the current is measured using the circuit of Figure A.5. The current is calculated from:

$$I = \frac{U}{500}$$

where

*I* is the current, in amperes;

*U* is the voltage, in volts, indicated by the voltmeter.



R1 = 375 Ω ±5 %

R2 = 500 Ω ±5 %

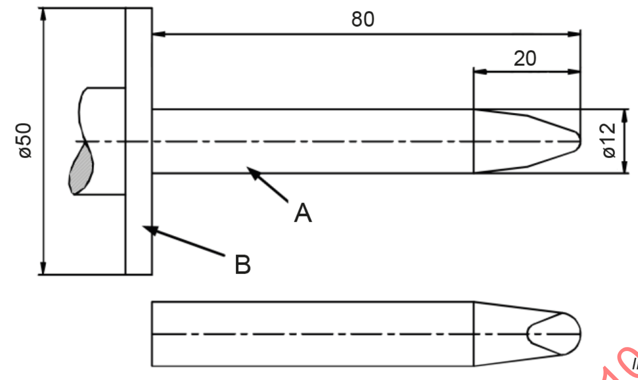
C1 = 0,22 µF ±10 %

**Figure A.5 – Current measuring circuit for WET LOCATIONS**

# Annex B
(normative)

# Standard test fingers

Dimensions in millimetres



**Key**

A metal

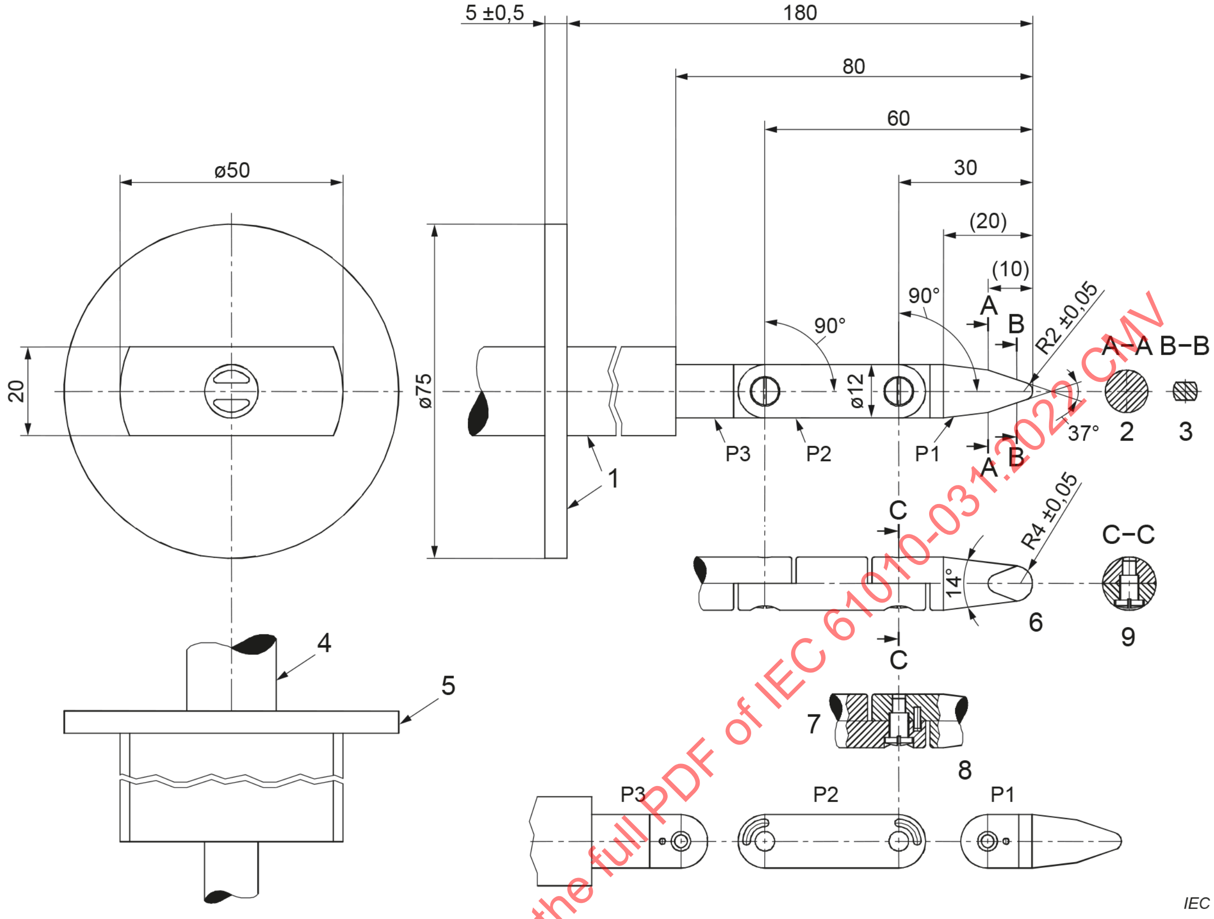
B insulating material

For tolerances and dimensions of the fingertip, see Figure B.2.

NOTE This test finger is identical to test probe 11 from IEC 61032:1997.

**Figure B.1 – Rigid test finger**

Dimensions in millimetres



**Key**

1 insulating material

2 section AA

3 section BB

4 handle

5 stop plate

6 spherical

7 detail × (example)

8 side view

9 chamfer all edges

Figure B.2 – Jointed test finger

Tolerances on dimensions without specific tolerance:

on angles: $^{\ 0}_{-10'}$

on linear dimensions:

up to 25 mm: $^{\ 0}_{-0,05}$ mm

over 25 mm: ±0,2 mm

Material of finger: heat-treated steel, etc.

Both joints of this finger may be bent through an angle of $(90^{+10}_{\ 0})$° but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design shall ensure a $(90^{+10}_{\ 0})°$ bending angle.

NOTE This test finger is identical to test probe B from Figure 2 of IEC 61032:1997.

# Annex C
(normative)

## Measurement of CLEARANCES and CREEPAGE DISTANCES

The methods of measuring CLEARANCES and CREEPAGE DISTANCES are indicated in Table C.2. These cases do not differentiate between gaps and grooves or between types of insulation.

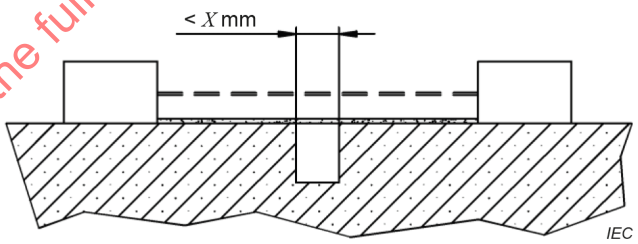
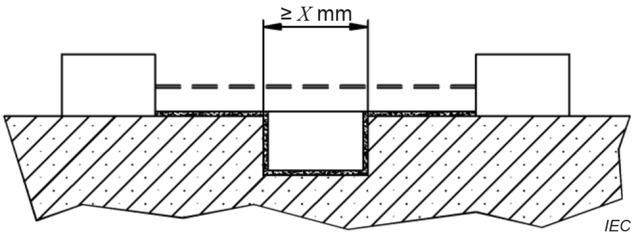
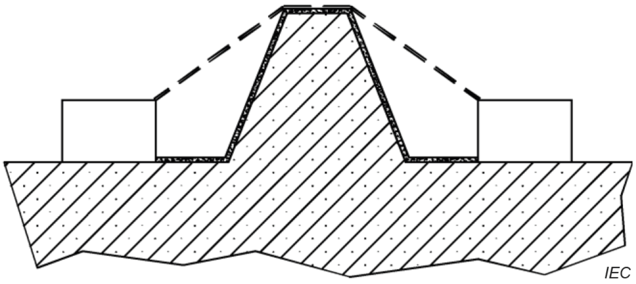
In the following examples dimension *X* has the value given in Table C.1 depending on the POLLUTION DEGREE.

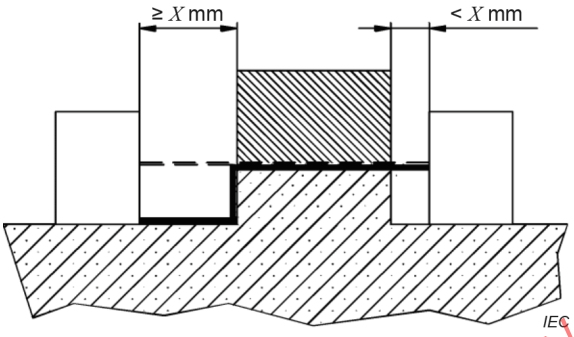
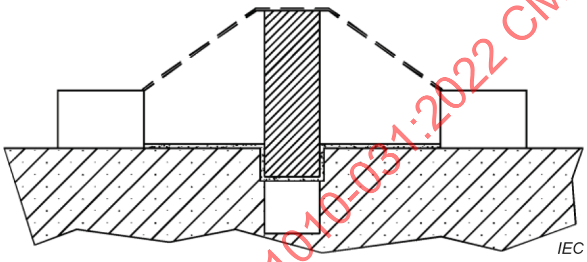
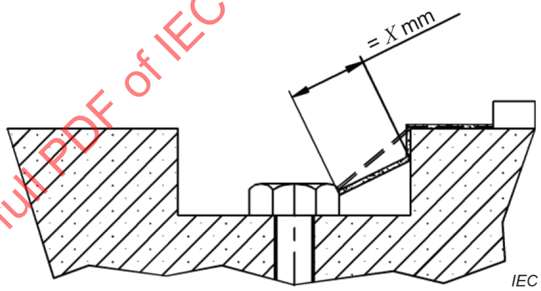
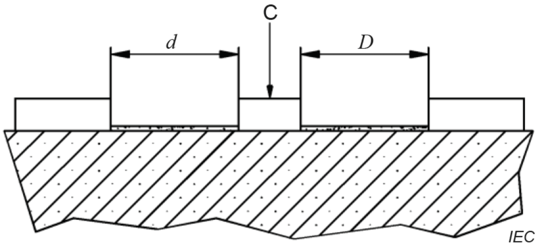
**Table C.1 – Dimension of *X***

| POLLUTION DEGREE | Dimension *X* mm |
|---|---|
| 1 | 0,25 |
| 2 | 1,0 |
| 3 | 1,5 |

If the associated CLEARANCE is less than 3 mm, the dimension *X* in Table C.1 may be reduced to one-third of this CLEARANCE.

**Table C.2 – Methods of measuring CLEARANCES and CREEPAGE DISTANCES**

| | |
|---|---|
| **Example 1:**<br>The path includes a parallel- or converging-sided groove of any depth with a width less than *X* mm.<br>The CLEARANCE and CREEPAGE DISTANCE are measured directly across the groove as shown. |  |
| **Example 2:**<br>The path includes a parallel-sided groove of any depth and equal to, or greater than, *X* mm.<br>CLEARANCE is the "line-of-sight" distance. The CREEPAGE DISTANCE follows the contour of the groove. |  |
| **Example 3:**<br>The path includes a rib.<br>The CLEARANCE is the shortest direct air path over the top of the rib. The CREEPAGE DISTANCE follows the contour of the rib. |  |

| | |
|---|---|
| **Example 4:**<br>The path includes an uncemented joint with a groove on one side less than *X* wide and the groove on the other side equal to, or greater than, *X* wide.<br>The CLEARANCE and the CREEPAGE DISTANCE are as shown. |  |
| **Example 5:**<br>The CLEARANCE is the shortest direct air path over the top of the barrier.<br>The CREEPAGE DISTANCE through uncemented joint is less than the CREEPAGE DISTANCE over the barrier. |  |
| **Example 6:**<br>The gap between the head of screw and the wall of the recess is too narrow to be taken into account.<br>Measurement of the CREEPAGE DISTANCE is from screw to wall when the distance is equal to *X*. |  |
| **Example 7:**<br>C is a floating part.<br>The CLEARANCE is the distance *d* + *D*.<br>The CREEPAGE DISTANCE is also *d* + *D*.<br>Minimum CLEARANCE *d* or *D* is 0,2 mm in POLLUTION DEGREE 2, and 0,8 mm in POLLUTION DEGREE 3. |  |
| ———————<br>– – – – – | CREEPAGE DISTANCE<br>CLEARANCE |

# Annex D
(normative)

## Routine spark tests on PROBE WIRE

## D.1 General

The spark test shall be performed by the manufacturer as a ROUTINE TEST on 100 % of the PROBE WIRE in accordance with the following spark test procedure and routine spark test method for PROBE WIRE.

## D.2 Spark test procedure

A DC or AC spark tester shall include a voltage source, an electrode, a voltmeter, a system for detecting and counting signalling faults, and the appropriate electrical connections.

The voltage source of a DC or AC spark tester shall maintain the following test voltage under all NORMAL CONDITIONS of leakage current:

a) a sinusoidal or nearly sinusoidal RMS voltage specified for an AC test of the wire type;

b) the voltage specified for a DC test of the wire type. The DC power supply output current capability shall not exceed 5 mA. Any ripple shall not exceed 1 %. After a fault, the DC test voltage shall recover to the specified level within 5 ms unless 610 mm or less of the product travels through the electrode in the time it takes for the full voltage recovery.

One TERMINAL of the DC power supply, the core of a transformer, and one end of the secondary winding in an AC power supply shall be solidly connected to earth. A voltage source shall not be connected to more than one electrode.

The electrode of a DC or AC spark tester shall be of the link- or bead-chain type or shall be of another evaluated and approved type. A link- or bead-chain electrode shall make intimate contact throughout its entire length with the surface of the insulated conductor being tested.

The bottom of a metal link- or bead-chain electrode enclosure shall be U- or V-shaped, the chains shall have a length appreciably greater than the depth of the enclosure, and the width of the trough shall be greater (typically 40 mm) than the diameter of the largest PROBE WIRE being tested.

For a bead-chain electrode, the longitudinal and transverse spacings of the chains and the diameter of each bead shall comply with Table D.1 (see also Figure D.1). The vertical spacing between beads in each chain shall not exceed the diameter of a bead.

**Table D.1 – Maximum centre-to-centre spacings of bead chains**

| Diameter of a bead [a] | Longitudinal spacing within each row [a] | Transverse spacing between rows [a] | |
|---|---|---|---|
| | | Chains staggered | Chains unstaggered |
| mm | mm | mm | mm |
| 5,0 | 13 | 13 | 10 |
| 2,5 | [b] | [b] | [b] |

[a] Other diameters and spacings are also acceptable if investigation shows that the chains contact an equal or greater area of the outer surface of the insulated conductor or initial assembly of conductors.

[b] The chains shall be staggered and shall touch one another in the longitudinal and transverse directions.

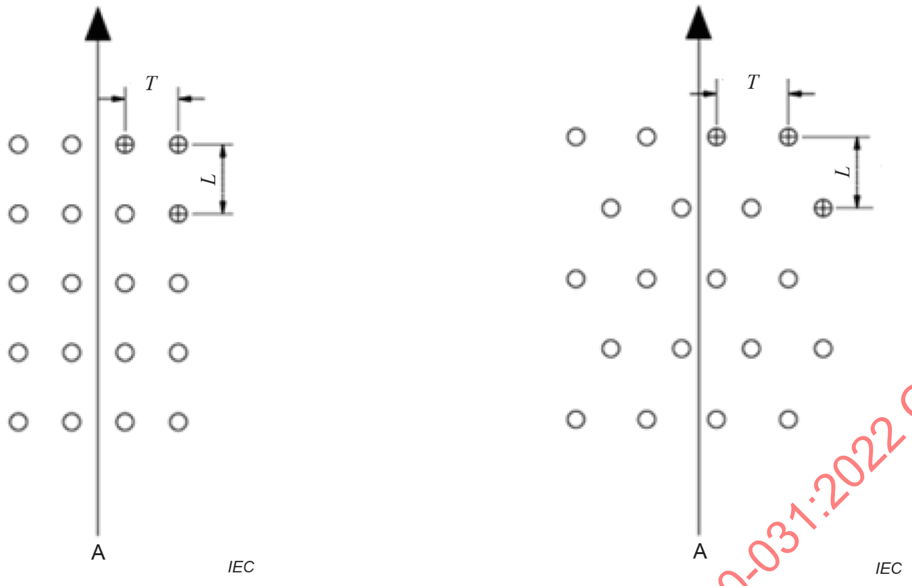


**Figure D.1 a) – Chains unstaggered**

**Figure D.1 b) – Chains staggered**

**Key**

A wire centre

T transverse spacing

L longitudinal spacing

**Figure D.1 – Bead chain configuration (if applicable)**

The electrode shall have an earthed metal screen or an equivalent guard that protects operating personnel against electric shock from the electrode and associated live parts.

The voltmeter shall be connected in the circuit to indicate the actual test potential at all times.

The test equipment shall include a fault detector, fault counter, and a means of signalling each fault that occurs. When a fault is detected, the signal shall be maintained until the indicator is reset manually.

The fault detector shall detect a voltage breakdown of the insulation. A breakdown is characterized by arcing between the electrode and the earthed conductor(s) under test. A breakdown is defined as a decrease of 25 % or more from the test voltage applied between the electrode and the earthed conductor(s). The output current of the test equipment shall not exceed 5 mA.

The fault detector shall consist of a trigger circuit that converts an input pulse of short time duration to an output pulse of a magnitude and duration that reliably operates the fault-indicating circuit.

The fault counter shall accumulate the faults as a numerically increasing sequence and shall display the accumulated total. The response time of the fault counter shall result in the counter registering faults spaced no farther than 610 mm apart for any combination of product speed and counter response time. This distance is to be calculated as follows:

$$D = S \times t$$

where

$D$ is the distance between faults, in metres;

$S$ is the product speed, in metres per second;

$t$ is the counter response time, in seconds.

For a DC test using a link- or bead-chain electrode, the surface of the insulated conductor(s) shall be in intimate contact with the link or bead chains for a distance of 125 mm ± 25 mm.

The length of a link- or bead-chain electrode is not specified for an AC test; however, the rate of speed at which the insulated conductor travels through the electrode shall keep any point on the product in contact with the electrode for not less than a total of 18 positive and negative crests of the AC supply voltage (the equivalent of a full 9 cycles of the AC supply voltage). The maximum speed $V$ of the product is to be determined for an AC test by means of the following formula:

$$V = (F \times L) / 150$$

where

$V$ is the speed in metres per minutes;

$F$ is the frequency in hertz;

$L$ is the electrode length in millimetres.

For convenience, Table D.2 shows the formulas for seven frequencies.

**Table D.2 – Formula for maximum speed of wire in terms of electrode length *L* of link- or bead-chain electrode**

| **Nominal supply frequency** ***F*** (Hz) | **Speed** ***V*** (m/min) **with electrode length** ***L*** (mm) |
|---|---|
| 50 | 0,333 × $L$ |
| 60 | 0,400 × $L$ |
| 100 | 0,667 × $L$ |
| 400 | 2,67 × $L$ |
| 1 000 | 6,67 × $L$ |
| 3 000 | 20,0 × $L$ |
| 4 000 | 26,7 × $L$ |

The conductor being tested shall be earthed during the spark test. Where the conductor coming from the pay-off reel is bare, the conductor shall be earthed at the pay-off reel or at another point at which continuous contact with the bare conductor, prior to the insulating process, is maintained and the conductor is not required to be tested for continuity or earthed at the take-up reel. Where the conductor coming from a pay-off reel is insulated, an earth connection shall be made at each pay-off reel and at the take-up reel. The earth connection shall be bonded to the protective earth TERMINAL in the spark tester.

## D.3 Routine spark test method for PROBE WIRE

For single-conductor wires with other than extruded insulation, the potential shall be 1 500 V if the wire is RATED for 300 V and shall be 2 000 V if the wire is RATED for 600 V.

For all other wires and insulations, the potential shall be 10 times the voltage RATING of the wire, up to 1 000 V, with a minimum potential of 1 500 V. If the RATED voltage is not specified, the potential shall be 3 000 V. For wire RATED more than 1 000 V, the potential shall be two times the RATED voltage with a minimum potential of 10 000 V. Insulated conductors or the insulated conductors of a jacketed wire shall be tested. In the case of a jacketed wire, the insulated conductors shall be tested prior to the application of the overall jacket or covering.

The spark test shall be performed at some point prior to the wire being cut to its final length or before being cut into shipping lengths.

Any faults shall be cut out or repaired. The insulation at points of repair shall be retested.

# Annex E
(informative)

# 4 mm CONNECTORS

## E.1 General

HAZARDS may arise from an OPERATOR's reliance on values displayed by the equipment when CONNECTORS appear to be in mated position but conductive parts are not in contact.

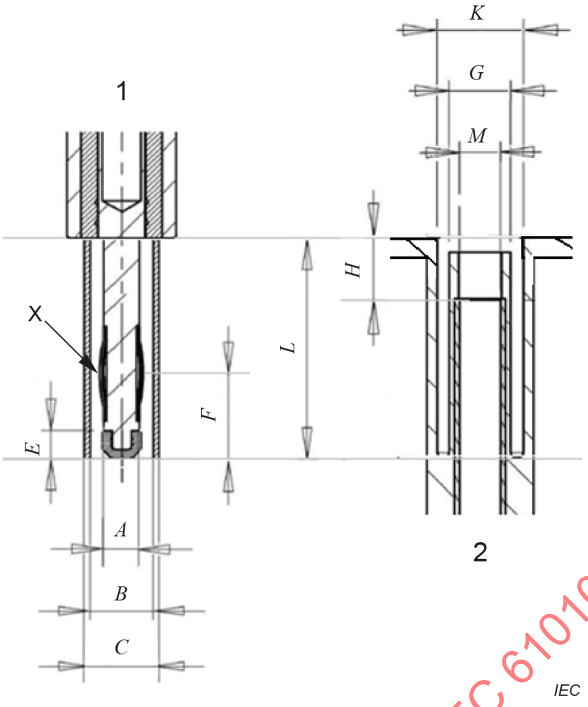
This annex gives the recommended dimensions for safety purposes of 4 mm CONNECTORS when used on probe assemblies and equipment to which probe assemblies can be connected. These 4 mm CONNECTORS are often called "banana connectors" or "banana plugs".

## E.2 Dimensions

The dimensions of Figure E.1 are compatible with 4 mm CONNECTORS RATED for MEASUREMENT CATEGORIES up to 1 000 V.

These dimensions ensure that SPACINGS values of 7.4.2 are met when the CONNECTORS and TERMINALS are mated, unmated or partially mated, and that conductive parts of mated CONNECTORS and TERMINALS are in contact.

NOTE Extraction or insertion forces and contact resistance values have not been considered.



**Key**

*A* = 3,90 mm ± 0,05 mm (compressed)

*B* ≥ 6,6 mm

*C* ≤ 7,9 mm

2,6 mm ≤ *E* ≤ 6 mm

*F* ≤ 12 mm

G ≤ 6,4 mm

*K* ≥ 8,1 mm

4 mm ≤ *H* ≤ 6 mm

*L* ≥ 20 mm

*M* = 4,00 mm + 0,05 mm

Tolerances on dimensions without specific tolerances: ± 0,1 mm

- 1 is a male CONNECTOR
- 2 is a female CONNECTOR
- X is the location where the best contact occurs and F is the distance to X
- A is the maximum diameter where the contact occurs
- The minimum value of *E* and *H* depends on whether or not plastic parts are present. CLEARANCES shall be at least 2,6 mm.

Figure E.1 – Recommended dimensions of 4 mm CONNECTORS

# Annex F
(normative)

# MEASUREMENT CATEGORIES

## F.1 General

For the purposes of this document, the following MEASUREMENT CATEGORIES are used. These MEASUREMENT CATEGORIES are not the same as the overvoltage categories according to IEC 61010-1:2010, K.1.1, IEC 60364-4-44:2007/AMD1:2015, 443.6 or IEC 60664-1:2020, 4.3.

MEASUREMENT CATEGORIES are based on locations on the mains supply system where measurements can be made.

NOTE IEC 60364-4-44 and IEC 60664-1 overvoltage categories are created to achieve an insulation coordination of the components and equipment used within low-voltage mains supply systems.

## F.2 MEASUREMENT CATEGORIES

### F.2.1 MEASUREMENT CATEGORY II

MEASUREMENT CATEGORY II is applicable to test and measuring circuits connected directly to utilization points (socket outlets and similar points) of the low-voltage mains installation (see Table F.1 and Figure F.1).

EXAMPLE Measurements on mains circuits of household appliances, portable tools and similar equipment, and on the consumer side only of socket-outlets in fixed installations.

### F.2.2 MEASUREMENT CATEGORY III

MEASUREMENT CATEGORY III is applicable to test and measuring circuits connected to the distribution part of the building's low-voltage mains installation (see Table F.1 and Figure F.1).

To avoid risks caused by the HAZARDS arising from these higher short-circuit currents, additional insulation and other provisions are required.

For equipment that is part of a fixed installation, the fuse or circuit breaker of the installation can be considered to provide adequate protection against short-circuit currents.

EXAMPLE Measurements on distribution boards (including secondary meters), photovoltaic panels, circuit-breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use and some other equipment such as stationary motors with permanent connection to the fixed installation.

### F.2.3 MEASUREMENT CATEGORY IV

MEASUREMENT CATEGORY IV is applicable to test and measuring circuits connected at the source of the building's low-voltage mains installation (see Table F.1 and Figure F.1).

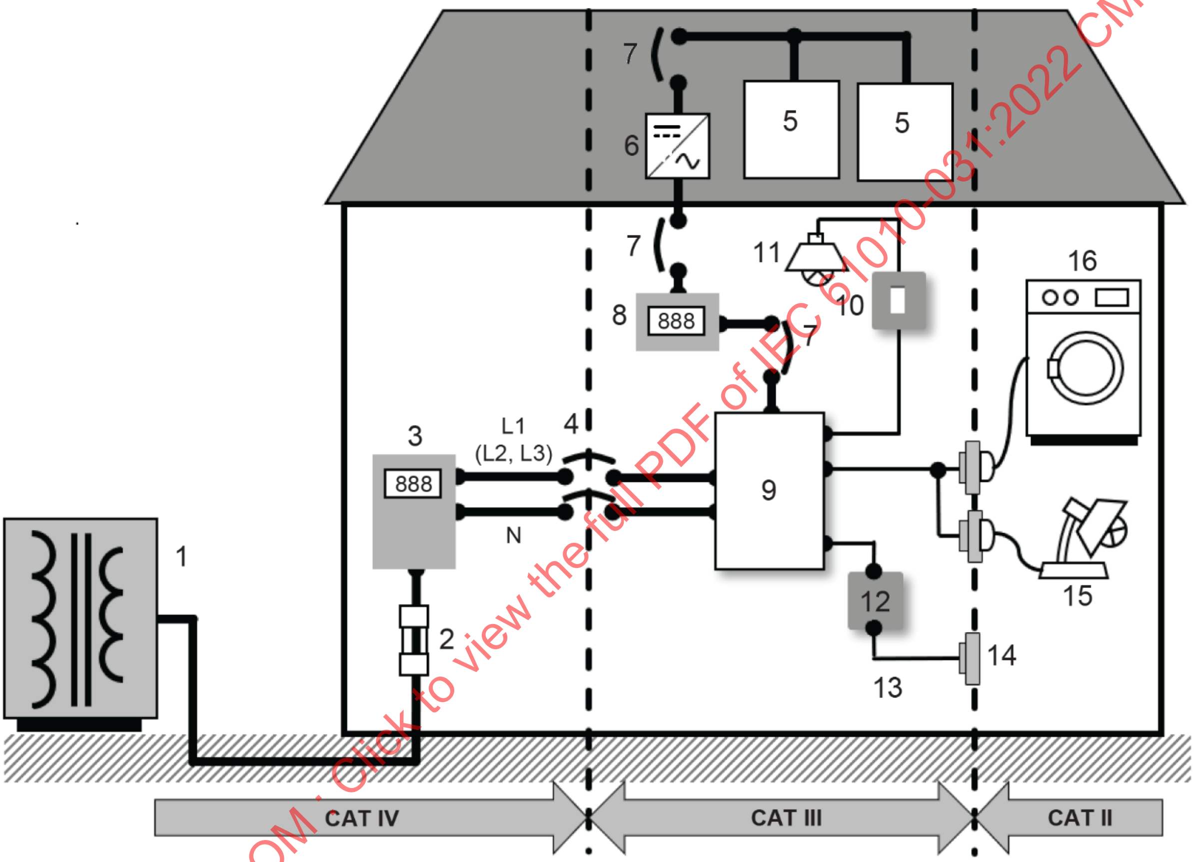
Owing to the high potential short-circuit currents existing in these circuits, any accidental short-circuit caused whilst making measurements can create a high-energy-level arc flash which is extremely dangerous to bystanders in the immediate vicinity. Great precautions must be taken to avoid any chance of a short circuit.

EXAMPLE Measurements on devices installed before the mains circuit breaker or isolator switch in the building installation.

### F.2.4 Probe assemblies without a MEASUREMENT CATEGORY RATING

Many types of test and measuring circuits are not intended to be directly connected to the mains supply. Some of these measuring circuits are intended for very low energy applications, but others of these measuring circuits may experience very high amounts of available energy because of high short-circuit currents or high open-circuit voltages. There are no standard transient levels defined for these circuits. An analysis of the WORKING VOLTAGES, loop impedances, temporary overvoltages, and transient overvoltages in these circuits is necessary to determine the insulation requirements and short-circuit current requirements.

EXAMPLE Thermocouple measuring circuits, high-frequency measuring circuits, automotive testers, and testers used to characterize the mains installation before the installation is connected to the mains supply.



IEC

**Key**

| | |
|---|---|
| 1 | low-voltage supply source over or under ground |
| 2 | service fuse |
| 3 | tariff meter |
| 4 | mains circuit breaker or isolator switch [a] |
| 5 | photovoltaic panel |
| 6 | DC to AC inverter |
| 7 | circuit breaker or isolator switch |
| 8 | generation meter |
| 9 | distribution board |
| 10 | light switch |
| 11 | lighting |
| 12 | junction box |
| 13 | socket wiring |
| 14 | socket outlets |
| 15 | plug-in lamps |
| 16 | household appliances, portable tools |

[a] The mains circuit breaker or isolator switch may be installed by the service provider. If not, the demarcation point between CAT IV and CAT III is the first isolating switch in the distribution board.

| | |
|---|---|
| CAT II | MEASUREMENT CATEGORY II |
| CAT III | MEASUREMENT CATEGORY III |
| CAT IV | MEASUREMENT CATEGORY IV |

Figure F.1 – Example to identify the locations of MEASUREMENT CATEGORIES

**Table F.1 – Characteristics of MEASUREMENT CATEGORIES**

| MEASUREMENT CATEGORY | Short-circuit current [a] (typical) kA | Location |
|---|---|---|
| II | < 10 | Circuits connected to mains socket outlets and similar points in the mains installation |
| III | < 50 | Mains distribution parts of the building |
| IV | > 50 | Source of the mains installation |

[a] The values of loop impedances (installation impedances) do not take into account the resistance of the test leads and impedances internal to the measuring equipment. These short-circuit currents vary, depending on the characteristics of the installation and the nominal voltage of the distribution system.

# Annex G
(informative)

## Determination of CLEARANCES for Table 2

$D_1$ values of Table 5 are interpolated values from Table F.2 of IEC 60664-1:2020. $D_2$ values of Table 5 below 100 mm are interpolated values from Table F.8 of IEC 60664-1:2020 and $D_2$ values of Table 5 above 100 mm are extrapolated values from Table F.8 of IEC 60664-1:2020.

CLEARANCES of Table G.1 have been calculated using linear interpolation of $D_2$ values from Table 5 for BASIC INSULATION (see 7.5.2.3.2) with a 25 % safety factor. Transient overvoltages have been disregarded.

### Table G.1 – CLEARANCES values for Table 2

| [A] | [B] | [C] | [D] | [E] | [F] | [G] | [H] |
|---|---|---|---|---|---|---|---|
| **AC RMS or DC voltage** | **Safety factor** | **Peak value** | | **Exact CLEARANCE** | | **Final CLEARANCE** | |
| | × 1,25 | AC | DC | AC | DC | AC | DC |
| V | V | V | V | mm | mm | mm | mm |
| 300 | 375 | 530 | 375 | 0,046 | 0,016 | 0,8 | 0,8 |
| 600 | 750 | 1 061 | 750 | 0,31 | 0,11 | 0,8 | 0,8 |
| 1 000 | 1 250 | 1 768 | 1 250 | 1,03 | 0,48 | 1,0 | 0,8 |
| 1 500 | 1 875 | 2 652 | 1 875 | 2,00 | 1,14 | 2,0 | 1,1 |
| 2 000 | 2 500 | 3 536 | 2 500 | 3,20 | 1,80 | 3,2 | 1,8 |
| 3 000 | 3 750 | 5 303 | 3 750 | 6,40 | 3,45 | 6,4 | 3,5 |
| 5 000 | 6 250 | 8 839 | 6 250 | 13 | 8,3 | 13 | 8,3 |
| 10 000 | 12 500 | 17 678 | 12 500 | 30 | 20 | 30 | 20 |
| 15 000 | 18 750 | 26 517 | 18 750 | 48 | 32 | 48 | 32 |
| 20 000 | 25 000 | 35 355 | 25 000 | 67 | 44 | 67 | 44 |

| | |
|---|---|
| Column [A]: | Nominal AC RMS or DC voltage to which the CONNECTOR of the probe assembly is RATED |
| Column [B]: | Values including a safety factor of +25 % |
| Column [C]: | Peak values of the AC RMS voltage |
| Column [D]: | Peak values of the DC voltage |
| Columns [E] and [F]: | Exact values according to Table 5 |
| Columns [G] and [H]: | Final CLEARANCES values with the following |
| | The 0,8 mm values are the minimum CLEARANCE values for POLLUTION DEGREE 3. Since CONNECTORS are external and exposed, POLLUTION DEGREE 3 has been used. |

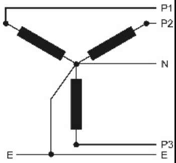
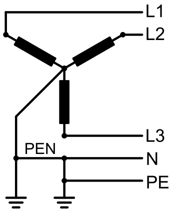
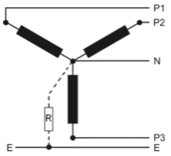
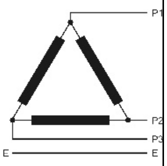
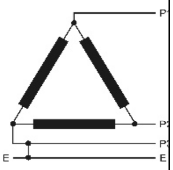
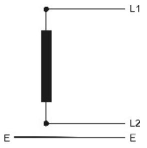
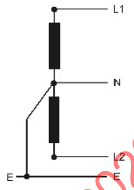
# Annex H
(informative)

## Line-to-neutral voltages for common mains supply systems

For the purposes of this document, Table H.1 gives the line-to-neutral voltage that should be used for determining CLEARANCE and solid insulation requirements of circuits connected to mains.

*Table H.1 is derived from Table B.1 of IEC 60664-1:2020. It is applicable to mains supply systems with inherent control (see IEC 60664-1:2020, 4.2.2.1).*

### Table H.1 – Line-to-neutral voltages for common mains supply systems

| Mains systems and nominal voltages | | | | | | Line-to-neutral voltage pertinent to mains system type and nominal voltage |
|---|---|---|---|---|---|---|
| **Three-phase four-wire systems [a]**<br>**with earthed neutral TT system** | **Three-phase four-wire systems [a]**<br>**with unearthed neutral (IT systems) [b, c]** | **Three-phase three-wire systems**<br>**unearthed** | **Three-phase three-wire systems**<br>**with earthed phase** | **Single-phase two-wire systems**<br>**AC or DC** | **Single-phase (split-phase) three-wire systems [a]**<br>**AC or DC** | |
|  <br>**TN-C-S System**<br> |  |  |  |  |  | |
| V | V | V | V | V | V | V |
| | | | | 12,5 to 48 | 30/60 | 50 |
| 66/115 | | 66 | | 60 | | 100 |
| 120/208<br>127/220 | 120/208 | 110, 115<br>120, 127 | 100<br>120 | 100<br>110, 115<br>120, 127 | 100/200 [d]<br>110/220<br>115/230<br>120/240 | 150 |
| 220/380<br>230/400<br>240/415<br>260/440<br>277/480 | 230/400<br>277/480 | 200<br>220, 230, 240<br>260, 277, 347<br>380, 400, 415<br>440, 480 | 200<br>240 | 220<br>230<br>240 | 220/440<br>240/480 | 300 |
| 347/600<br>380/660<br>400/690<br>417/720<br>480/830 | 347/600<br>400/690 | 500<br>577<br>600 | 347<br>380, 400, 415<br>440, 480, 600 | 480 | 480/960 | 600 |
| | | 660<br>690, 720<br>830, 1 000 | | 1 000 | | 1 000 |
| | | | | 1 250, 1 500 | | 1 500 [e] |

[a] Voltages shown as two voltages separated by a "/" represent the phase-to-neutral (or line-to-neutral) voltage followed by the phase-to-phase (or line-to-line) voltage. For example, "120/208" indicates that the voltage from any phase to neutral is 120 V, and the voltage from any phase to another phase is 208 V. Likewise, "220/440" indicates that the voltage from either line-to-neutral is 220 V, and the voltage from line-to-line is 440 V.

[b] Z is an impedance which may connect neutral to earth (usually 1 500 Ω).

[c] When insulation is monitored, neutral of these systems is considered to be earthed.

[d] Practice in Japan.

[e] Only applicable for DC.

# Annex I
(informative)

## Index of defined terms

# Bibliography

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IEC 60364-4-44:2007/AMD2:2018

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IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60664-4:2005, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 61010-2-030, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

IEC 61010-2-032:2019, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-032: Particular requirements for hand-held and hand-manipulated current sensors for electrical test and measurement*

IEC 61010-2-033, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-033: Particular requirements for hand-held multimeters and other meters for domestic and professional use, capable of measuring mains voltage*

IEC 61010-2-034, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-034: Particular requirements for measurement equipment for insulation resistance and test equipment for electric strength*

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

ISO 7000, *Graphical symbols for use on equipment* (available at: http://www.iso.org/obp)

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# SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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# EXIGENCES DE SÉCURITÉ POUR APPAREILS ÉLECTRIQUES DE MESURAGE, DE RÉGULATION ET DE LABORATOIRE –

## Partie 031: Exigences de sécurité pour sondes équipées tenues à la main et manipulées pour mesurage et essais électriques

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L'IEC 61010-031 a été établie par le comité d'études 66 de l'IEC: Sécurité des appareils de mesure, de commande et de laboratoire. Il s'agit d'une Norme internationale.

Elle a le statut d'une publication groupée de sécurité conformément au Guide IEC 104.

Cette troisième édition annule et remplace la deuxième édition parue en 2015 et l'Amendement 1:2018. L'IEC 61010-031 est une norme autonome.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) le domaine d'application a été raccourci. Les informations générales du domaine d'application de l'Edition 2 ont été déplacées dans un nouvel Article 4. Par conséquent, les Articles 4 à 8 de l'Edition 2 ont été renumérotés. L'Article 9 de l'Edition 2 a été supprimé;

b) à l'Article 2, les références normatives ont été datées et de nouvelles références normatives ont été ajoutées;

c) en 3.1.4, la définition de POINTE DE TOUCHE a été modifiée;

d) en 4.1, il n'y a plus de distinction entre les sondes équipées haute tension et basse tension. Les sondes équipées de types B et C ont été fusionnées;

e) en 4.1 d), les sondes "Kelvin" ont été ajoutées à la liste des sondes équipées en tant que nouveau type E, ainsi qu'une nouvelle Figure 5;

f) en 4.1 e), des sondes de mesure de la tension sans connexion électrique aux conducteurs ont été ajoutées à la liste des sondes équipées en tant que nouveau type F, ainsi qu'une nouvelle Figure 6;

g) en 4.2.1, la propagation du feu n'est plus considérée comme un DANGER;

h) le paragraphe 4.4.2.5 de l'Edition 2 a été supprimé;

i) le paragraphe 4.4.4.3 de l'Edition 2 a été supprimé;

j) en 5.4.4.1, une attention particulière a été accordée aux ESPACEMENTS et à l'impédance;

k) en 6.1.1, les parties amovibles des POINTES DE TOUCHE qui portent des marquages sont autorisées;

l) en 6.1.5, la tension à marquer pour les CATEGORIES DE MESURE est la tension alternative phase-neutre ou la tension continue;

m) en 7.4.2, les exigences relatives aux CONNECTEURS découplés ont été modifiées comme suit:

   1) le Tableau 2 a été modifié et étendu;

   2) une méthode de calcul des DISTANCES D'ISOLEMENT des CONNECTEURS au-delà de 20 kV a été définie;

   3) les LIGNES DE FUITE ont été alignées avec les DISTANCES D'ISOLEMENT;

n) en 7.4.3.1 et 7.4.3.5, des exigences ont été ajoutées pour les POINTES DE TOUCHE IP2X avec manchon rétractable;

o) en 7.4.3.2, les POINTES DE TOUCHE sont désormais applicables aux sondes équipées sans contact;

p) en 7.5.2.3.2, les valeurs du Tableau 5 ont été modifiées;

q) en 7.6.2, les essais de tension des DISTANCES D'ISOLEMENT sont effectués sans préconditionnement à l'humidité;

r) les prétraitements pour l'essai de rigidité de l'Article 10 de l'Edition 2 ont été déplacés en 9.2;

s) le paragraphe 11.1 de l'Edition 2 a été supprimé;

t) en 13.2, une exception a été ajoutée pour la sonde équipée de type E. Les parties amovibles des POINTES DE TOUCHE qui portent des marquages sont autorisées;

u) la Figure F.1 a été modifiée;

v) l'Annexe G a été ajoutée pour déterminer les DISTANCES D'ISOLEMENT du Tableau 2;

w) l'Annexe H a été ajoutée pour couvrir les tensions phase-neutre des réseaux de distribution généralement utilisés.

Le texte de cette Norme internationale est issu des documents suivants:

| Projet | Rapport de vote |
|---|---|
| 66/770/FDIS | 66/771/RVD |

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 61010, publiées sous le titre général, *Exigences de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire*, se trouve sur le site web de l'IEC.

Dans le présent document, les caractères d'imprimerie suivants sont utilisés:

- exigences et définitions: caractères romains;
- NOTES et EXEMPLES: petits caractères romains;
- *conformité et essais: caractères italiques;*
- termes définis à l'Article 3 et utilisés dans tout le présent document: CARACTERES ROMAINS EN PETITES CAPITALES.

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- reconduit,
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- amendé.

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# EXIGENCES DE SÉCURITÉ POUR APPAREILS ÉLECTRIQUES DE MESURAGE, DE RÉGULATION ET DE LABORATOIRE –

# Partie 031: Exigences de sécurité pour sondes équipées tenues à la main et manipulées pour mesurage et essais électriques

## 1 Domaine d'application

La présente partie de l'IEC 61010 spécifie les exigences de sécurité relatives aux sondes équipées tenues à la main et manipulées prévues pour le mesurage et les essais électriques, ainsi que leurs accessoires connexes. Ces sondes équipées sont prévues pour une connexion sans contact électrique ou une connexion électrique directe entre une partie et un appareil de mesure et d'essai électrique. Elles peuvent être solidaires de l'appareil ou en être des accessoires détachables.

La présente publication groupée de sécurité, qui est axée sur les exigences essentielles de sécurité, est avant tout destinée à être utilisée en tant que norme de sécurité de produits pour les produits cités dans le domaine d'application, mais elle est aussi destinée à être utilisée par les comités d'études dans le cadre de l'élaboration de publications pour des produits similaires à ceux cités dans le domaine d'application de la présente publication groupée de sécurité, conformément aux principes établis dans le Guide IEC 104 et le Guide ISO/IEC 51.

L'une des responsabilités d'un comité d'études consiste, le cas échéant, à utiliser les publications fondamentales de sécurité et/ou les publications groupées de sécurité dans le cadre de l'élaboration de ses publications.

## 2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60027-1:1992, *Symboles littéraux à utiliser en électrotechnique – Partie 1: Généralités*
IEC 60027-1:1992/AMD1:1997
IEC 60027-1:1992/AMD2:2005

IEC 60027-2:2019, *Symboles littéraux à utiliser en électrotechnique – Partie 2: Télécommunications et électronique*

IEC 60027-4:2006, *Symboles littéraux à utiliser en électrotechnique – Partie 4: Machines électriques tournantes*

IEC 60529:1989, *Degrés de protection procurés par les enveloppes (code IP)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 61010-1:2010, *Règles de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire – Partie 1: Exigences générales*
IEC 61010-1:2010/AMD1:2016

IEC 61180:2016, *Techniques des essais à haute tension pour matériel à basse tension – Définitions, exigences et modalités relatives aux essais, matériel d'essai*

## 3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent (voir l'Annexe I pour obtenir l'index des termes définis).

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes :

- IEC Electropedia : disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform : disponible à l'adresse https://www.iso.org/obp

### 3.1 Parties et accessoires

#### 3.1.1

**BORNE**

composant destiné à raccorder un dispositif (appareil) à des conducteurs extérieurs

Note 1 à l'article: Les BORNES peuvent comporter un ou plusieurs contacts, ce terme inclut donc les prises, etc.

#### 3.1.2

**ENVELOPPE**

partie assurant la protection d'une sonde équipée contre certaines influences extérieures et, dans toutes les directions, la protection contre le contact direct

#### 3.1.3

**PROTEGE-DOIGTS**

partie de l'ENVELOPPE qui indique la limite de l'accès sûr et qui réduit le risque que l'OPERATEUR touche des parties SOUS TENSION DANGEREUSE

#### 3.1.4

**POINTE DE TOUCHE**

partie d'une sonde équipée ou d'un accessoire qui peut être en contact avec le point mesuré ou soumis à essai

#### 3.1.5

**CONNECTEUR**

composant qui est lié au FIL DE SONDE, pour la connexion de la sonde équipée à une BORNE du matériel ou à une autre sonde équipée

#### 3.1.6

**CONNECTEUR DE REFERENCE**

CONNECTEUR pour la connexion à un point de référence

#### 3.1.7

**OUTIL**

dispositif extérieur, englobant les clés et les pièces de monnaie, utilisé pour aider quelqu'un à réaliser une fonction mécanique

#### 3.1.8

**FIL DE SONDE**

fil ou câble souple utilisé comme partie de la sonde équipée ou de ses accessoires, consistant en un ou plusieurs conducteurs et l'isolation associée

#### 3.1.9

**PINCE A RESSORT**

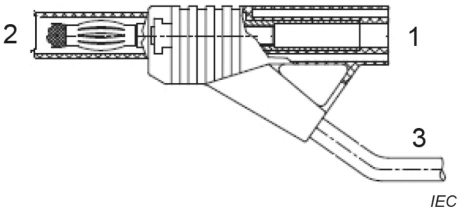
sonde ou accessoire de sonde avec un ou plusieurs crochets ou mâchoires contraints par un ressort pour agripper la partie mesurée ou soumise à essai

### 3.1.10

**CONNECTEUR EMPILABLE**

assemblage de CONNECTEUR qui contient une BORNE supplémentaire

EXEMPLE La Figure 1 est un exemple d'un CONNECTEUR EMPILABLE avec un CONNECTEUR mâle et une BORNE femelle.



**Légende**

1 BORNE pour CONNECTEUR supplémentaire

2 CONNECTEUR

3 FIL DE SONDE

**Figure 1 – Exemple de CONNECTEUR EMPILABLE avec un CONNECTEUR mâle et une BORNE femelle**

## 3.2 Grandeurs

### 3.2.1

**ASSIGNE**

valeur ASSIGNEE

condition ou valeur d'une grandeur assignée, généralement par un fabricant, correspondant à une condition de fonctionnement spécifiée d'un composant, d'un dispositif ou d'une sonde équipée

### 3.2.2

**CARACTERISTIQUES ASSIGNEES**

ensemble des valeurs ASSIGNEES et des conditions de fonctionnement

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

### 3.2.3

**TENSION DE SERVICE**

valeur efficace la plus élevée de la tension alternative ou continue pouvant être présente de façon permanente en UTILISATION NORMALE sur n'importe quelle isolation particulière

Note 1 à l'article: Les transitoires et les fluctuations de tension ne sont pas considérés comme faisant partie de la TENSION DE SERVICE.

## 3.3 Essais

### 3.3.1

**ESSAI DE TYPE**

essai effectué sur un ou plusieurs échantillons d'une sonde équipée (ou parties d'une sonde équipée) réalisés selon une conception donnée, pour vérifier que cette conception et la construction répondent aux exigences du présent document

Note 1 à l'article: Cette définition étend celle de l'IEC 60050-151:2001, 151-16-16, pour tenir compte des exigences de conception et de construction.

### 3.3.2
**ESSAI INDIVIDUEL DE SERIE**
essai de conformité effectué sur chaque entité en cours ou en fin de fabrication

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

## 3.4 Termes de sécurité

### 3.4.1
**ACCESSIBLE**
pouvant être touché au moyen du doigt d'épreuve normalisé ou d'une broche d'essai comme spécifié en 7.2

### 3.4.2
**TENSION DANGEREUSE**
**SOUS TENSION DANGEREUSE**
capable de causer un choc électrique ou une brûlure électrique

### 3.4.3
**DANGER**
**phénomène DANGEREUX**
source potentielle de dommage

### 3.4.4
**IMPEDANCE DE PROTECTION**
composant, ensemble de composants, dont l'impédance, la construction et la fiabilité sont aptes à assurer la protection contre les chocs électriques

### 3.4.5
**UTILISATION NORMALE**
fonctionnement y compris en position d'attente, conformément aux instructions d'utilisation ou à l'usage prévu évident

### 3.4.6
**CONDITION NORMALE**
état dans lequel tous les moyens de protection contre les DANGERS sont intacts

### 3.4.7
**CONDITION DE PREMIER DEFAUT**
état dans lequel un seul moyen de protection contre un DANGER est défectueux ou un seul DEFAUT est présent, ce qui pourrait entraîner un danger

Note 1 à l'article: Si une CONDITION DE PREMIER DEFAUT entraîne inévitablement une ou plusieurs autres conditions de défaut, toutes les défaillances sont considérées comme la même CONDITION DE PREMIER DEFAUT.

### 3.4.8
**OPERATEUR**
personne qui utilise la sonde équipée pour l'usage auquel elle est destinée

### 3.4.9
**ORGANISME RESPONSABLE**
individu ou groupe responsable de l'utilisation et de la maintenance des sondes équipées en sécurité

### 3.4.10
**EMPLACEMENT HUMIDE**
emplacement où peuvent être présents de l'eau ou d'autres liquides conducteurs et qui risquent de réduire l'impédance du corps humain à cause du mouillage du contact entre le corps humain et la sonde équipée, ou du mouillage du contact entre le corps humain et l'environnement

**3.4.11**

**CATEGORIE DE MESURE**

classification des circuits d'essai et de mesure selon les types de réseaux auxquels ils sont destinés à être reliés

Note 1 à l'article: Les CATEGORIES DE MESURE tiennent compte des CATEGORIES DE SURTENSION, des niveaux des courants de court-circuit, de l'endroit où l'essai ou le mesurage est à réaliser et de certaines dispositions de limitation de l'énergie ou de protection contre les transitoires de l'installation du bâtiment (voir l'Annexe F pour de plus amples informations).

**3.4.12**

**MAUVAIS USAGE RAISONNABLEMENT PREVISIBLE**

utilisation d'un produit dans des conditions ou à des fins non prévues par le fournisseur, mais qui peut provenir d'un comportement humain envisageable

## 3.5 Isolation

**3.5.1**

**ISOLATION PRINCIPALE**

isolation qui assure la protection principale

Note 1 à l'article: Cette notion n'est pas applicable à l'isolation exclusivement utilisée à des fins fonctionnelles.

[SOURCE: IEC 60050-195:2021, 195-06-06]

**3.5.2**

**ISOLATION SUPPLEMENTAIRE**

isolation indépendante prévue, en plus de l'ISOLATION PRINCIPALE, EN TANT que protection en cas de défaut

[SOURCE: IEC 60050-195:2021, 195-06-07]

**3.5.3**

**DOUBLE ISOLATION**

isolation comprenant à la fois une ISOLATION PRINCIPALE et une ISOLATION SUPPLEMENTAIRE

[SOURCE: IEC 60050-195:2021, 195-06-08]

**3.5.4**

**ISOLATION RENFORCEE**

isolation assurant un degré de protection contre les chocs électriques équivalant à celui d'une DOUBLE ISOLATION

Note 1 à l'article: L'ISOLATION RENFORCEE peut comporter plusieurs couches qui ne peuvent pas être soumises aux essais séparément en tant qu'ISOLATION PRINCIPALE ou ISOLATION SUPPLEMENTAIRE.

[SOURCE: IEC 60050-195:2021, 195-06-09]

**3.5.5**

**POLLUTION**

toute addition de corps étrangers, solides, liquides ou gazeux (gaz ionisés), qui peut produire une réduction de rigidité diélectrique ou de résistivité superficielle

**3.5.6**

**DEGRE DE POLLUTION**

nombre indiquant le niveau de POLLUTION qui peut être présent dans l'environnement

**3.5.7**

**DEGRE DE POLLUTION 1**

pas de POLLUTION ou uniquement une POLLUTION sèche, non conductrice qui n'a pas d'influence

**3.5.8**

**DEGRE DE POLLUTION 2**

POLLUTION non conductrice seulement, pouvant occasionnellement présenter une conductivité temporaire provoquée par la condensation

**3.5.9**

**DEGRE DE POLLUTION 3**

présence d'une POLLUTION conductrice ou d'une POLLUTION sèche, non conductrice, qui devient conductrice par suite de la condensation qui peut se produire

Note 1 à l'article: Dans de telles conditions, la sonde équipée est normalement protégée contre l'exposition directe aux rayons du soleil, à la pluie et à la pression du vent, mais ni la température, ni l'humidité ne sont contrôlées.

**3.5.10**

**DISTANCE D'ISOLEMENT (dans l'air)**

distance la plus courte dans l'air entre deux parties conductrices

**3.5.11**

**LIGNE DE FUITE**

distance la plus courte, le long de la surface d'un isolant solide, entre deux parties conductrices

[SOURCE: IEC 60050-151:2001, 151-15-50]

**3.5.12**

**ESPACEMENT**

toute combinaison de DISTANCES D'ISOLEMENT et de LIGNES DE FUITE

# 4 Généralités

## 4.1 Types de sondes équipées

La sécurité des types de sondes équipées suivants est couverte par le présent document.

a) Type A: sondes équipées sans atténuation, ASSIGNEES pour connexion directe à des tensions supérieures à 30 V alternatifs efficaces, à 42,4 V crête ou à 60 V continus, mais ne dépassant pas 63 kV. Elles ne comportent pas de composants qui sont prévus pour assurer une fonction de diviseur de tension ou une fonction de mise en forme de signaux, mais elles peuvent contenir des composants ne provoquant pas d'atténuation tels que des fusibles (voir Figure 2).

b) Type B: sondes équipées avec atténuation ou diviseur, ASSIGNEES pour connexion directe à des tensions supérieures à 30 V alternatifs efficaces, à 42,4 V crête ou à 60 V continus, mais ne dépassant pas 63 kV. La fonction de diviseur peut être réalisée dans sa totalité à l'intérieur de la sonde équipée, ou en partie dans l'appareil de mesure ou d'essai destiné à être utilisé avec la sonde équipée [voir Figure 3 a) et Figure 3 b)].

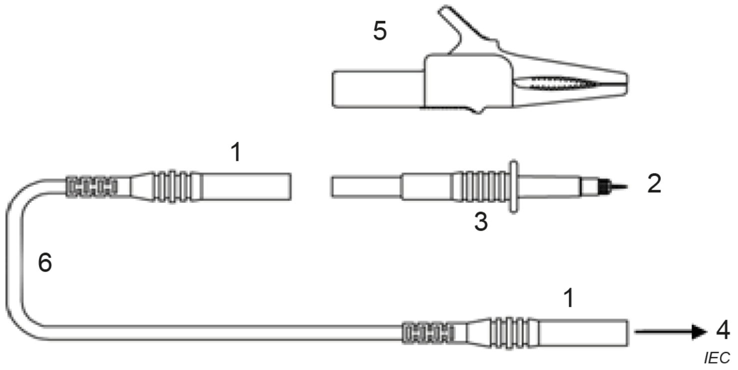
c) Type D: sondes équipées avec atténuation, sans atténuation ou autres sondes de mise en forme de signaux ASSIGNEES pour connexion directe uniquement à des tensions n'excédant pas 30 V alternatifs efficaces, 42,4 V crête ou 60 V continus, et qui sont appropriées pour des courants dépassant 8 A (voir Figure 4).

d) Type E: sondes équipées sans atténuation pour mesurages précis à 4 fils de résistances (voir Figure 5).

EXEMPLE: Sondes Kelvin.

e) Type F: sondes équipées pour mesurages et essais sans contact de tensions alternatives. Ces sondes équipées sont destinées à être utilisées sans contact électrique sur des conducteurs isolés ou non isolés (voir Figure 6).

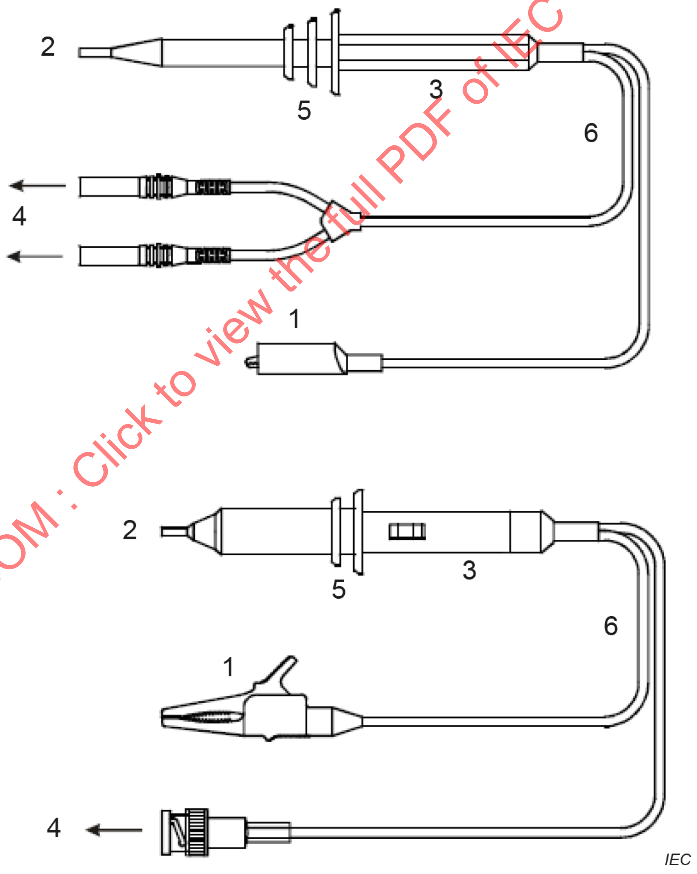
NOTE Les sondes équipées de type F peuvent être des sondes autonomes ou connectées par un FIL DE SONDE à un appareil.



**Légende**

| | | | |
|---|---|---|---|
| 1 | CONNECTEUR (typique) | 4 | vers l'appareil |
| 2 | POINTE DE TOUCHE | 5 | PINCE A RESSORT |
| 3 | partie du corps de la sonde tenue à la main | 6 | FIL DE SONDE |

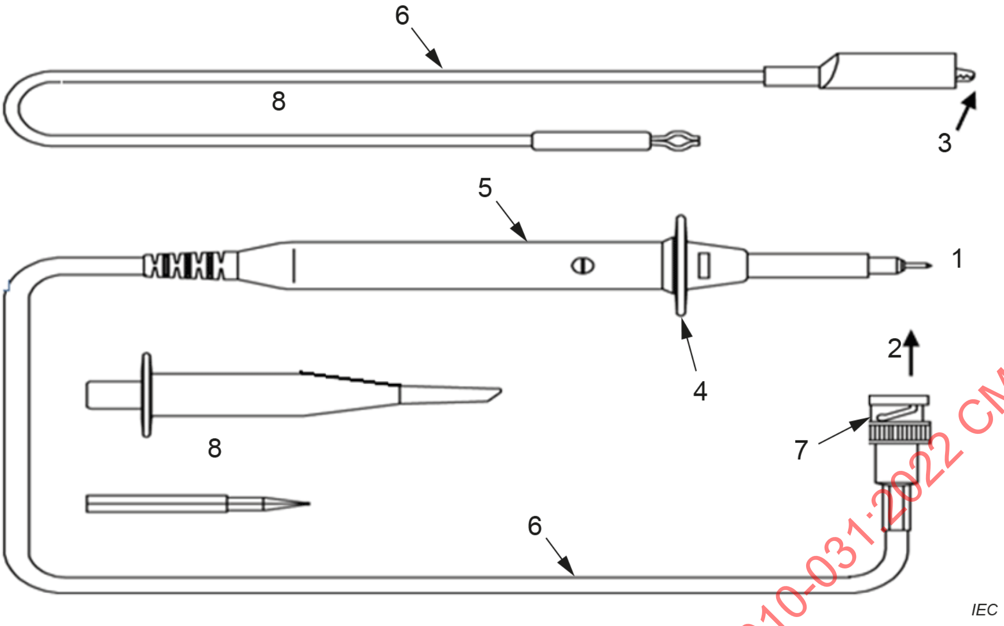
Figure 2 – Exemples de sondes équipées de type A



**Légende**

| | | | |
|---|---|---|---|
| 1 | CONNECTEUR DE REFERENCE | 4 | vers l'appareil |
| 2 | POINTE DE TOUCHE | 5 | PROTEGE-DOIGTS |
| 3 | partie du corps de la sonde tenue à la main | 6 | FIL DE SONDE |

Figure 3 a) – Sondes équipées à haute tension de type B

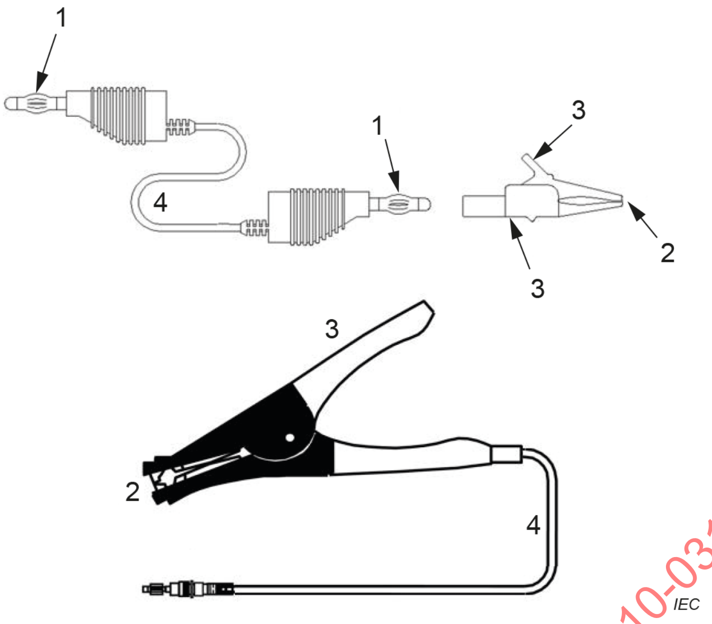


**Légende**

| | | | |
|---|---|---|---|
| 1 | POINTE DE TOUCHE | 5 | partie du corps de la sonde tenue à la main |
| 2 | vers l'appareil | 6 | FIL DE SONDE |
| 3 | CONNECTEUR DE REFERENCE | 7 | CONNECTEUR BNC |
| 4 | PROTEGE-DOIGTS | 8 | exemples d'accessoires |

**Figure 3 b) – Sondes équipées à basse tension de type B**

**Figure 3 – Exemples de sondes équipées de type B**



**Légende**

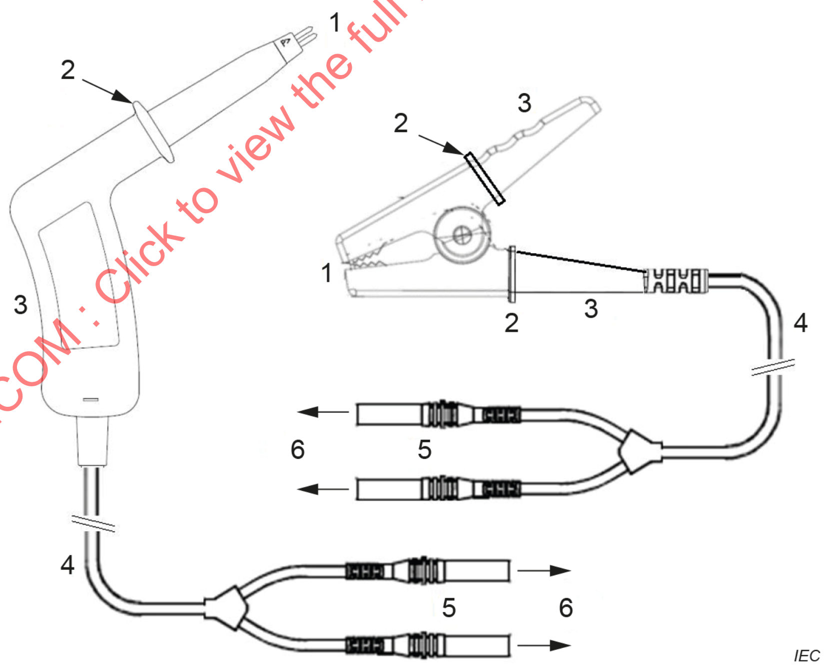
1 CONNECTEUR

2 POINTE DE TOUCHE

3 partie d'une PINCE A RESSORT tenue à la main

4 FIL DE SONDE

Figure 4 – Exemples de sondes équipées de type D



**Légende**

1 POINTE DE TOUCHE

2 PROTEGE-DOIGTS

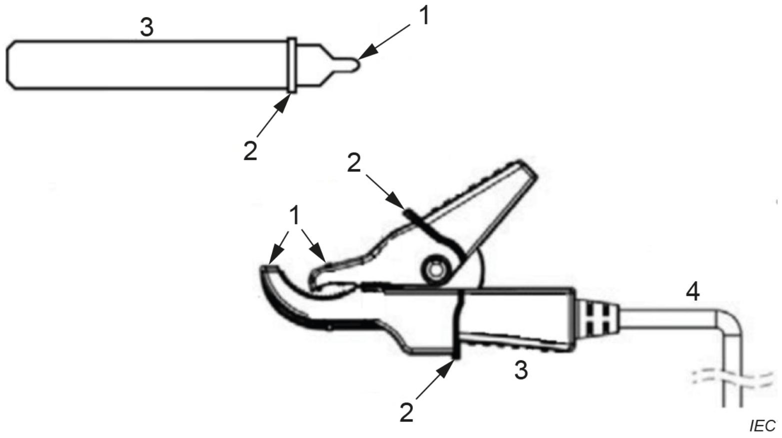
3 partie du corps de la sonde tenue à la main

4 FIL DE SONDE

5 CONNECTEURS

6 vers l'appareil

Figure 5 – Exemples de sondes équipées de type E



**Légende**

| | | | |
|---|---|---|---|
| 1 | POINTE DE TOUCHE | 3 | partie du corps de la sonde tenue à la main |
| 2 | PROTEGE-DOIGTS | 4 | FIL DE SONDE vers l'appareil |

**Figure 6 – Exemples de sondes équipées de type F**

Le présent document ne s'applique pas aux capteurs de courant relevant du domaine d'application de l'IEC 61010-2-032:2019.

## 4.2 Aspects liés à la sécurité

### 4.2.1 DANGERS identifiés

Les exigences du présent document ont pour but d'assurer que les DANGERS pour l'OPERATEUR et la zone alentour sont réduits à un niveau tolérable.

Les exigences relatives à la protection contre des types particuliers de DANGERS sont présentées dans les Articles 7 à 11 et dans l'Article 13, comme suit:

a) les chocs électriques et les brûlures (voir Article 7);
b) les DANGERS mécaniques (voir Articles 8 et 9);
c) les températures excessives (voir Article 10);
d) les effets des fluides (voir Article 11);
e) les arcs électriques (voir Article 13).

Les exigences supplémentaires relatives aux sondes équipées qui sont conçues pour être alimentées à partir d'une alimentation réseau à basse tension, ou comportent d'autres caractéristiques qui ne sont pas spécifiquement traitées dans le présent document, sont données dans d'autres parties de l'IEC 61010.

NOTE L'attention est attirée sur l'existence possible d'exigences supplémentaires relatives à la santé et à la sécurité des travailleurs.

### 4.2.2 Aspects exclus

Le présent document ne vise pas:

a) la fiabilité de fonctionnement, les qualités de fonctionnement ou autres propriétés de la sonde équipée;
b) l'efficacité de l'emballage de transport.

### 4.3 Vérification

Le présent document spécifie également des méthodes permettant de vérifier, par examen, ESSAIS DE TYPE et ESSAIS INDIVIDUELS DE SERIE, que la sonde équipée satisfait aux exigences du présent document.

### 4.4 Conditions d'environnement

#### 4.4.1 Conditions environnementales normales

Le présent document est applicable aux sondes équipées conçues pour être sûres au moins dans les conditions suivantes:

a) altitude inférieure ou égale à 2 000 m;

b) température ambiante de 5 °C à 40 °C;

c) humidité relative maximale de 80 % pour des températures jusqu'à 31 °C, avec décroissance linéaire jusqu'à 50 % d'humidité relative à 40 °C;

d) DEGRE DE POLLUTION applicable de l'environnement prévu.

#### 4.4.2 Conditions d'environnement étendues

Le présent document s'applique aux sondes équipées conçues pour être sûres non seulement dans les conditions d'environnement spécifiées en 4.4.1, mais aussi dans n'importe laquelle des conditions suivantes ASSIGNEES par le fabricant de la sonde équipée:

a) usage en extérieur;

b) altitude supérieure à 2 000 m;

c) températures ambiantes inférieures à 5 °C ou supérieures à 40 °C;

d) humidité relative supérieure aux niveaux spécifiés en 4.4.1;

e) EMPLACEMENT HUMIDE.

## 5 Essais

### 5.1 Généralités

Tous les essais dans le présent document sont des ESSAIS DE TYPE qui sont à effectuer sur des échantillons de sondes équipées ou de parties de sondes équipées. Leur seule fin est de vérifier que la conception et la construction assurent la conformité au présent document. En outre, les ESSAIS INDIVIDUELS DE SERIE selon l'Annexe D doivent être réalisés sur le FIL DE SONDE.

La sonde équipée doit au moins satisfaire aux exigences du présent document. Il est admis de dépasser les exigences. Si le présent document spécifie une limite inférieure pour une valeur de conformité, la sonde équipée peut démontrer une valeur plus élevée. Si une limite supérieure est spécifiée pour une valeur de conformité, la sonde équipée peut démontrer une valeur inférieure. Les variations et les tolérances de fabrication doivent être prises en compte.

Les essais réalisés sur des composants ou parties de la sonde équipée qui satisfont aux exigences des normes applicables spécifiées dans le présent document, et qui sont utilisés conformément à celles-ci, peuvent ne pas être répétés au cours des ESSAIS DE TYPE de la sonde équipée au complet.

Si une sonde équipée est constituée de plusieurs types de sondes (voir 4.1), chaque type doit être soumis à essai selon les exigences appropriées.

*La conformité aux exigences du présent document est vérifiée en effectuant tous les essais applicables, mais un essai peut être omis lorsque l'examen de la sonde équipée et de la documentation relative à la conception démontre de façon incontestable que la sonde équipée en question serait en mesure de subir cet essai avec succès. Les essais sont effectués tant dans des conditions de référence pour essais (voir 5.3) que dans des conditions de défaut (voir 5.4).*

*Lorsque les déclarations de conformité du présent document exigent une inspection, celle-ci peut inclure l'examen de la sonde équipée par mesure, l'examen des marquages sur la sonde équipée, l'examen des instructions livrées avec la sonde équipée, l'examen des fiches techniques des matériaux ou des composants qui ont servi à fabriquer la sonde équipée, etc. Dans chaque cas, l'inspection démontre que la sonde équipée satisfait aux exigences applicables ou indique que des essais complémentaires sont exigés.*

*Si, en effectuant un essai de conformité, il existe une incertitude concernant la valeur exacte d'une grandeur appliquée ou mesurée (par exemple la tension) en raison de la tolérance, il convient que:*

*a) les fabricants s'assurent que la valeur appliquée est supérieure ou égale à la valeur d'essai spécifiée;*

*b) les laboratoires d'essai s'assurent que la valeur appliquée n'est pas supérieure à la valeur d'essai spécifiée.*

Si la plage des conditions d'environnement ASSIGNEES pour la sonde équipée est plus large que celle qui est énoncée en 4.4.1, il convient que le fabricant s'assure (par exemple par une modification appropriée des exigences d'essai ou par la réalisation d'essais supplémentaires) que les exigences de sécurité du présent document sont encore respectées.

Les sondes équipées qui ont été soumises à des ESSAIS DE TYPE peuvent ne plus être adaptées à leur fonction prévue en raison des contraintes résiduelles résultant de certains de ces essais. Par conséquent, une sonde équipée qui a été soumise à des ESSAIS DE TYPE ne doit pas être utilisée.

### 5.2 Séquence d'essais

La séquence d'essais est facultative, sauf spécification contraire. La sonde équipée soumise à l'essai doit être soigneusement examinée après chaque essai. Si le résultat d'un essai engendre un doute sur la question de savoir si des essais antérieurs ont été subis avec succès en cas d'inversion de la séquence, ces essais préalables doivent être répétés.

### 5.3 Conditions de référence pour les essais

#### 5.3.1 Conditions d'environnement

Sauf spécification contraire dans le présent document, les conditions d'environnement suivantes (qui ne doivent cependant pas être en contradiction avec celles de 4.4.1) doivent prévaloir dans le local d'essai:

a) une température de 15 °C à 35 °C;

b) une humidité relative non supérieure à 75 %;

c) une pression d'air comprise entre 75 kPa et 106 kPa;

d) pas de gelée blanche, de rosée, d'eau d'infiltration, de pluie, de rayonnement solaire, etc.

#### 5.3.2 Etat des sondes équipées

Sauf spécification contraire, les essais doivent être effectués sur les sondes équipées complètes pour une UTILISATION NORMALE et suivant la combinaison la moins favorable des conditions données de 5.3.3 à 5.3.9.

En cas de doute, les essais doivent être effectués dans plus d'une combinaison de conditions.

S'il n'est pas approprié, en raison des dimensions ou de la masse, d'effectuer des essais particuliers sur une sonde équipée complète, les essais sur des sous-ensembles sont admis, à condition de vérifier que la sonde équipée complète satisfait aux exigences du présent document.

### 5.3.3 Position de la sonde équipée

Toutes les orientations possibles de la sonde équipée sont considérées comme étant des positions d'UTILISATION NORMALE.

### 5.3.4 Accessoires

Les accessoires et parties interchangeables par un OPERATEUR, mis à disposition ou recommandés par le fabricant pour utilisation avec la sonde équipée soumise à l'essai, doivent être raccordés ou non à la sonde équipée.

### 5.3.5 Couvercles et parties amovibles

Les couvercles ou les parties qui peuvent être retirés sans utiliser d'OUTIL doivent être retirés ou non retirés suivant la condition la plus défavorable.

### 5.3.6 Tensions d'entrée et de sortie

Les tensions d'entrée et de sortie, y compris les tensions flottantes, doivent être ajustées à n'importe quelle tension dans la plage de tensions ASSIGNEE.

### 5.3.7 Commandes

Les dispositifs de commande qu'un OPERATEUR peut manipuler sans l'aide d'un OUTIL doivent être réglés sur n'importe quelle position, sauf pour les combinaisons de présélections interdites par un marquage apposé par le fabricant sur la sonde équipée.

### 5.3.8 Connexions

La sonde équipée doit être connectée pour une UTILISATION NORMALE ou non connectée selon la condition la plus défavorable.

### 5.3.9 Fonctionnement intermittent ou de durée limitée

Les sondes équipées destinées à être utilisées en fonctionnement intermittent ou de durée limitée doivent être mises en service pendant la période ASSIGNEE la plus longue et avoir la période de récupération ASSIGNEE la plus courte qui soit conforme aux instructions du fabricant.

## 5.4 Essais en CONDITION DE PREMIER DEFAUT

### 5.4.1 Généralités

Les exigences suivantes s'appliquent:

a) l'examen de la sonde équipée et de son schéma de circuit indique généralement les conditions de défaut qui sont susceptibles de provoquer des DANGERS et qui doivent par conséquent être appliquées;

b) les essais de défauts doivent être effectués comme spécifié lors de la vérification de conformité, sauf s'il peut être démontré qu'aucun DANGER ne peut résulter d'une condition de défaut particulière;

c) la sonde équipée doit être utilisée suivant la combinaison la moins favorable des conditions de référence pour les essais (voir 5.3). Ces combinaisons peuvent être différentes pour des défauts différents et elles doivent être consignées pour chaque essai.

### 5.4.2 Application des conditions de défaut

#### 5.4.2.1 Généralités

Les conditions de défaut doivent inclure celles qui sont spécifiées de 5.4.2.2 à 5.4.2.4. Elles doivent être appliquées à tour de rôle selon l'ordre le plus pratique. Des défauts multiples ne doivent pas être appliqués simultanément, à moins qu'ils ne soient une conséquence du défaut appliqué.

Après chaque application d'une condition de défaut, la sonde équipée ou la partie doit subir avec succès les essais applicables de 5.4.4.

#### 5.4.2.2 IMPEDANCE DE PROTECTION

Les exigences suivantes s'appliquent:

a) si une IMPEDANCE DE PROTECTION est formée par une combinaison de composants, chaque composant doit être court-circuité ou déconnecté selon la condition la moins favorable;

b) si une IMPEDANCE DE PROTECTION est formée d'un seul composant qui satisfait aux exigences de 7.4.5, il n'est pas nécessaire de la court-circuiter ou déconnecter.

#### 5.4.2.3 Sondes équipées ou parties de sondes équipées à fonctionnement de courte durée ou intermittent

Les sondes équipées ou les parties de sondes équipées à fonctionnement de courte durée ou intermittent doivent être mises en fonctionnement en permanence si le fonctionnement continu peut se produire lors d'une CONDITION DE PREMIER DEFAUT.

#### 5.4.2.4 Sorties

Les sorties des sondes équipées de type B doivent être court-circuitées.

### 5.4.3 Durée des essais

La sonde équipée doit fonctionner jusqu'au moment où il est peu probable qu'un changement ultérieur se produise par suite du défaut appliqué. La durée de chaque essai est normalement limitée à 1 h car un défaut secondaire occasionné par une CONDITION DE PREMIER DEFAUT se manifeste habituellement dans ce délai. S'il y a une indication qu'un DANGER de choc électrique ou de préjudice à des personnes puisse finalement se produire, l'essai doit être poursuivi pendant une durée maximale de 4 h.

### 5.4.4 Conformité après application des conditions de défaut

#### 5.4.4.1 Choc électrique

*La conformité aux exigences de protection contre les chocs électriques après application des conditions de premier défaut est vérifiée comme suit:*

*a) en effectuant les mesures indiquées en 7.3.3 pour vérifier qu'aucune partie conductrice ACCESSIBLE n'est devenue SOUS TENSION DANGEREUSE, sauf dans les conditions permises en 7.1;*

*b) en effectuant un essai de tension sur la DOUBLE ISOLATION, l'ISOLATION RENFORCEE ou l'ISOLATION PRINCIPALE plus l'impédance lorsque l'impédance est court-circuitée pour vérifier que la protection est toujours au moins au niveau de celle de l'ISOLATION PRINCIPALE. Les essais de tension sont effectués comme spécifié en 7.6 (sans l'essai de préconditionnement à l'humidité) avec la tension d'essai de l'ISOLATION PRINCIPALE;*

c) *par examen et en effectuant les mesurages des ESPACEMENTS pour les niveaux de l'ISOLATION PRINCIPALE. Cela s'applique également à l'impédance ou à l'IMPEDANCE DE PROTECTION.*

#### 5.4.4.2 Température

*La conformité aux exigences de protection thermique est vérifiée en déterminant la température de la surface extérieure de la sonde équipée (voir Article 10).*

*Cette température est déterminée en mesurant l'échauffement de la surface ou de la partie et en l'ajoutant à la température ambiante de 40 °C, ou à la température ambiante maximale ASSIGNEE si elle est supérieure.*

#### 5.4.4.3 Autres DANGERS

*La conformité aux exigences de protection contre les autres DANGERS est vérifiée conformément aux spécifications des Articles 8 à 13.*

## 5.5 Essais en MAUVAIS USAGE RAISONNABLEMENT PREVISIBLE

### 5.5.1 Généralités

Les essais nécessaires pour venir à l'appui d'une appréciation du risque relatif à un MAUVAIS USAGE RAISONNABLEMENT PREVISIBLE sont réalisés dans les combinaisons de conditions et de fonctionnements déterminées au cours de l'appréciation du risque.

### 5.5.2 Fusibles

Les sondes équipées avec fusible sont utilisées quand l'appareil, auquel les sondes équipées tenues à la main sont connectées, apporte une protection insuffisante en particulier dans les conditions de MAUVAIS USAGE RAISONNABLEMENT PREVISIBLE susceptibles de provoquer un incendie ou un arc électrique.

Pour les besoins de cet essai, il est supposé que l'appareil auquel ces sondes équipées sont connectées constitue une condition de court-circuit. Il est également supposé que les sondes équipées avec fusible peuvent être connectées à n'importe quelle source de tension suivant les CARACTERISTIQUES ASSIGNEES de la sonde équipée. Cela conduit à une condition d'essai où n'importe quelle valeur de courant pouvant atteindre le courant maximal présumé de court-circuit peut être appliquée. En ce qui concerne les courants présumés de court-circuit liés aux installations du réseau, la valeur ASSIGNEE du fusible doit être selon 12.2 et aucun essai supplémentaire lié aux valeurs ASSIGNEES du courant de coupure n'est nécessaire. Cependant, des essais sont nécessaires à des niveaux de courant proches des CARACTERISTIQUES ASSIGNEES du fusible qui pourraient potentiellement conduire à une augmentation excessive de la température sur les parties tenues à la main, ainsi qu'à des dommages aux parties isolantes, ENVELOPPES et barrières.

Il doit être démontré que la température maximale du fusible de la sonde équipée avec fusible ne conduit pas à un DANGER dans n'importe quelle condition de charge du courant ne dépassant pas 5 fois les valeurs ASSIGNEES du fusible.

*La conformité est vérifiée par examen et mesurage.*

# 6 Marquage et documentation

## 6.1 Marquage

### 6.1.1 Généralités

Les sondes équipées doivent porter des marquages selon 6.1.2 à 6.2. Les marquages concernant la sonde équipée dans son ensemble ne doivent pas être apposés sur des parties qui peuvent être retirées par un OPERATEUR sans l'aide d'un OUTIL, à l'exception des parties amovibles des POINTES DE TOUCHE si elles sont conformes à 13.2.

Les symboles littéraux pour les grandeurs et les unités doivent être conformes à l'IEC 60027-1:1992, l'IEC 60027-1:1992:AMD1:1997 et l'IEC 60027-1:1992/AMD2:2005, l'IEC 60027-2:2019 et l'IEC 60027-4:2006. Les symboles graphiques doivent être conformes au Tableau 1, le cas échéant. Il n'y a aucune exigence relative à la taille ou à la couleur. S'il n'y a pas de symbole applicable dans le Tableau 1, tout autre symbole graphique peut être utilisé sur la sonde équipée, à condition de l'expliquer dans la documentation d'accompagnement (voir 6.4.1).

S'il n'est pas possible d'apposer tous les marquages qui sont exigés sur la partie, les informations nécessaires doivent être incluses dans la documentation spécifiée en 6.4.1. Le symbole 7 du Tableau 1 doit aussi être utilisé.

*La conformité est vérifiée par examen.*

### 6.1.2 Identification

Chaque sonde équipée et, si possible, ses accessoires doivent être marqués avec:

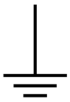
a) le nom ou la marque déposée du fabricant ou du fournisseur;

b) en supplément pour le type B seulement, le numéro du modèle ou le nom ou tout autre moyen permettant d'identifier la sonde équipée ou la partie.

Si une sonde équipée est conçue pour n'être utilisée qu'avec un modèle d'appareil spécifique, cela doit apparaître de façon claire, et l'appareil ou le modèle spécifique doit être désigné soit par un marquage sur la sonde équipée, soit dans la documentation d'accompagnement.

*La conformité est vérifiée par examen.*

**Tableau 1 – Symboles**

| Numéro | Symbole | Référence | Description |
|---|---|---|---|
| 1 |  | IEC 60417-5031 (2002-10) | Courant continu |
| 2 |  | IEC 60417-5032 (2002-10) | Courant alternatif |
| 3 |  | IEC 60417-5033 (2002-10) | Courant continu et courant alternatif |
| 4 |  | IEC 60417-5017 (2006-08) | BORNE de terre (masse) |
| 5 |  | IEC 60417-6042 (2010-11) | Attention, risque de choc électrique |
| 6 |  | IEC 60417-5041 (2002-10) | Attention, surface chaude |
| 7 |  | ISO 7000-0434A (2004-01) ou<br>ISO 7000-0434B (2004-01) | Attention [a] |

[a] Voir 6.4.1 qui exige que les fabricants indiquent qu'il faut consulter la documentation chaque fois que ce symbole est marqué.

### 6.1.3 Fusibles

Les sondes équipées contenant des fusibles conçus pour être remplacés par un OPERATEUR doivent être marquées avec tous les détails nécessaires pour que l'OPERATEUR puisse obtenir le fusible correct. Ces marquages doivent comprendre la valeur ASSIGNEE de la tension, ainsi que le pouvoir de coupure (courant maximal que le fusible peut interrompre de manière sûre à la tension ASSIGNEE la plus élevée). Si l'espace est insuffisant pour marquer ces détails, le symbole 7 du Tableau 1 doit être marqué sur la sonde équipée et les informations nécessaires doivent être incluses dans la documentation.

*La conformité est vérifiée par examen.*

### 6.1.4 CONNECTEURS et dispositifs de manœuvre

Si cela est nécessaire à des fins de sécurité, une indication doit être donnée sur le rôle des CONNECTEURS, des BORNES, des dispositifs de commande, ainsi que sur toutes les séquences de fonctionnement.

*La conformité est vérifiée par examen.*

### 6.1.5 CARACTERISTIQUES ASSIGNEES

Les CARACTERISTIQUES ASSIGNEES des sondes équipées doivent être marquées comme suit:

a) les sondes équipées qui n'ont pas de CATEGORIES DE MESURE ASSIGNEES doivent être marquées avec la tension ASSIGNEE à la terre et avec le symbole 7 du Tableau 1 [voir aussi 6.4.3 k)];

b) les sondes équipées prévues pour le mesurage dans les CATEGORIES DE MESURE II, III et IV doivent être marquées avec la tension ASSIGNEE phase-neutre alternative efficace ou continue et avec les CATEGORIES DE MESURE pertinentes.

   Les marquages des CATEGORIES DE MESURE doivent être "CAT II", "CAT III" ou "CAT IV", suivant le cas.

   NOTE Les DISTANCES D'ISOLEMENT et l'isolation solide sont spécifiées pour une tension nominale alternative efficace phase-neutre ou continue du réseau de distribution en cours de mesure. Le neutre est considéré relié à la terre (voir Annexe H).

Si cela est possible (voir 6.1.1), le marquage sur une sonde équipée doit être apposé sur le corps de la sonde. La nature de la tension (courant alternatif, courant continu, etc.) doit également être marquée, sauf si la valeur marquée de tension s'applique à la fois au courant alternatif efficace et au courant continu. Si un CONNECTEUR DE REFERENCE est conçu pour une connexion à des points d'un niveau de tension supérieur aux valeurs prévues en 7.3.2, la tension ASSIGNEE par rapport à la terre doit être marquée sur le CONNECTEUR ou aussi près que possible du CONNECTEUR.

Pour les sondes équipées de types A, D et E seulement, la valeur ASSIGNEE du courant de la sonde équipée doit être marquée conjointement avec la valeur ASSIGNEE de la tension. La valeur ASSIGNEE du courant peut ne pas être marquée sur les sondes équipées spécifiées pour une utilisation uniquement avec un appareil ayant des entrées à haute impédance ou des sorties limitées en courant.

*La conformité est vérifiée par examen.*

## 6.2 Marquages d'avertissement

Les marquages d'avertissement doivent être lisibles lorsque la sonde équipée est prête pour l'UTILISATION NORMALE.

S'il est nécessaire à l'OPERATEUR de se reporter aux instructions d'emploi pour conserver les protections offertes par la sonde équipée, la sonde équipée doit porter le symbole 7 du Tableau 1. Si un avertissement s'applique à une partie particulière de la sonde équipée, cet avertissement doit être placé sur la partie en question ou à proximité de celle-ci.

Si les instructions d'utilisation indiquent que l'OPERATEUR est autorisé à avoir accès, en utilisant un OUTIL, à une partie qui peut être SOUS TENSION DANGEREUSE en UTILISATION NORMALE, un avertissement doit être marqué pour indiquer que la sonde équipée doit être isolée ou déconnectée de la TENSION DANGEREUSE avant l'accès ou le symbole 7 du Tableau 1 peut être utilisé à condition que l'information soit comprise dans les instructions d'utilisation.

A moins que leur état chaud ne soit évident ou implicite d'après la fonction de la sonde équipée, les parties aisément touchées et aussi admises à dépasser les limites de température selon l'Article 10 doivent être marquées du symbole 6 du Tableau 1.

*La conformité est vérifiée par examen.*

## 6.3 Durabilité du marquage

Les marquages exigés doivent rester clairs et lisibles dans les conditions d'UTILISATION NORMALE et doivent résister aux effets des agents de nettoyage spécifiés par le fabricant (voir 11.1).

*La conformité est vérifiée en réalisant l'essai suivant pour la durabilité des marquages apposés sur l'extérieur de la sonde équipée. Les marquages sont frottés à la main, sans pression excessive pendant 30 s avec un tissu imbibé avec chacun des agents de nettoyage spécifié, un à la fois, ou, si aucun agent n'est spécifié, avec une solution aqueuse contenant au moins 70 % d'alcool isopropylique.*

*Après le traitement ci-dessus, les marquages doivent rester clairement lisibles et les étiquettes adhésives ne doivent pas se décoller ni présenter de bords enroulés.*

## 6.4 Documentation

### 6.4.1 Généralités

Les sondes équipées doivent être accompagnées de la documentation nécessaire à la sécurité. Cette documentation doit au moins inclure:

a) la spécification technique;

b) les instructions d'utilisation;

c) le nom et l'adresse du fabricant ou du fournisseur auprès duquel il est possible d'obtenir l'assistance technique nécessaire;

d) les informations spécifiées de 6.4.2 à 6.4.4.

Le cas échéant, des avertissements et une explication claire des symboles d'avertissement marqués sur les sondes équipées doivent être donnés dans la documentation ou doivent être marqués de façon durable et lisible sur les sondes équipées. En particulier, il doit y avoir une déclaration expliquant qu'il faut consulter la documentation chaque fois que le symbole 7 du Tableau 1 est utilisé, afin de connaître la nature du DANGER potentiel et toutes les actions nécessaires à prendre.

*La conformité est vérifiée par examen.*

### 6.4.2 CARACTERISTIQUES ASSIGNEES des sondes équipées

La documentation doit comporter les CARACTERISTIQUES ASSIGNEES de tension et de courant, suivant le cas, et la CATEGORIE DE MESURE, ainsi qu'une déclaration indiquant la gamme des conditions d'environnement pour lesquelles la sonde équipée est conçue (voir 4.4).

*La conformité est vérifiée par examen.*

### 6.4.3 Fonctionnement des sondes équipées

Les instructions d'utilisation doivent inclure, le cas échéant:

a) l'identification des dispositifs de commande et leur utilisation dans tous les modes opératoires;

b) pour les sondes équipées conçues pour être utilisées seulement avec un modèle spécifique de matériel, une identification claire et nette du matériel;

c) une explication des symboles relatifs à la sécurité qui sont utilisés sur la sonde équipée;

d) une définition de la CATEGORIE DE MESURE applicable si le marquage est exigé sur la sonde équipée (voir 6.1.5);

e) une spécification des limites de fonctionnement intermittent, le cas échéant;

f) les instructions pour l'interconnexion aux accessoires et à d'autres appareils, y compris l'indication des accessoires appropriés, pièces amovibles et tous matériaux spéciaux;

g) les instructions pour le nettoyage;

h) les instructions pour le remplacement des matériaux consommables;

i) pour les sondes équipées qui n'ont pas de FIL DE SONDE avec indicateur d'usure, les instructions pour l'examen périodique du FIL DE SONDE;

j) pour les sondes équipées qui ont un FIL DE SONDE avec un indicateur d'usure, un avertissement interdisant d'utiliser la sonde équipée si l'indicateur d'usure est devenu visible (voir 12.3.2);

k) pour les sondes équipées qui n'ont pas de CATEGORIES DE MESURE ASSIGNEES, un avertissement interdisant d'utiliser les sondes équipées pour des mesures sur les circuits de réseaux de distribution;

l) pour les sondes équipées de type B, ayant des valeurs ASSIGNEES de tensions supérieures à 1 000 V alternatifs efficaces ou 1 500 V continus, si la tension ASSIGNEE du FIL DE SONDE est inférieure à la tension ASSIGNEE de la POINTE DE TOUCHE, un avertissement indiquant que le FIL DE SONDE ne fournit pas la protection adéquate s'il entre en contact avec une partie SOUS TENSION DANGEREUSE;

m) un avertissement précisant que la CATEGORIE DE MESURE applicable d'un assemblage d'une sonde équipée et d'un accessoire est la CATEGORIE DE MESURE la plus basse entre celle de la sonde équipée et celle de l'accessoire.

Les instructions doivent indiquer que, si la sonde équipée est utilisée d'une façon qui n'est pas spécifiée par le fabricant, la protection assurée par la sonde équipée peut être compromise.

*La conformité est vérifiée par examen.*

### 6.4.4 Maintenance et entretien des sondes équipées

L'ORGANISME RESPONSABLE doit recevoir des instructions suffisamment détaillées pour permettre la maintenance et l'examen en toute sécurité de la sonde équipée et assurer la sécurité permanente de la sonde équipée après la procédure de maintenance et d'examen.

Le fabricant doit spécifier toutes les parties qui ne doivent être vérifiées ou fournies que par le fabricant ou son représentant.

Les CARACTERISTIQUES ASSIGNEES et les caractéristiques des fusibles utilisés doivent être indiquées (voir 6.1.3).

Les instructions relatives aux sujets suivants doivent être fournies pour le personnel d'entretien, selon les besoins afin de permettre un entretien sûr et une sécurité permanente de la sonde équipée après l'entretien si la sonde équipée se prête à être entretenue:

a) les risques spécifiques à un produit qui peuvent affecter le personnel d'entretien;

b) les mesures de protection contre ces risques;

c) la confirmation par vérification que la sonde équipée est dans un état sûr après réparation.

Les instructions pour le personnel d'entretien peuvent ne pas être fournies à l'ORGANISME RESPONSABLE, mais il convient qu'elles soient disponibles pour le personnel d'entretien.

*La conformité est vérifiée par examen.*

## 7 Protection contre les chocs électriques

### 7.1 Généralités

La protection contre les chocs électriques doit être maintenue en CONDITION NORMALE et en CONDITION DE PREMIER DEFAUT. Les parties ACCESSIBLES des sondes équipées ne doivent pas être SOUS TENSION DANGEREUSE (voir 7.3).

S'il n'est pas possible pour des raisons fonctionnelles d'éviter que les parties suivantes soient à la fois ACCESSIBLES et SOUS TENSION DANGEREUSE, il est admis qu'elles soient ACCESSIBLES à l'OPERATEUR en UTILISATION NORMALE tout en étant SOUS TENSION DANGEREUSE:

a) les parties destinées à être remplacées par l'OPERATEUR (par exemple les fusibles) et qui peuvent être SOUS TENSION DANGEREUSE pendant leur remplacement, mais seulement si elles portent un marquage d'avertissement conforme à 6.2;
b) les POINTES DE TOUCHE, à condition qu'elles satisfassent aux exigences de 7.4.3;
c) les CONNECTEURS découplés tels que spécifiés en 7.4.2.4 1).

*La conformité est vérifiée par la détermination de 7.2 et les mesures de 7.3, suivies des examens et des essais de 7.4 à 7.7.*

## 7.2 Détermination des parties ACCESSIBLES

### 7.2.1 Généralités

*A moins que cela ne soit évident, la détermination pour savoir si une partie est ACCESSIBLE est effectuée telle que spécifiée en 7.2.2 et 7.2.3. Les doigts d'épreuve (voir Figure B.1 et Figure B.2 de l'Annexe B) et les broches d'essai sont appliqués sans effort. Des parties sont considérées comme étant ACCESSIBLES si elles peuvent être touchées par une partie quelconque d'un doigt d'épreuve ou d'une broche d'essai ou si elles peuvent être touchées en l'absence de couvercle considéré comme n'assurant pas une isolation appropriée (voir 7.7.2).*

*Si, en UTILISATION NORMALE, des actions quelconques prévues (avec ou sans l'aide d'un OUTIL) d'un OPERATEUR sont susceptibles d'augmenter l'accessibilité des parties, ces actions sont entreprises avant d'accomplir les examens indiqués en 7.2.2 et 7.2.3.*

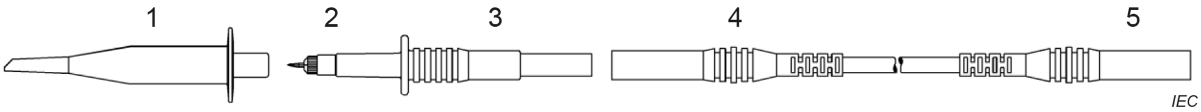
*NOTE Exemples de ces actions:*

*a) retrait des couvercles,*
*b) réglage des dispositifs de commande,*
*c) remplacement des matériaux consommables,*
*d) dépose ou installation de parties et d'accessoires fournies.*

*La Figure 7 donne des méthodes pour la détermination des parties ACCESSIBLES des SONDES EQUIPEES.*

### 7.2.2 Examen

*Le doigt d'épreuve articulé (voir Figure B.2) est appliqué sans effort dans toutes les positions possibles. L'essai est appliqué à toutes les surfaces extérieures.*



**Légende**

1 POINTE DE TOUCHE d'accessoire

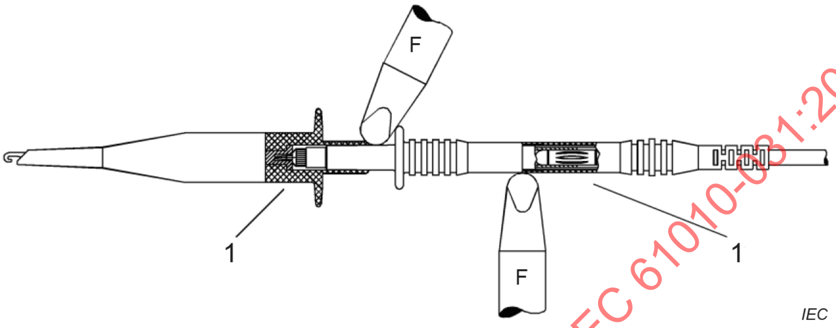
2 POINTE DE TOUCHE

3 partie du corps de la sonde tenue à la main

4 CONNECTEUR

5 CONNECTEUR vers l'appareil

**Figure 7 a) – Parties d'une sonde équipée**

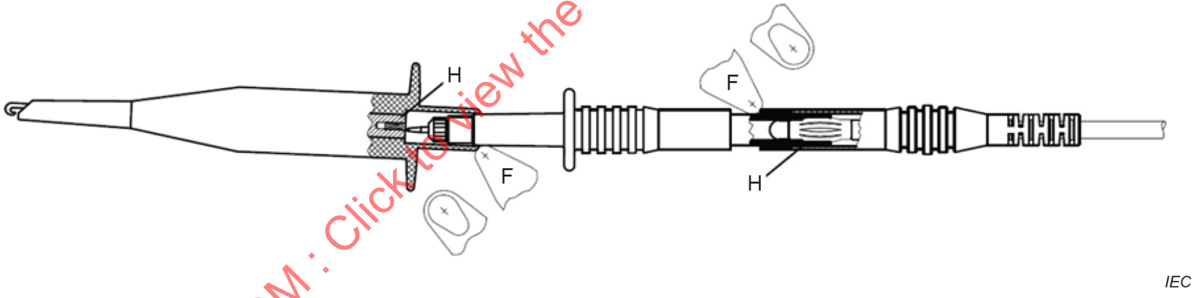


**Légende**

1 CONNECTEUR

F doigt d'épreuve articulé (voir Figure B.2)

**Figure 7 b) – Sonde équipée totalement couplée (voir 7.4.2.2)**



**Légende**

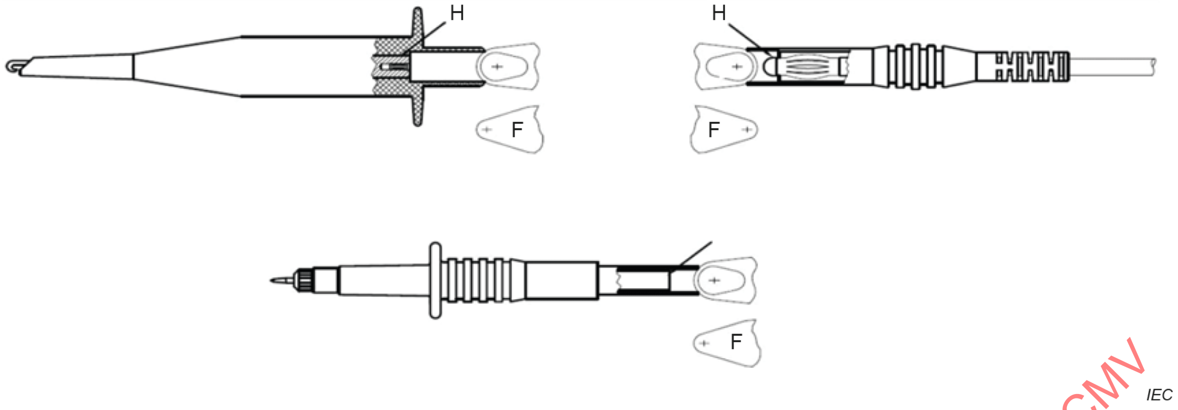
F doigt d'épreuve articulé (voir Figure B.2)

H partie potentiellement SOUS TENSION DANGEREUSE

Les parties de connexion sont partiellement couplées dans le seul but d'établir un contact électrique tout en autorisant un accès maximal au doigt d'épreuve.

Noter que le doigt d'épreuve a deux positions possibles.

**Figure 7 c) – Sonde équipée partiellement couplée (voir 7.4.2.3)**



**Légende**

F doigt d'épreuve articulé (voir Figure B.2)

H partie potentiellement SOUS TENSION DANGEREUSE

Noter les deux positions possibles du doigt d'épreuve.

**Figure 7 d) – Parties découplées d'une sonde équipée (voir 7.4.2.4)**

**Figure 7 – Méthodes de détermination des parties ACCESSIBLES**

### 7.2.3 Ouvertures d'accès aux commandes préréglées

*Une broche d'essai métallique de 3 mm de diamètre est insérée à travers les orifices prévus pour l'accès aux commandes préréglées qui exigent l'utilisation d'un tournevis ou d'un autre OUTIL. La broche d'essai est appliquée dans toutes les directions possibles à travers l'orifice. La pénétration ne doit pas dépasser trois fois la distance entre la surface de l'ENVELOPPE et l'axe de la commande ou 100 mm, selon la valeur la plus faible.*

## 7.3 Valeurs limites pour les parties ACCESSIBLES

### 7.3.1 Généralités

A l'exception des cas permis en 7.1, la tension entre une partie ACCESSIBLE et la terre ou entre deux parties ACCESSIBLES quelconques de la même sonde équipée, ne doit pas dépasser les niveaux indiqués en 7.3.2 en CONDITION NORMALE ou indiqués en 7.3.3 en CONDITION DE PREMIER DEFAUT.

Les conducteurs extérieurs (blindages) des sondes équipées, destinés à être flottants, sont considérés comme étant portés à la même tension que la POINTE DE TOUCHE.

La tension ACCESSIBLE doit être mesurée (voir 7.3.4). Si la tension est inférieure aux niveaux selon 7.3.2 a) ou 7.3.3 a), suivant le cas, il n'est pas nécessaire de mesurer le courant de contact et la capacité. Si la tension dépasse ce niveau, le courant de contact et la capacité doivent être mesurés. Pour les sondes d'essai avec des hautes fréquences ASSIGNEES supérieures à 100 kHz, la méthode alternative de 7.3.4.3 peut aussi être utilisée.

*La conformité est vérifiée par examen et de la manière spécifiée en 7.3.2, 7.3.3 et 7.3.4.*

### 7.3.2 Niveaux en CONDITION NORMALE

Les tensions supérieures aux niveaux selon 7.3.2 a) sont réputées être SOUS TENSION DANGEREUSE si des niveaux en 7.3.2 b) ou 7.3.2 c) sont dépassés en même temps.

a) Le niveau de tension alternative est 30 V efficaces ou 42,4 V crête et le niveau de tension continue est 60 V. Pour ce qui concerne les sondes équipées destinées à être utilisées dans des EMPLACEMENTS HUMIDES, le niveau de tension alternative est 16 V efficaces ou 22,6 V crête et le niveau de tension continue est 35 V.

b) Les niveaux de courant de contact sont:

   1) 0,5 mA efficaces pour la forme d'onde sinusoïdale, 0,7 mA crête pour les fréquences non sinusoïdales ou les fréquences mixtes, ou 2 mA continus, lorsque le courant est mesuré avec le circuit de mesure de la Figure A.1. Si la fréquence ne dépasse pas 100 Hz, le circuit de mesure de la Figure A.2 peut être utilisé. Le circuit de mesure de la Figure A.5 est utilisé pour les sondes équipées qui sont destinées à être utilisées dans des EMPLACEMENTS HUMIDES;

   2) 70 mA efficaces, lorsque le courant est mesuré avec le circuit de mesure de la Figure A.3. Cela se rapporte aux brûlures possibles à des fréquences supérieures à 100 kHz.

c) Les niveaux de charge capacitive ou d'énergie sont:

   1) une charge de 45 μC pour les tensions inférieures ou égales à 15 kV crête ou 15 kV continus. La droite A à la Figure 8 représente la capacité en fonction de la tension dans les cas où la charge est de 45 μC;

   2) une énergie accumulée de 350 mJ pour les tensions supérieures à 15 kV crête ou à 15 kV continus.

### 7.3.3 Niveaux en CONDITION DE PREMIER DEFAUT

En CONDITION DE PREMIER DEFAUT, les tensions supérieures aux niveaux selon 7.3.3 a) sont réputées être SOUS TENSION DANGEREUSE si des niveaux en 7.3.3 b) ou 7.3.3 c) sont dépassés en même temps.

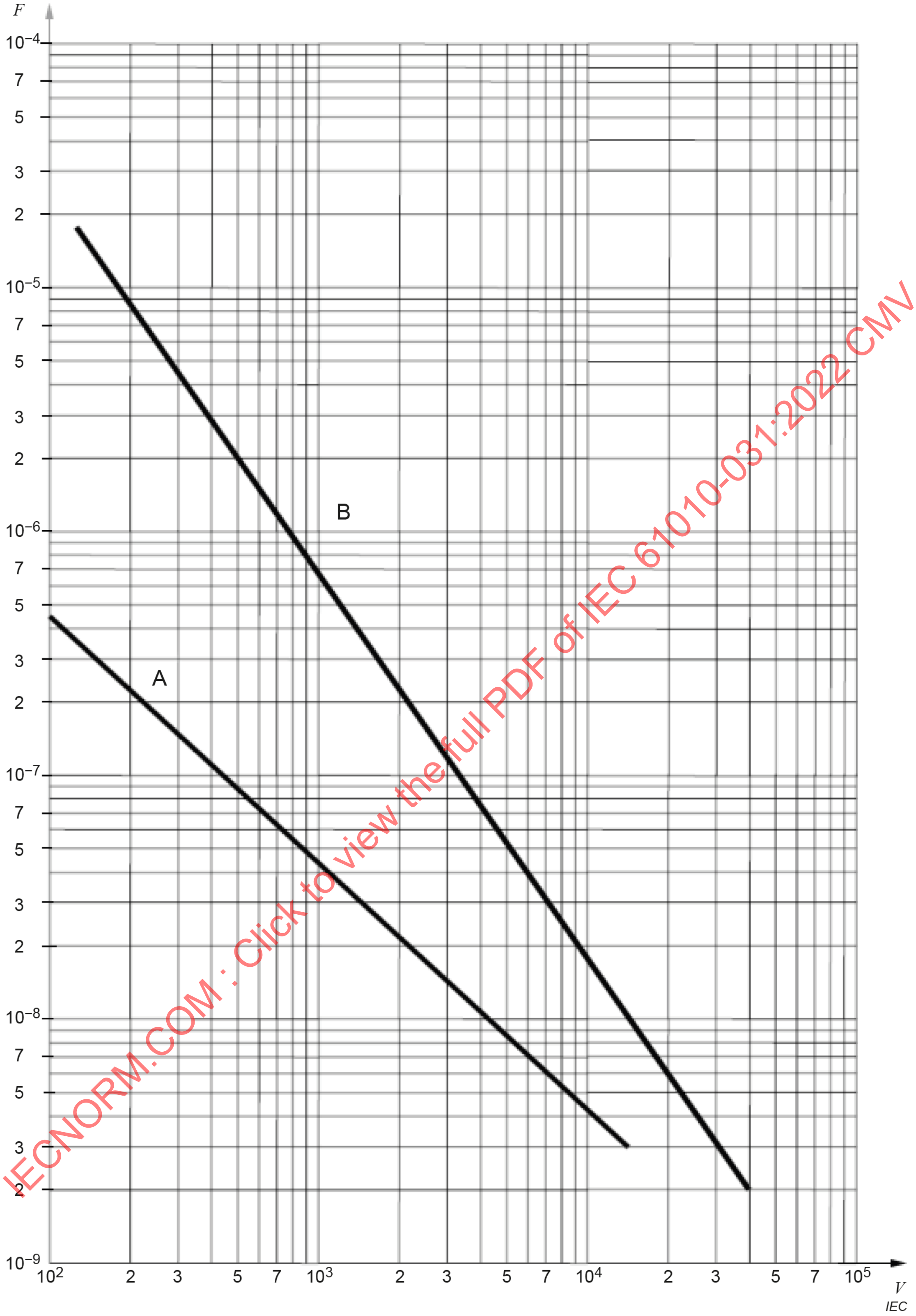
a) Le niveau de tension alternative est 50 V efficaces ou 70,7 V crête et le niveau de tension continue est 120 V. Pour ce qui concerne les sondes équipées destinées à être utilisées dans des EMPLACEMENTS HUMIDES, le niveau de tension alternative est 33 V efficaces ou 46,7 V crête et le niveau de tension continue est 70 V.

b) Les niveaux de courant de contact sont:

   1) 3,5 mA efficaces pour la forme d'onde sinusoïdale, 5 mA crête pour les fréquences non sinusoïdales ou les fréquences mixtes, ou 15 mA continus, lorsque le courant est mesuré avec le circuit de mesure de la Figure A.1. Si la fréquence ne dépasse pas 100 Hz, le circuit de mesure de la Figure A.2 peut être utilisé. Le circuit de mesure de la Figure A.5 est utilisé pour les sondes équipées qui sont destinées à être utilisées dans des EMPLACEMENTS HUMIDES;

   2) 500 mA efficaces, lorsque le courant est mesuré avec le circuit de mesure de la Figure A.3. Cela se rapporte aux brûlures possibles à des fréquences supérieures à 100 kHz.

c) Le niveau de capacité est représenté par la droite B à la Figure 8.



**Légende**

A = CONDITION NORMALE

B = CONDITION DE PREMIER DEFAUT

**Figure 8 – Niveau de capacité en fonction de la tension en CONDITION NORMALE et en CONDITION DE PREMIER DEFAUT [voir 7.3.2 c) et 7.3.3 c)]**

### 7.3.4 Mesurage de la tension et du courant de contact

#### 7.3.4.1 Généralités

*Le mesurage de la tension et du courant de contact sur des parties ACCESSIBLES des sondes équipées est effectué avec une feuille de métal enveloppant chacune des parties, individuellement:*

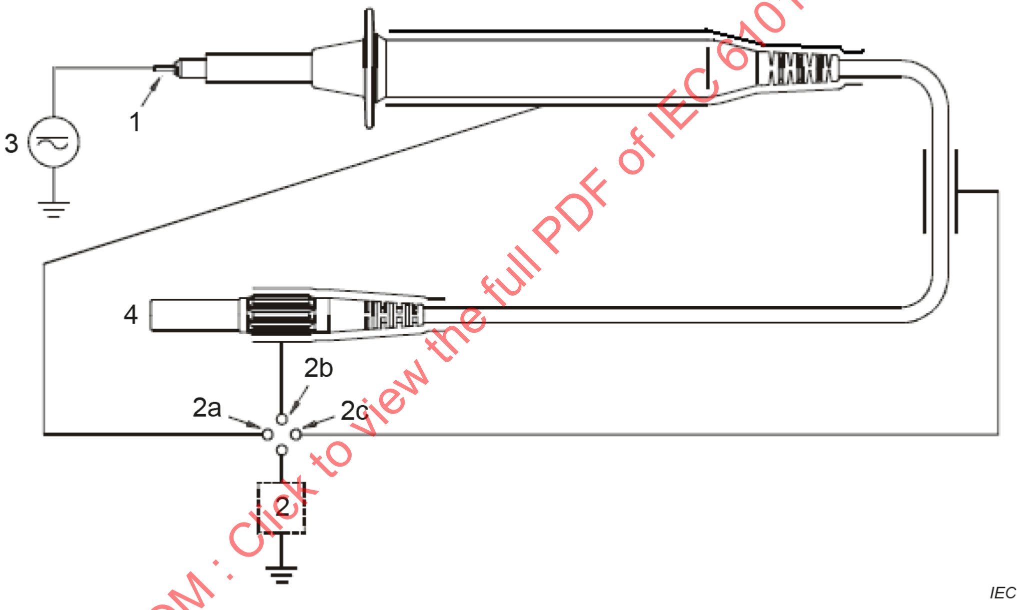
*a) corps de la sonde;*

*b) parties portatives tenues à la main ou manipulées de chaque CONNECTEUR;*

*c) (150 ± 20) mm du FIL DE SONDE ou sur la longueur maximale du câble, selon la valeur la plus courte;*

*d) autres parties tenues à la main ou manipulées.*

*La tension ASSIGNEE la plus élevée à la terre est appliquée entre la POINTE DE TOUCHE (1) et la terre. La tension est mesurée entre la feuille et la terre. Si cela est nécessaire, le circuit de mesure est raccordé tour à tour (2a puis 2b puis 2c de la Figure 9) entre chacun des éléments enveloppés dans une feuille et la terre (voir Figure 9 et Figure 10).*



**Légende**

1 POINTE DE TOUCHE

2 mesurage de tension ou de courant de contact (voir Annexe A pour les circuits de mesure applicables aux mesures de courant de contact)

2a connexion à la feuille métallique bien serrée autour des parties prévues pour être tenues à la main ou manipulées

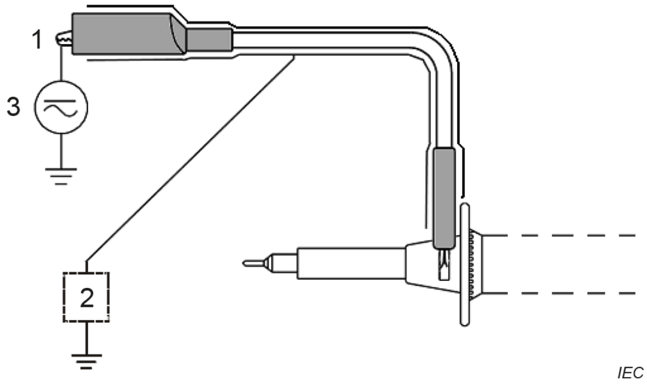
2b connexion à la feuille métallique bien serrée autour du CONNECTEUR

2c connexion à la feuille métallique bien serrée autour du câble

3 tension ASSIGNEE la plus élevée avec connexion au conducteur interne du FIL DE SONDE

4 non connecté à l'appareil d'essai ou de mesure

**Figure 9 – Mesure de la tension et du courant de contact**



**Légende**

1 POINTE DE TOUCHE du CONNECTEUR DE REFERENCE

2 mesurage de tension ou de courant de contact (voir Annexe A pour les circuits de mesure applicables aux mesures de courant de contact)

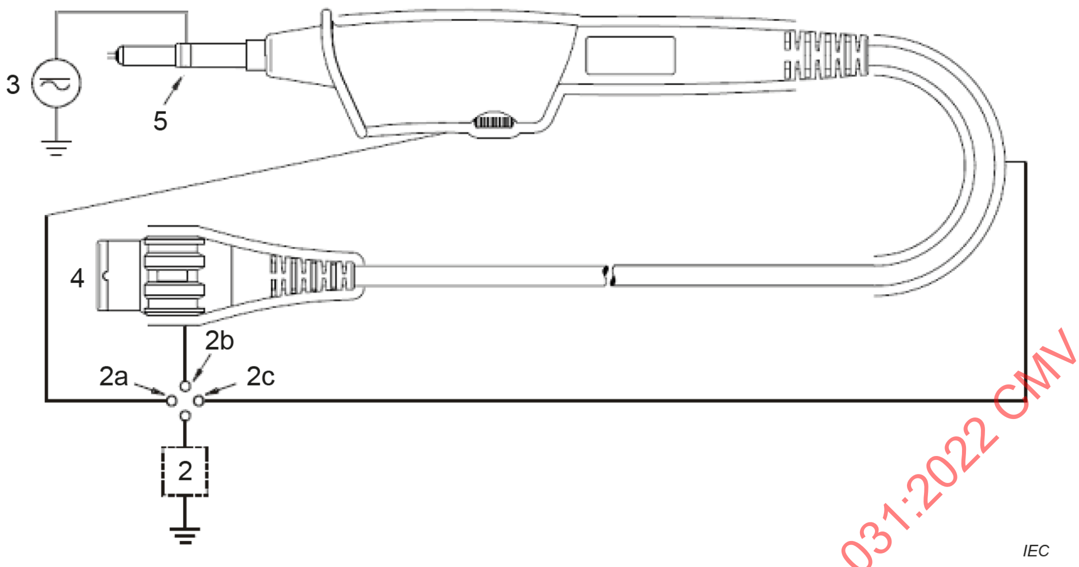
3 tension ASSIGNEE la plus élevée pour le CONNECTEUR DE REFERENCE

**Figure 10 – Mesure de la tension et du courant de contact pour le CONNECTEUR DE REFERENCE**

### 7.3.4.2 Sondes équipées avec connecteurs extérieurs flottants

*Pour ce qui concerne les sondes équipées où la connexion du conducteur extérieur (blindage) peut être destinée à être flottante, l'essai est également effectué entre la* POINTE DE TOUCHE *(Figure 11, point 5) du conducteur extérieur et la terre (voir Figure 11).*

*Le courant de contact est déterminé en utilisant le circuit de mesure applicable selon l'Annexe A.*



**Légende**

2 mesurage de tension ou de courant (voir Annexe A pour les circuits de mesure applicables aux mesures de courant de contact)

- 2a connexion à la feuille métallique bien serrée autour des parties prévues pour être tenues à la main ou manipulées
- 2b connexion à la feuille métallique bien serrée autour du CONNECTEUR
- 2c connexion à la feuille métallique bien serrée autour du câble

3 tension ASSIGNEE la plus élevée avec connexion à la POINTE DE TOUCHE du conducteur extérieur

4 non connecté à l'appareil d'essai ou de mesure

5 POINTE DE TOUCHE flottante connectée au blindage ou au conducteur extérieur du FIL DE SONDE

**Figure 11 – Mesurage de la tension et du courant de contact avec sonde d'essai blindée**

#### 7.3.4.3 Sondes d'essai à hautes fréquences

*Dans le cas des sondes d'essai AVEC des fréquences supérieures à 100 kHz, avec un conducteur extérieur (blindage) flottant, la tension maximale admissible entre le blindage et les parties ACCESSIBLES est déterminée pour éviter les brûlures électriques. Le courant de contact est mesuré dans toute la gamme de fréquences et à la tension maximale dans chaque gamme de fréquences.*

*Les mesurages sont réalisés (voir Figure 11):*

*a) entre le blindage et la feuille autour du corps de la sonde (Figure 11, point 2a); et*

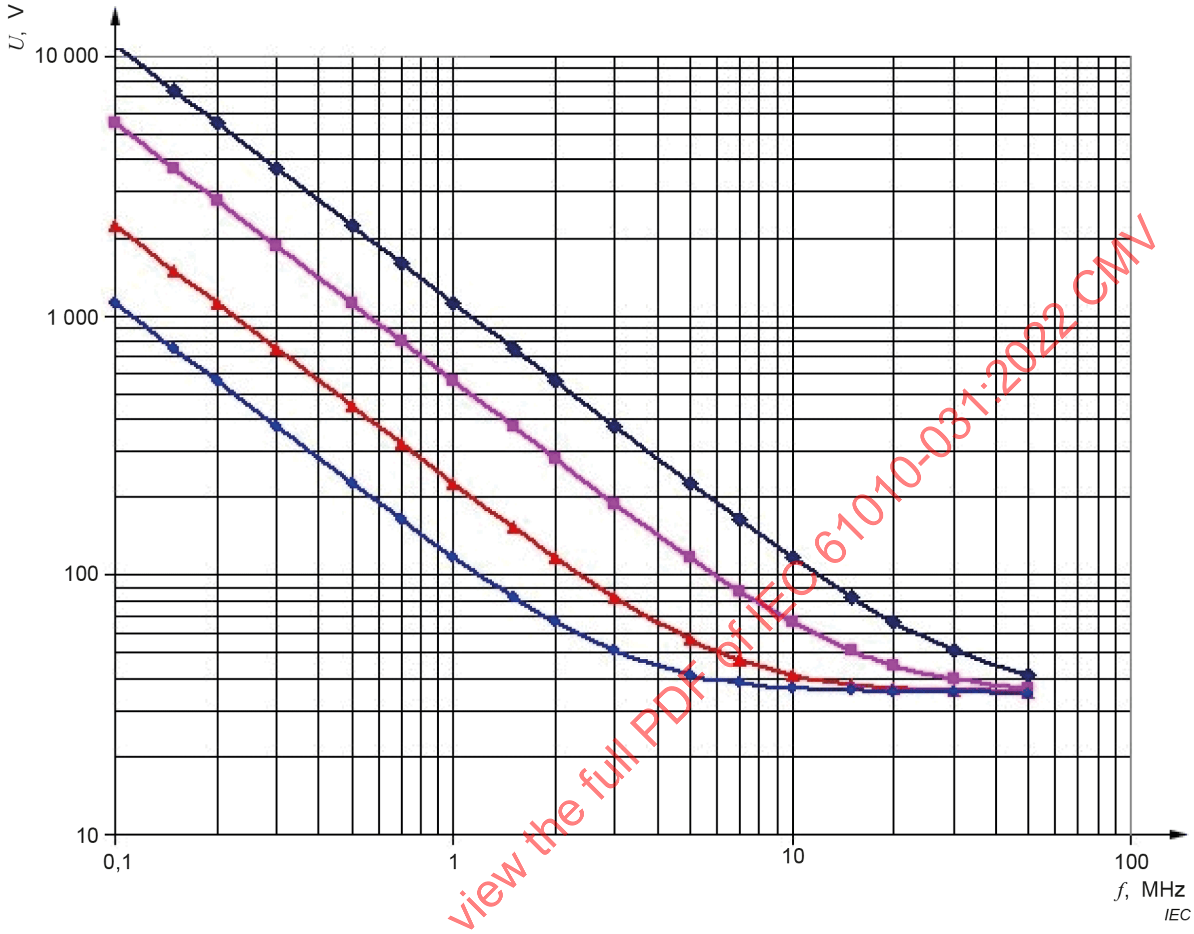
*b) entre le blindage et la feuille du CONNECTEUR coaxial (Figure 11, point 2b); et*

*c) entre le blindage et la feuille autour du FIL DE SONDE (Figure 11, point 2c).*

*En alternative aux mesures de courant de contact, la capacité entre le blindage et la feuille peut être mesurée pour les cas a) à c).*

*La capacité Cs (mesurée entre le blindage et la feuille) conjointement avec le circuit représenté à la Figure A.3 constitue l'impédance représentée à la Figure A.4. Les paramètres variables de cette impédance sont la capacité Cs et la fréquence (R1, C1 et R2 sont fixes). Au moyen de ces deux paramètres et concernant les brûlures électriques, la tension admissible maximale pour la sonde d'essai peut être calculée, par exemple pour un courant de contact admissible de 70 mA (c'est-à-dire 35 V sur R2) comme représenté à la Figure 12 pour certaines valeurs de la capacité Cs.*

*La tension maximale pour chaque fréquence peut alors être calculée. En pratique, les valeurs de R1 et C1 peuvent être ignorées dans le calcul pour le cas des fréquences supérieures à 100 kHz.*



**Légende**

- ◆ 10 pF entre sonde (blindage) et feuille
- ■ 20 pF entre sonde (blindage) et feuille
- ▲ 50 pF entre sonde (blindage) et feuille
- ◆ 100 pF entre sonde (blindage) et feuille

**Figure 12 – Tension d'entrée maximale de la sonde d'essai pour un courant de contact de 70 mA**

## 7.4 Moyens de protection contre les chocs électriques

### 7.4.1 Généralités

Les CONNECTEURS doivent satisfaire aux exigences de 7.4.2.

Les POINTES DE TOUCHE doivent satisfaire aux exigences de 7.4.3.

Toutes les autres parties ACCESSIBLES des sondes équipées doivent être empêchées de devenir SOUS TENSION DANGEREUSE tant en CONDITION NORMALE qu'en CONDITION DE PREMIER DEFAUT par l'un ou plusieurs des moyens suivants:

a) une ISOLATION PRINCIPALE plus une impédance (voir 7.4.4);

b) UNE IMPEDANCE DE PROTECTION (voir 7.4.5);

c) une DOUBLE ISOLATION, constituée d'une ISOLATION PRINCIPALE plus une ISOLATION SUPPLEMENTAIRE (voir 7.4.6);

d) une ISOLATION RENFORCEE (voir 7.4.6).

NOTE Le FIL DE SONDE est considéré comme étant tenu en main. Voir également l'Article 12 pour ce qui concerne les exigences relatives au FIL DE SONDE.

*La conformité est vérifiée par examen et de la manière spécifiée de 7.4.2 à 7.4.6, suivant le cas.*

### 7.4.2 CONNECTEURS

#### 7.4.2.1 Généralités

L'isolation, les parties ACCESSIBLES et les ESPACEMENTS pour les CONNECTEURS des sondes équipées doivent satisfaire aux exigences applicables indiquées de 7.4.2.2 à 7.4.2.4. Lorsqu'un CONNECTEUR est destiné à être couplé avec un autre CONNECTEUR ou une BORNE ayant des CARACTERISTIQUES ASSIGNEES différentes, la valeur ASSIGNEE la plus faible s'applique.

Les couvercles d'isolement ou les manchons par-dessus les CONNECTEURS qui sont destinés à être tenus en main ou manipulés par l'OPERATEUR pendant le mesurage ou l'essai, et qui peuvent être retirés ou déplacés par l'OPERATEUR sans l'utilisation d'un OUTIL, ne sont pas considérés comme fournissant la protection exigée contre les chocs électriques sauf lorsqu'ils sont nécessaires à la connexion à l'appareil d'essai ou de mesure qui est équipé de BORNES qui ne peuvent pas recevoir de CONNECTEURS totalement enveloppés. Par exemple, les manchons d'isolement rétractables ne sont pas considérés comme fournissant la protection adéquate.

L'Annexe E fournit des informations relatives aux dimensions recommandées des CONNECTEURS de 4 mm jusqu'à 1 000 V.

*La conformité est vérifiée par examen.*

#### 7.4.2.2 CONNECTEURS en position totalement couplée

a) Les parties ACCESSIBLES des CONNECTEURS qui sont utilisés seulement pour la connexion de la sonde équipée à l'appareil d'essai ou de mesure et qui ne sont pas destinés à être tenues à la main pendant le mesurage doivent être isolées des parties SOUS TENSION DANGEREUSE par une ISOLATION PRINCIPALE.

b) Les parties ACCESSIBLES des CONNECTEURS qui sont utilisés à d'autres fins ou qui sont destinés à être tenus en main pendant le mesurage doivent être isolées des parties SOUS TENSION DANGEREUSE par une DOUBLE ISOLATION ou par une ISOLATION RENFORCEE.

*La conformité est vérifiée par la détermination des parties ACCESSIBLES effectuée tel que spécifié en 7.2 [voir Figure 7 b)] et tel que spécifié en 7.4.6 pour l'ISOLATION PRINCIPALE et l'ISOLATION RENFORCEE.*

#### 7.4.2.3 CONNECTEURS en position partiellement couplée

Les parties ACCESSIBLES des CONNECTEURS en position partiellement couplée doivent être isolées des parties SOUS TENSION DANGEREUSE par une ISOLATION PRINCIPALE.

*La conformité est vérifiée par la détermination des parties ACCESSIBLES tel que spécifié en 7.2 (voir Figure 7 c) et tel que spécifié en 7.4.6 pour l'ISOLATION PRINCIPALE.*

### 7.4.2.4 CONNECTEURS en position découplée

Lorsque des valeurs ASSIGNEES de tension sont appliquées à d'autres CONNECTEURS ou POINTES DE TOUCHE de la sonde équipée, les exigences suivantes s'appliquent aux CONNECTEURS en position découplée:

1) Il est admis que les parties ACCESSIBLES des CONNECTEURS de type verrouillable ou à vis en position découplée, y compris les CONNECTEURS qui n'exigent pas l'utilisation d'un OUTIL pour le déverrouillage ou le dévissage, soient SOUS TENSION DANGEREUSE.

   *La conformité est vérifiée par examen.*

2) Les parties ACCESSIBLES des BORNES intégrées découplées des CONNECTEURS EMPILABLES doivent être isolées des parties SOUS TENSION DANGEREUSE par une ISOLATION PRINCIPALE.

   *La conformité est vérifiée par la détermination des parties ACCESSIBLES spécifiée en 7.2 (voir Figure 7 d) pour la partie définie par le point 1 de la Figure 1 et le mesurage des DISTANCES D'ISOLEMENT spécifié en 7.5.2 pour l'ISOLATION PRINCIPALE.*

3) Les parties ACCESSIBLES d'autres CONNECTEURS en position découplée doivent être isolées des parties SOUS TENSION DANGEREUSE par une IMPEDANCE DE PROTECTION (voir 7.4.5) ou des ESPACEMENTS satisfaisant aux exigences de a) et b) ci-après:

   a) Pour les CONNECTEURS ayant une tension ASSIGNEE inférieure ou égale à 20 kV, la DISTANCE D'ISOLEMENT doit être au moins égale à la valeur applicable indiquée dans le Tableau 2.

**Tableau 2 – DISTANCES D'ISOLEMENT pour CONNECTEURS désaccouplés**

| Tension maximale appliquée aux parties conductrices des CONNECTEURS V | DISTANCE D'ISOLEMENT | |
|---|---|---|
| | Tension alternative efficace mm | Tension continue mm |
| 600 | 0,8 | 0,8 |
| 1 000 | 1,0 | 0,8 |
| 1 500 | 2,0 | 1,1 |
| 2 000 | 3,2 | 1,8 |
| 3 000 | 6,4 | 3,5 |
| 5 000 | 13 | 8,3 |
| 10 000 | 30 | 20 |
| 15 000 | 48 | 32 |
| 20 000 | 67 | 44 |

Pour les tensions maximales comprises entre 30 V alternatifs efficaces, ou 60 V continus, et 600 V, les DISTANCES D'ISOLEMENT sont de 0,8 mm.

L'interpolation linéaire est admise au-delà de 600 V.

NOTE Voir Annexe G.

Pour les CONNECTEURS ayant une tension ASSIGNEE supérieure à 20 kV, la DISTANCE D'ISOLEMENT doit être au moins égale à la valeur $D_2$ indiquée dans le Tableau 5 avec $U_m$ égale à 1,25 fois la valeur de crête de la tension ASSIGNEE (voir 7.5.2.3.2).

Si l'altitude de fonctionnement ASSIGNEE à la sonde équipée est supérieure à 2 000 m, la valeur de la DISTANCE D'ISOLEMENT doit être multipliée par le coefficient applicable indiqué dans le Tableau 3.

*La conformité est vérifiée par un des essais suivants:*

*i) la détermination des parties ACCESSIBLES spécifiée en 7.2 [voir Figure 7 d)] et le mesurage de la DISTANCE D'ISOLEMENT; ou*

ii) *l'essai en tension alternative de 7.6.5.1 ou l'essai en tension continue de 7.6.5.2 pour une sonde équipée contrainte uniquement en tension continue pendant au moins 5 s ou l'essai de tension de choc de 7.6.5.3 en utilisant la tension d'essai indiquée dans le Tableau 11 pour la DISTANCE D'ISOLEMENT exigée.*

*Les coefficients de correction indiqués dans le Tableau 12 sont applicables aux valeurs des tensions d'essai pour les DISTANCES D'ISOLEMENT indiquées dans le Tableau 11.*

b) Les valeurs des LIGNES DE FUITE doivent être au moins égales aux valeurs des DISTANCES D'ISOLEMENT applicables définies en a).

*La conformité est vérifiée par la détermination des parties ACCESSIBLES spécifiée en 7.2 [voir Figure 7 d)] et le mesurage de la LIGNE DE FUITE.*

### 7.4.3 POINTES DE TOUCHE

#### 7.4.3.1 Généralités

Les POINTES DE TOUCHE qui peuvent devenir sous TENSION DANGEREUSE en UTILISATION NORMALE [voir aussi 7.1 b)] doivent satisfaire aux exigences de l'un des paragraphes suivants: 7.4.3.2 (si protection par PROTEGE-DOIGTS), 7.4.3.3 (si protection par distance) ou 7.4.3.4 (si protection par indicateur tactile). De plus, les POINTES DE TOUCHE IP2X avec manchon rétractable doivent satisfaire aux exigences de 7.4.3.5.

Les POINTES DE TOUCHE qui peuvent être utilisées comme des CONNECTEURS doivent aussi satisfaire aux exigences de 7.4.3.6.

NOTE Voir l'Article 13 pour les exigences supplémentaires relatives aux parties conductrices exposées des POINTES DE TOUCHE.

Les PINCES A RESSORT et sondes similaires qui sont destinées à percer l'isolant d'un fil afin de toucher le conducteur pour les besoins du mesurage de la tension ne doivent pas avoir des VALEURS ASSIGNEES de tension supérieures aux niveaux indiqués en 7.3.2 a).

*La conformité est vérifiée par examen et mesurage.*

#### 7.4.3.2 Protection par un PROTEGE-DOIGTS

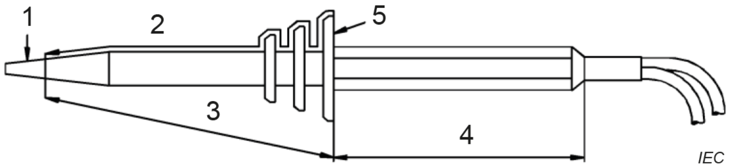
Si une partie conductrice d'une POINTE DE TOUCHE peut devenir SOUS TENSION DANGEREUSE ou si l'extrémité d'une POINTE DE TOUCHE peut entrer en contact avec un conducteur sous tension DANGEREUSE, un PROTEGE-DOIGTS doit être adapté pour réduire le risque de toucher la partie non protégée de la POINTE DE TOUCHE et pour donner une indication de la limite au-delà de laquelle il peut être dangereux de toucher l'ENVELOPPE de la sonde durant son utilisation.

Les ESPACEMENTS entre la POINTE DE TOUCHE et le côté pris en main du PROTEGE-DOIGTS doivent être ceux qui sont spécifiés pour une ISOLATION RENFORCEE.

La hauteur du PROTEGE-DOIGTS par rapport au côté sur lequel il est prévu de placer les doigts doit être au moins de 2 mm.

Le PROTEGE-DOIGTS des sondes équipées qui ont des valeurs ASSIGNEES de tension supérieures aux niveaux indiqués en 7.3.2 a) doit s'étendre sur au moins 80 % des côtés où les doigts sont censés être placés.

La Figure 13 donne des exemples de sondes équipées avec un PROTEGE-DOIGTS et indique les ESPACEMENTS applicables.



**Légende**

1 POINTE DE TOUCHE

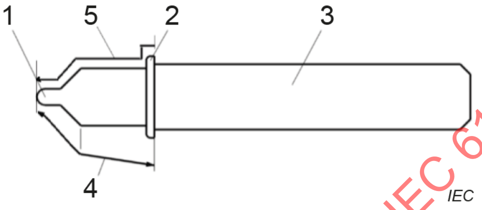
2 LIGNE DE FUITE (en surface)

3 DISTANCE D'ISOLEMENT (dans l'air)

4 partie du corps de la sonde tenue à la main

5 PROTEGE-DOIGTS

**Figure 13 a) – Sonde équipée pour connexion électrique directe**



**Légende**

1 POINTE DE TOUCHE (isolée)

2 PROTEGE-DOIGTS

3 partie du corps de la sonde tenue à la main

4 DISTANCE D'ISOLEMENT (dans l'air)

5 LIGNE DE FUITE (en surface)

**Figure 13 b) – Sonde équipée de type F pour mesure sans contact**

**Figure 13 – Protection par un PROTEGE-DOIGTS**

### 7.4.3.3 Protection par la distance

Les PINCES A RESSORT ayant des valeurs ASSIGNEES de tension inférieures ou égales à 1 kV sont acceptables sans PROTEGE-DOIGTS sous réserve que:

a) la mise en marche d'un mécanisme à ressort empêche l'OPERATEUR de toucher une partie SOUS TENSION DANGEREUSE; et

b) les ESPACEMENTS entre la POINTE DE TOUCHE et la plus proche surface que l'OPERATEUR a besoin de toucher pour actionner le mécanisme sont augmentés d'une distance de protection supplémentaire de 45 mm.

La Figure 14 donne un exemple d'une sonde équipée protégée par la distance et indique les ESPACEMENTS applicables.