UL 61010-031

STANDARD FOR SAFETY

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

UL Standard for 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, UL 61010-031

Second Edition, Dated January 27, 2017

Summary of Topics

This revision of ANSI/UL 61010-031, dated January 7, 2020 includes the following changes in requirements:

Revision to remove existing national deviation clause 8.4DV.

Revision to the national deviations in the Normative Reference.

Adoption of IEC 61010-031 Edition 2.1 issued 2018-05 Amendment 1 which included a title change.

UL 61010-031 is an adoption of IEC 61010-031, 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, second edition (issued May 2015) and its amendment 1 (issued May 2018). Please note that the National Difference document incorporates all of the US National Differences for UL 61010-031.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL and CSA are committed to updating this bi-national standard jointly.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 16, 2019.

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CSA Group
CAN/CSA-C22.2 No. 61010-031:17
Second Edition
(IEC 61010-031:2015, MOD)

Underwriters Laboratories Inc.
UL 61010-031
Second Edition

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

January 27, 2017

(Title Page Reprinted: January 7, 2020)

This national standard is based on publication IEC 61010-031, second edition (2015-05) and Amendment 1 (2018-05).

Approved American National Standard

ANSI/UL 61010-031-2020

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as “CSA Group”) and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

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This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. The technical content of IEC and ISO publications is kept under constant review by IEC and ISO. To submit a proposal for change, please send the following information to inquiries@csagroup. org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Second edition including revisions through January 7, 2020. The most recent designation of ANSI/UL 61010-031 as an American National Standard (ANSI) occurred on January 7, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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PREFACE

This is the harmonized CSA Group and UL standard for *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*. It is the second edition of CAN/CSA-C22.2 No. 61010-031 and the second edition of UL 61010-031. This edition of CAN/CSA-C22.2 No. 61010-031 supersedes the previous edition published on March 30, 2007. This edition of UL 61010-031 supersedes the previous edition published on March 30, 2007. This harmonized standard has been jointly revised on January 7, 2020. For this purpose, CSA Group and UL are issuing revision pages dated January 20, 2020.

This harmonized standard is based on IEC Publication 61010-031: second edition, *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,* issued May 2015, as revised by Amendment 1 issued May 2018. IEC 61010-031 is copyrighted by the IEC.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Subcommittee on Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, under the jurisdiction of the CSA Technical Committee on Consumer and Commercial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of Harmonization

This standard adopts the IEC text with national differences.

This standard is published as an identical standard for CSA Group and UL.

An identical standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

All national differences from the IEC text are included in the CSA Group and UL versions of the standard. While the technical content is the same in each organization's version, the format and presentation may differ.

Reasons for Differences from IEC

National Differences from the IEC are being added in order to address safety and regulatory situations present in the US and Canada.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

IEC Copyright

For CSA Group, the text, figures, and tables of International Electrotechnical Commission Publication 61010-031, 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, copyright 2015 including Amendment 1 2018, are used in this standard with the consent of the International Electrotechnical Commission. The IEC Foreword is not a part of the requirements of this standard but is included for information purposes only.

NATIONAL DIFFERENCES

In the CSA Group and UL publications of this standard, National Differences from the text of International Electrotechnical Commission (IEC) Publication 61010-031, 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, copyright 2015 including Amendment 1, 2018, are indicated by notations (differences) and are presented in bold text. The national difference type is included in the body.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

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FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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) 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.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

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

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

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

a) Voltages above the levels of 30 V r.m.s., 42,4 V peak, or 60 V d.c. are deemed to be HAZARDOUS LIVE instead of 33 V r.m.s., 46,7 V peak, or 70 V d.c.

b) Servicing is now included within the scope.

c) Extended environmental conditions are included within the scope.

d) New terms have been defined.

e) Tests for REASONABLY FORESEEABLE MISUSE have been added, in particular for fuses.

f) Additional instruction requirements for probe assembly operation have been specified.

g) Limit values for ACCESSIBLE parts and for measurement of voltage and touch current have been modified.

h) SPACINGS requirements for mating of CONNECTORS have been modified.

i) PROBE TIPS and SPRING-LOADED CLIPS requirements have been modified. The PROTECTIVE FINGERGUARD replace the BARRIER with new requirements.

j) Insulation requirements (6.5) and test procedures (6.6.5) have been rewritten and aligned when relevant with Part 1. Specific requirements have been added for solid insulation and thin-film insulation.

k) The terminology for MEASUREMENT CATEGORY I has been replaced with the designation “not RATED for measurements within MEASUREMENT CATEGORIES II, III, or IV”.

l) The flexing/pull test (6.7.4.3) has been partially rewritten.

m) Surface temperature limits (Clause 10) have been modified to conform to the limits of IEC Guide 117.

n) Requirements for resistance of PROBE WIRES to mechanical stresses have been added in Clause 12 and a new Annex D.

o) Requirements have been added regarding the prevention of HAZARD from arc flash and short-circuits for SPRING-LOADED CLIPS.

p) A new informative Annex E defines the dimension of the 4 mm banana CONNECTORS.

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

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

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

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

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

In this standard, the following print types are used:

– requirements and definitions: in roman type;

– NOTES and EXAMPLES: in smaller roman type;

– *conformity and tests: in italic type;*

– terms used throughout this standard which have been defined in Clause 3: SMALL ROMAN CAPITALS.

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

• reconfirmed,

• withdrawn,

• replaced by a revised edition, or

• amended.

1DV DE *Addition:*

Add the following to the end of the IEC Foreword:

The numbering system in the standard uses a space instead of a comma to indicate thousands and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means 1,000 and 1,01 means 1.01.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

No Text on This Page

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 Scope

1.1.1 Probe assemblies included in scope

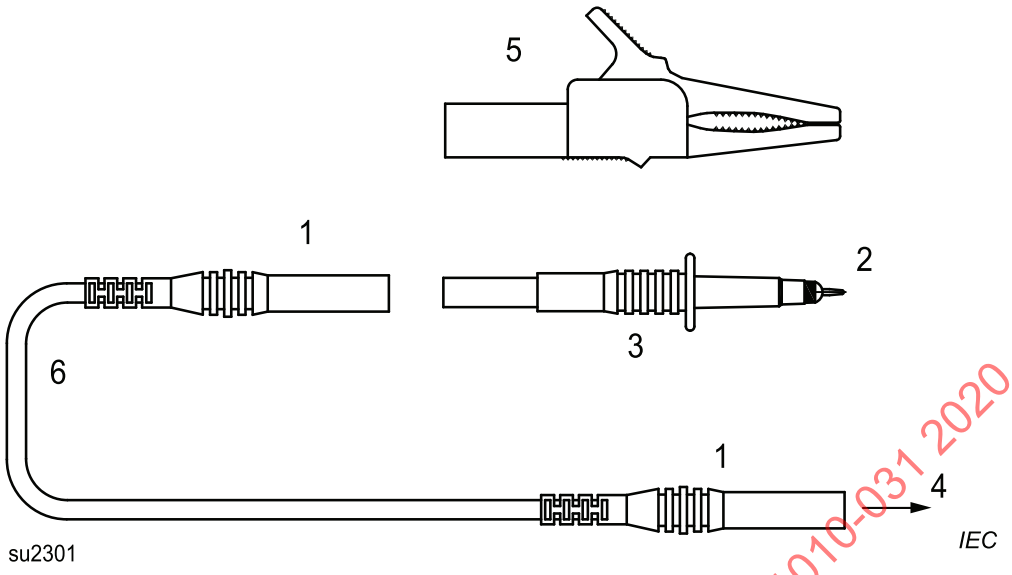
This part of IEC 61010 specifies safety requirements for hand-held and hand-manipulated probe assemblies of the types described below, and their related accessories. These probe assemblies are for direct electrical connection between a part and electrical test and measurement equipment. They may be fixed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

a) Type A: low-voltage and high-voltage, non-attenuating probe assemblies. Non-attenuating probe assemblies that are RATED for direct connection to voltages exceeding 30 V r.m.s., 42,4 V peak, or 60 V d.c., 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 contain non-attenuating components such as fuses (see Figure 1.)

b) Type B: high-voltage attenuating or divider probe assemblies. Attenuating or divider probe assemblies that are RATED for direct connection to secondary voltages exceeding 1 kV r.m.s. or 1,5 kV d.c. but not exceeding 63 kV r.m.s. or d.c. The divider function may be carried out wholly within the probe assembly, or partly within the test or measurement equipment to be used with the probe assembly (see Figure 2).

c) Type C: low-voltage attenuating or divider probe assemblies. Attenuating or divider 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).

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

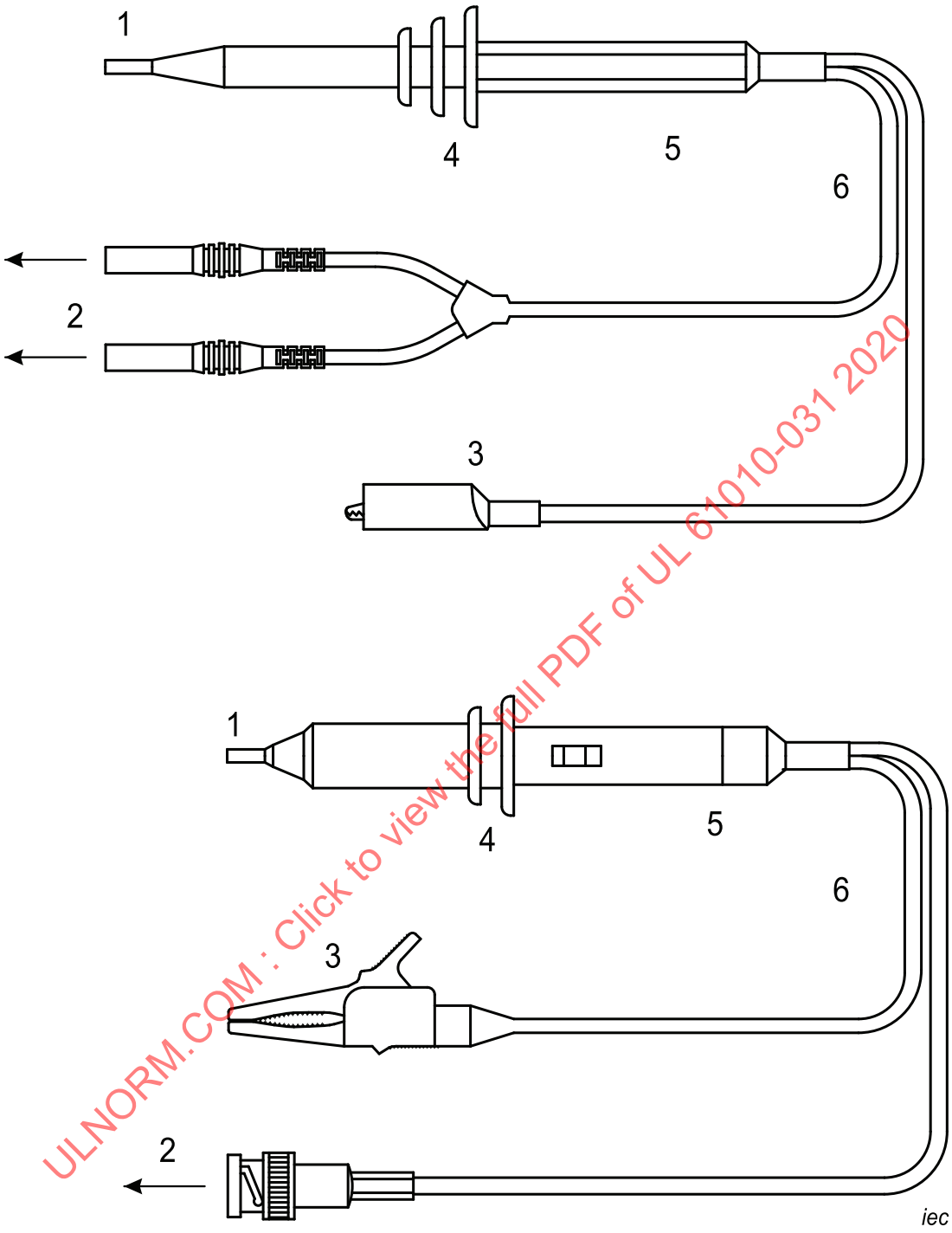


Key

1 typical CONNECTORS
2 PROBE TIP
3 probe body
4 to equipment
5 SPRING-LOADED CLIP
6 PROBE WIRE

Figure 1

Examples of type A probe assemblies

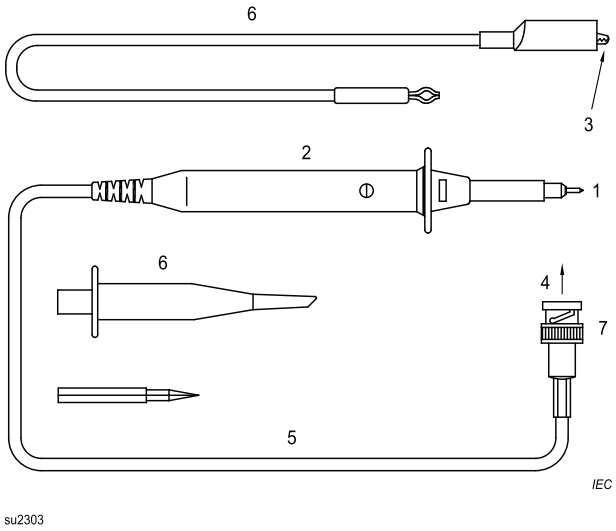


Key

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

Figure 2

Examples of type B probe assemblies

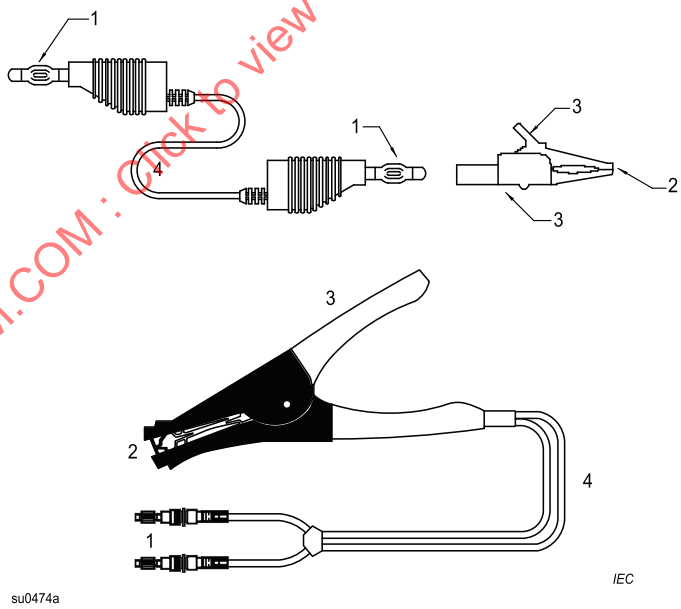


Key

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

1.1.2 Probe assemblies excluded from scope

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

1.2 Object

1.2.1 Aspects included in scope

The purpose of the requirements of this standard is to ensure that 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 Clauses 6 to 13, as follows:

a) electric shock or burn (see Clauses 6, 10 and 11);

b) mechanical HAZARDS (see Clauses 7, 8 and 11);

c) excessive temperature (see Clause 9);

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

e) arc flash (see Clause 13).

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

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

1.2.2 Aspects excluded from scope

This standard does not cover:

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

b) effectiveness of transport packaging.

1.3 Verification

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

1.4 Environmental conditions

1.4.1 Normal environmental conditions

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

a) altitude up to 2 000 m;

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.

1.4.2 Extended environmental conditions

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

a) outdoor use;

b) altitudes above 2 000 m;

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

d) relative humidities above the levels specified in 1.4.1;

e) WET LOCATIONS.

1.4.3DV DR *Addition of the following clause referencing the National Electrical Code and the Canadian Electrical Code:*

This standard applies to equipment:

a) To be employed in accordance with ANSI/NFPA 70, National Electrical Code® (NEC);

b) Designed to comply with the general requirements of CAN/CSA-C22.2 No. 0 and to be installed in accordance with the Canadian Electrical Code (CE Code), Part I, CSA C22.1; or

c) Both (a) and (b).

2 Normative references

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

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

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

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

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

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

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

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

2DV DR *Modification of Clause 2 to add the following reference publications:*

CSA C22.1-15, *Canadian Electrical Code, Part I*

CAN/CSA-C22.2 No. 0-10 (R2015), *General requirements – Canadian Electrical Code, Part II*

CAN/CSA C22.2 No. 61010-1-12 (R2017) / UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements

ANSI/NFPA 70, *National Electrical Code (NEC)*

IEC 60664-3-2016, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

UL 746E *Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards*

3 Terms and definitions

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

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 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 to a TERMINAL of the equipment or to another probe assembly

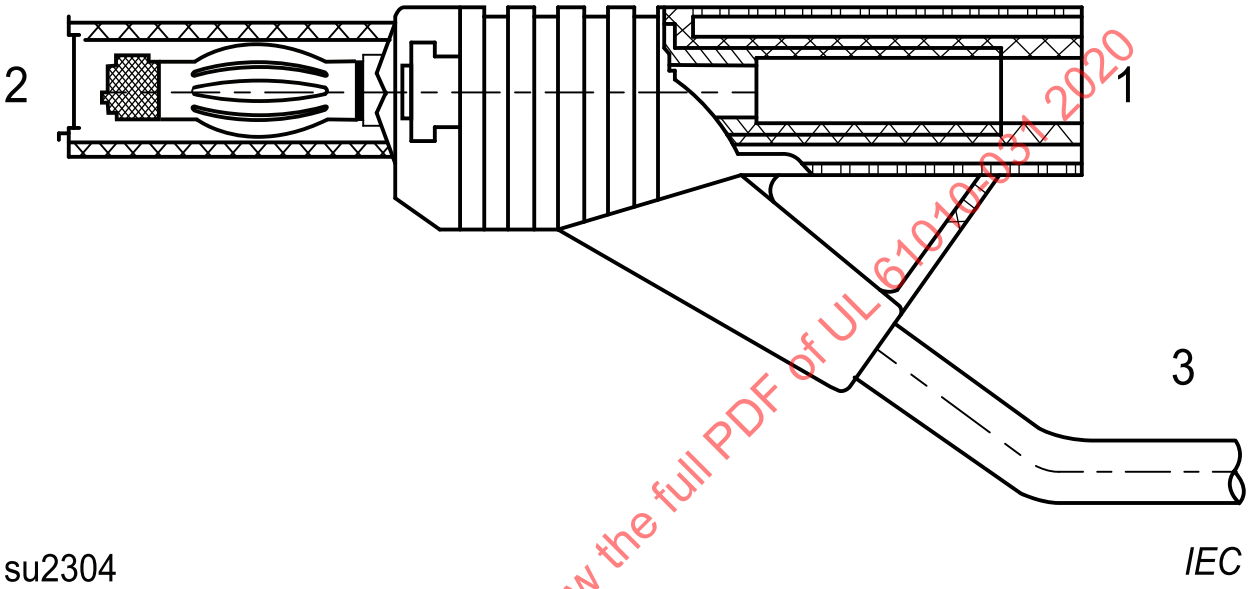
3.1.6 TOOL – external device, including a key or coin, used to aid a person performing a mechanical function

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

3.1.8 SPRING-LOADED CLIP – probe or probe accessory with one or more hooks or jaws forced by a spring to grip the part being measured or tested

3.1.9 STACKABLE CONNECTOR – CONNECTOR assembly which contains an additional TERMINAL

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



Key

1 TERMINAL for additional CONNECTOR

2 CONNECTOR

3 PROBE WIRE

Figure 5

Example of a STACKABLE CONNECTOR with a male CONNECTOR and a female TERMINAL

3.2 Quantities

3.2.1 RATED (condition or value) – condition or quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device, or 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 r. m. s. value of the a. c. or d. c. voltage across any particular insulation which can continuously appear during NORMAL USE

Note 1 to entry: 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 standard

Note 1 to entry: This is an amplification 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 6.2

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

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

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 of HAZARDOUS LIVE parts which provides basic protection

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

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

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

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

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

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

3.5.6 POLLUTION DEGREE – numeral indicating the level of POLLUTION that may be present in the environment

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

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

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 Tests

4.1 General

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

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

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

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

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

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

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 1.4.1, the manufacturer should make sure (for example, by suitable alteration of test requirements or additional tests) that the safety requirements of this standard are still fulfilled.

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

4.2 Sequence of tests

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

4.3 Reference test conditions

4.3.1 Environmental conditions

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

a) a temperature of 15 °C to 35 °C;

b) a relative humidity of not more than 75 %;

c) an air pressure of 75 kPa to 106 kPa;

d) no hoarfrost, dew, percolating water, rain, solar irradiation, etc.

4.3.2 State of probe assemblies

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

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

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

4.3.3 Position of the probe assembly

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

4.3.4 Accessories

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

4.3.5 Covers and removable parts

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

4.3.6 Input and output voltages

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

4.3.7 Controls

Controls which the OPERATOR can adjust 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.

4.3.8 Connections

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

4.3.9 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.

4.4 Testing in SINGLE FAULT CONDITION

4.4.1 General

The following requirements apply.

a) Examination of the probe assembly and its circuit diagram will generally show the fault conditions which are liable to result in HAZARDS and which, therefore, shall be applied.

b) Fault tests shall be made as specified for checking conformity, unless it can be demonstrated that no HAZARD could arise from a particular fault condition.

c) The probe assembly shall be operated under the least favourable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they shall be recorded for each test.

4.4.2 Application of fault conditions

4.4.2.1 General

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

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

4.4.2.2 PROTECTIVE IMPEDANCE

The following requirements apply.

a) If a PROTECTIVE IMPEDANCE is formed by a combination of components, each component shall be short-circuited or disconnected, whichever is less favourable.

b) If a PROTECTIVE IMPEDANCE is formed with a single component that meets the requirements of 6.4.5, it need not be short-circuited or disconnected.

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

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

4.4.2.4 Outputs

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

4.4.2.5 Insulation between circuits and parts

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

4.4.3 Duration of tests

The probe assembly shall be operated until further change as a result of the applied fault is unlikely. Each test is normally limited to 1 h since a secondary fault arising from a SINGLE FAULT CONDITION will usually manifest itself within that time. If 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.

4.4.4 Conformity after application of fault conditions

4.4.4.1 Electric shock

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

a) by making the measurements of 6.3.3 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE, except as permitted by 6.1;

b) by performing a voltage test on DOUBLE INSULATION or REINFORCED INSULATION to check that the protection is still at least at the level of BASIC INSULATION. The voltage tests are made as specified in 6.6 (without humidity preconditioning) with the test voltage for BASIC INSULATION.

4.4.4.2 Temperature

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

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

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.

4.4.4.4 Other HAZARDS

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

4.5 Tests in REASONABLY FORESEEABLE MISUSE

4.5.1 General

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

4.5.2 Fuses

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

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

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

Conformity is checked by inspection and measurement.

5 Marking and documentation

5.1 Marking

5.1.1 General

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

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

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

Conformity is checked by inspection.

5.1.2 Identification

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

a) the name or registered trade mark 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 of electric shock
6		IEC 60417-5041 (2002-10)	Caution, hot surface
7		ISO 7000-0434 (2004-01)	Caution [a]

[a] See 5.4.1 which requires manufacturers to state that documentation must be consulted in all cases where this symbol is marked.

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5.1.3 Fuses

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

Conformity is checked by inspection.

5.1.4 CONNECTORS and operating devices

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

Conformity is checked by inspection.

5.1.5 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 6.5.2) shall be marked with the RATED voltage to earth and with Symbol 7 of Table 1 (see also 5.4.3 k).

b) Probe assemblies for measurements within MEASUREMENT CATEGORIES II, III and IV (see 6.5.2) shall be marked with the RATED voltages to earth and the relevant MEASUREMENT CATEGORIES. The MEASUREMENT CATEGORY markings shall be "CAT II", "CAT III" or "CAT IV" as applicable.

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

For Type A and Type D 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.

5.2 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 the Symbol 7 of Table 1. If a warning applies to a particular part of the probe assembly, the marking shall be placed on or near this part.

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

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

Conformity is checked by inspection.

5.3 Durability of markings

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

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

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

5.4 Documentation

5.4.1 General

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

a) technical specification;

b) instructions for use;

c) name and address of manufacturer or supplier from whom technical assistance may be obtained;

d) the information specified in 5.4.2 to 5.4.4.

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

Conformity is checked by inspection.

5.4.2 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 1.4).

Conformity is checked by inspection.

5.4.3 Probe assembly operation

Instructions for use shall include, if applicable:

a) identification of operating controls and their use in all operating modes;

b) for probe assemblies designed for use only with a specific model of equipment, a clear identification of the equipment;

c) an explanation of symbols related to safety which are used on the probe assembly;

d) a definition of the relevant MEASUREMENT CATEGORY if marking is required on the probe assembly (see 5.1.5);

e) a specification of limits for intermittent operation, if applicable;

f) instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts and any special materials;

g) instructions for cleaning;

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, if the RATED voltage of the PROBE WIRE is lower than the RATED voltage of the PROBE TIP, a warning that the PROBE WIRE may not provide adequate protection if it comes into contact with a HAZARDOUS LIVE part;

m) a warning that the applicable MEASUREMENT CATEGORY of a combination of a probe assembly and an accessory is the lower of the MEASUREMENT CATEGORIES of the probe assembly and of the accessory.

There shall be a statement in the instructions that, if the probe assembly is used in a manner not specified by the manufacturer, the protection provided by the probe assembly may be impaired.

Conformity is checked by inspection.

5.4.4 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 his agent.

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

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

a) product-specific risks that may affect the service personnel;

b) protective measures for these risks;

c) verification of the safe state of the probe assembly after repair.

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

Conformity is checked by inspection.

6 Protection against electric shock

6.1 General

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

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

a) parts intended to be replaced by the OPERATOR (for example, fuses) and which may be HAZARDOUS LIVE during replacement, but only if they have warning markings in accordance with 5.2;

b) PROBE TIPS, provided that they meet the requirements of 6.4.3;

c) unmated CONNECTORS as specified in 6.4.2 c).

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

6.2 Determination of ACCESSIBLE parts

6.2.1 General

Unless obvious, determination of whether a part is ACCESSIBLE is made as specified in 6.2.2 and 6.2.3. Test fingers (see 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 6.7.2).

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 6.2.2 and 6.2.3.

NOTE Examples of such actions include:

a) removing covers;

b) adjusting controls;

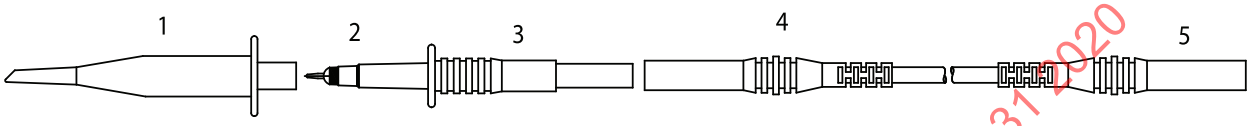
c) replacing consumable materials;

d) removing or installing parts and supplied accessories.

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

6.2.2 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.



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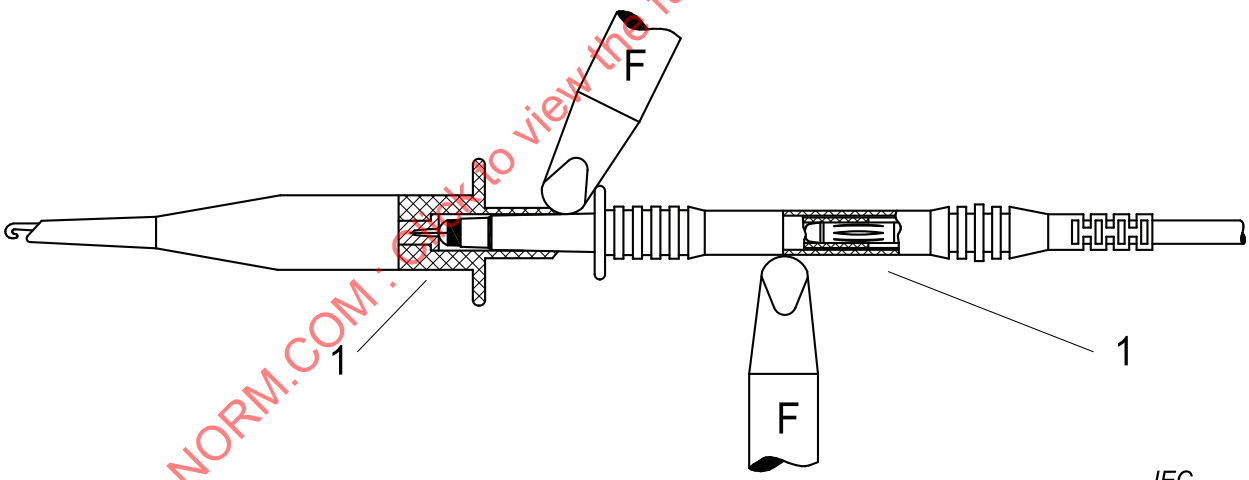
Key

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

Figure 6a – Parts of a probe assembly



IEC

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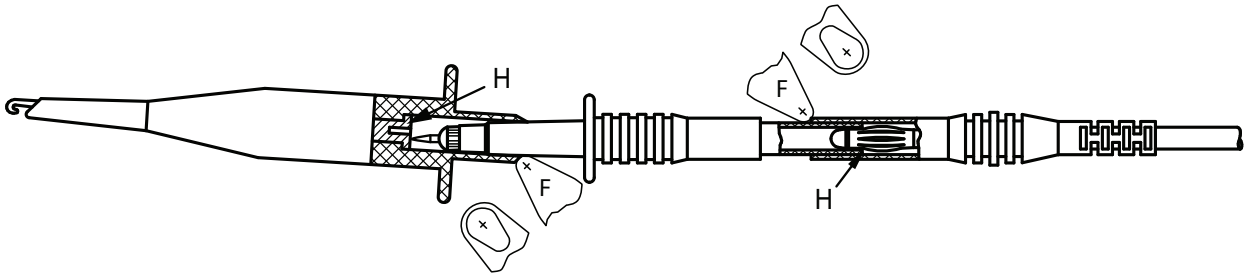
Key

1 CONNECTOR

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



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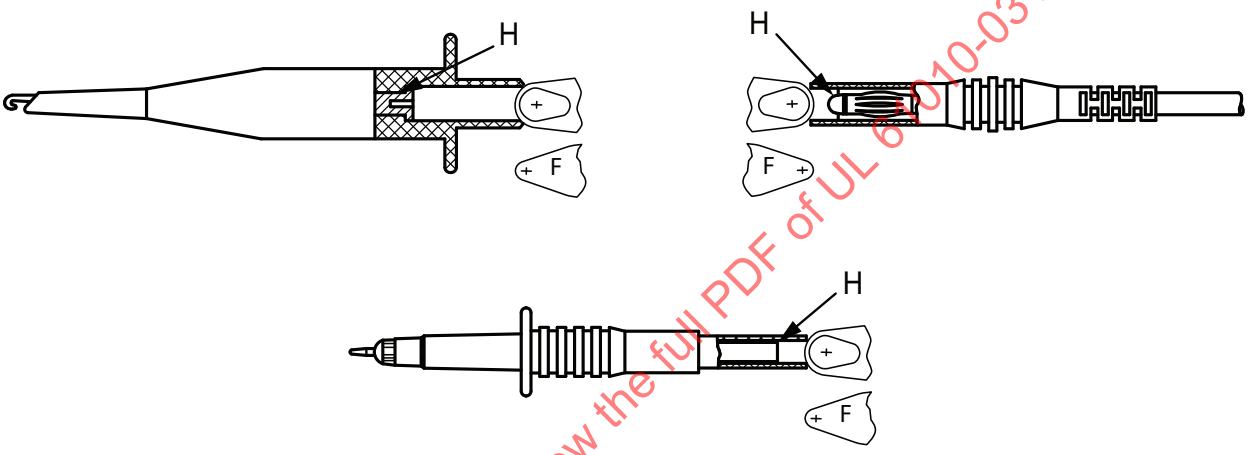
Connecting parts are partially mated so as just to make electrical contact while allowing maximum access to the test finger.

Note the two possible positions of the test finger.

Figure 6c – Partially mated probe assemblies (see 6.2 and 6.4.2 b))



su2309a IEC

Key

F rigid test finger (see Figure B.1)

H potentially HAZARDOUS LIVE part

Note the two possible positions of the test finger.

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

Figure 6

Methods for determination of ACCESSIBLE parts (see 6.2) and for voltage tests of (see 6.4.2)

6.2.3 Openings for pre-set controls

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

6.3 Limit values for ACCESSIBLE parts

6.3.1 General

Except as permitted in 6.1, 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 6.3.2 in NORMAL CONDITION or of 6.3.3 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 6.3.4). If the voltage is below the levels of 6.3.2 a) or 6.3.3 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, the alternative method of 6.3.4.3 can also be used.

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

6.3.2 Levels in NORMAL CONDITION

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

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

b) The touch current levels are:

1) 0,5 mA r.m.s. for sinusoidal waveforms, 0,7 mA peak for non-sinusoidal waveforms or mixed frequencies, or 2 mA d.c., when measured with the measuring circuit of Figure A.1. If the frequency does not exceed 100 Hz, the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.5 is used for probe assemblies intended for use in WET LOCATIONS.

2) 70 mA r.m.s. when measured with measuring circuit of Figure A.3. This relates to possible burns at 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 d.c. Line A of Figure 7 shows the capacitance versus voltage for cases where the charge is 45 µC.

2) 350 mJ stored energy for voltages above 15 kV peak or d.c.

6.3.3 Levels in SINGLE FAULT CONDITION

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

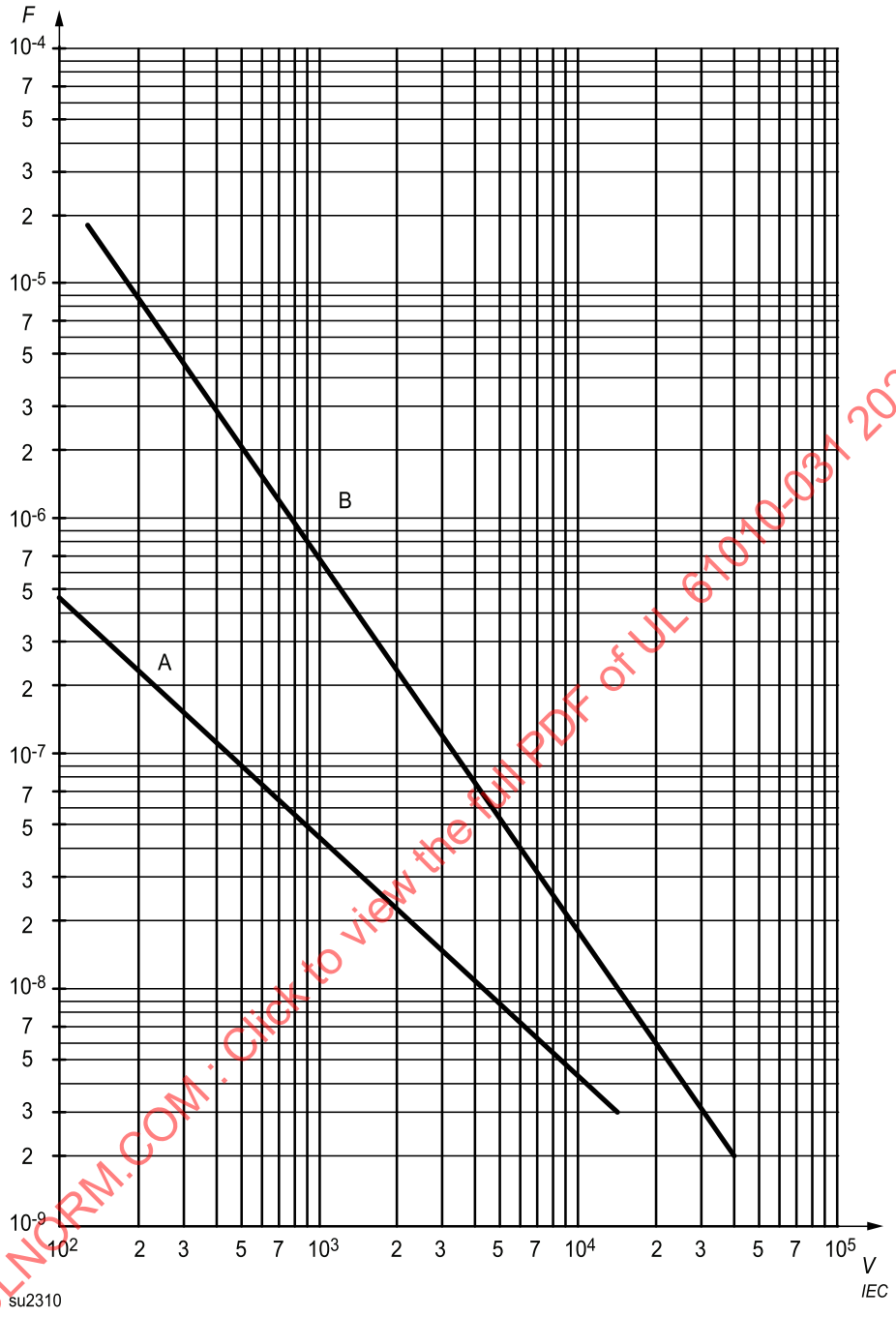
a) The a.c. voltage levels are 50 V r.m.s. or 70,7 V peak, and the d.c. voltage level is 120 V. For probe assemblies intended for use in WET LOCATIONS, the a.c. voltage levels are 33 V r.m.s. or 46,7 V peak, and the d.c. voltage level is 70 V.

b) The touch current levels are:

1) 3,5 mA r.m.s. for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA d.c., when measured with the measuring circuit of Figure A.1. If the frequency does not exceed 100 Hz; the measuring circuit of Figure A.2 can be used. The measuring circuit of Figure A.5 is used for probe assemblies intended for use in WET LOCATIONS.

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

c) The capacitance level is line B of Figure 7.



Key

A = NORMAL CONDITION

B = SINGLE FAULT CONDITION

Figure 7

Capacitance level versus voltage in NORMAL CONDITION and SINGLE-FAULT CONDITION (see 6.3.2 c) and 6.3.3 c))

6.3.4 Measurement of voltage and touch current

6.3.4.1 General

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

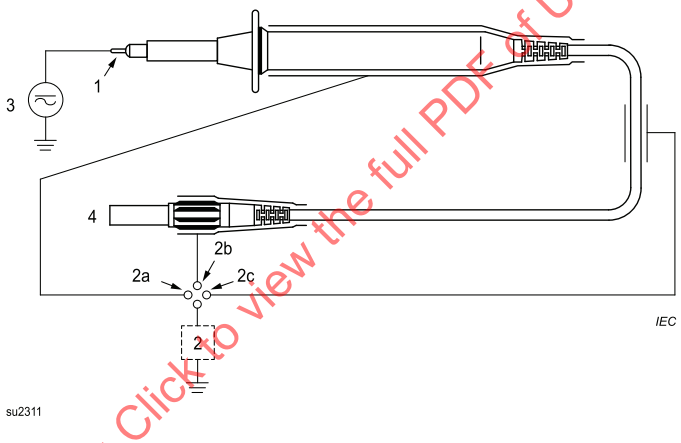
a) the probe body;

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



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

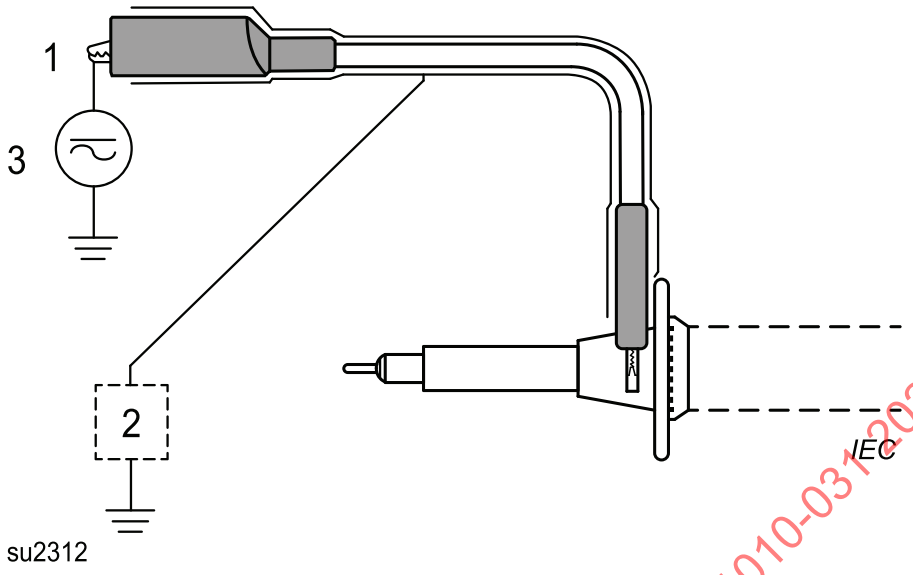
2c Connection to metal foil tightly wrapped around the cable

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

4 Not connected to test or measuring equipment

Figure 8

Voltage and touch current measurement



Key

1 PROBE TIP of the reference CONNECTOR

2 Measurement of voltage or touch current (see annex A for applicable measuring circuits for touch current measurements)

3 Maximum RATED voltage for the reference CONNECTOR

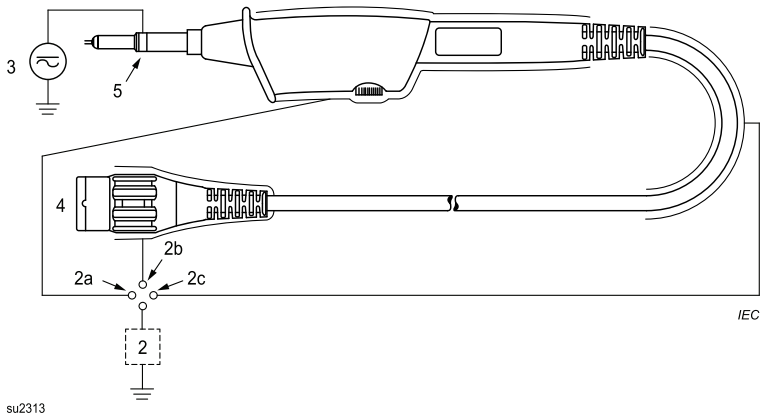
Figure 9

Voltage and touch current measurement for the reference CONNECTOR

6.3.4.2 Probe assemblies with floating outer conductors

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

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



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 RATED voltage with connection to outer conductor PROBE TIP

4 Not connected to test or measuring equipment

5 A floating PROBE TIP connected to the shield or outer conductor of the PROBE WIRE

Figure 10

Voltage and touch current measurement with shielded test probe

6.3.4.3 High frequency test probes

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

The measurements are made (see Figure 10):

a) between the shield and the foil around the probe body (2a), and

b) between the shield and the foil around the coaxial CONNECTOR (2b), and

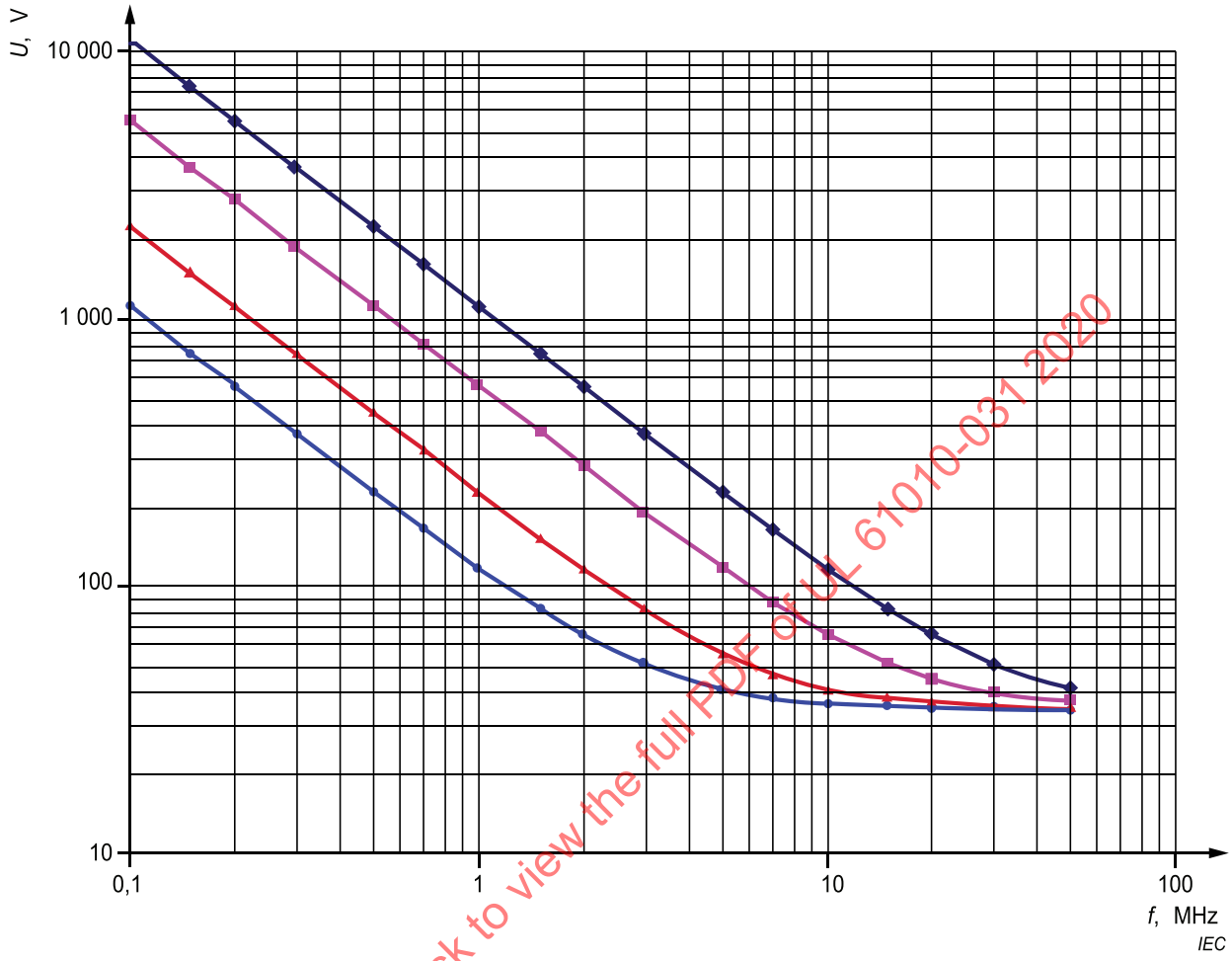
c) between the shield and the foil around the PROBE WIRE (2c).

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

The capacitance 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 Cs and the frequency (R1, C1 and R2 are fixed). With the means of these two parameters and with regard to electrical burns the maximum allowable voltage for the test probe can be calculated, for example for an allowable touch current of 70 mA (i.e. 35 V over R2) as shown in Figure 11 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

su2314

Figure 11

Maximum test probe input voltage for 70 mA touch current

6.4 Means of protection against electric shock

6.4.1 General

CONNECTORS shall meet the requirements of 6.4.2.

PROBE TIPS shall meet the requirements of 6.4.3.

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

a) DOUBLE INSULATION, consisting of BASIC INSULATION plus SUPPLEMENTARY INSULATION (see 6.4.6);

b) BASIC INSULATION plus impedance (see 6.4.4);

c) REINFORCED INSULATION (see 6.4.6);

d) PROTECTIVE IMPEDANCE (see 6.4.5).

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

Conformity is checked by inspection and as specified in 6.4.2 to 6.4.6, as applicable.

6.4.2 CONNECTORS

Insulation, ACCESSIBLE parts and SPACINGS for CONNECTORS of probe assemblies shall meet the applicable requirements of a) to c) below.

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

a) CONNECTORS in fully-mated position.

1) ACCESSIBLE parts of CONNECTORS used only for connecting the probe assembly to the test or measurement equipment and which are not intended to be hand-held during the measurement operation shall be insulated from HAZARDOUS LIVE parts by BASIC INSULATION.

2) 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 6.2 (see Figure 6 b)) and as specified in 6.4.6 for BASIC INSULATION and REINFORCED INSULATION.

b) CONNECTORS in partially-mated position.

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

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

c) CONNECTORS in unmated position.

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

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

2) unmated integrated TERMINALS of STACKABLE CONNECTORS shall be protected by BASIC INSULATION (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.

6.4.3 PROBE TIPS

6.4.3.1 General

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

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

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

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

Conformity is checked by inspection and measurement.

6.4.3.2 Protection by a PROTECTIVE FINGERGUARD

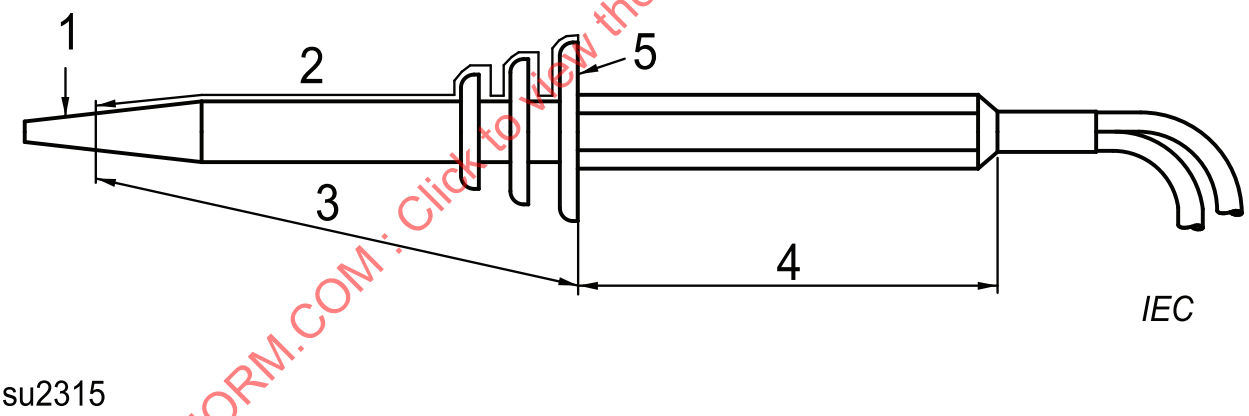
If a conductive part of a PROBE TIP can become HAZARDOUS LIVE, a PROTECTIVE FINGERGUARD shall be fitted to reduce the risk of touching an exposed conductive part of the PROBE TIP, and to provide an indication of the limit beyond which it may be hazardous to touch the probe body during use.

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

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

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

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



Key

1 PROBE TIP

2 CREEPAGE DISTANCE (along surface)

3 CLEARANCE (in air)

4 hand-held area of probe body

5 PROTECTIVE FINGERGUARD

Figure 12

Protection by a PROTECTIVE FINGERGUARD

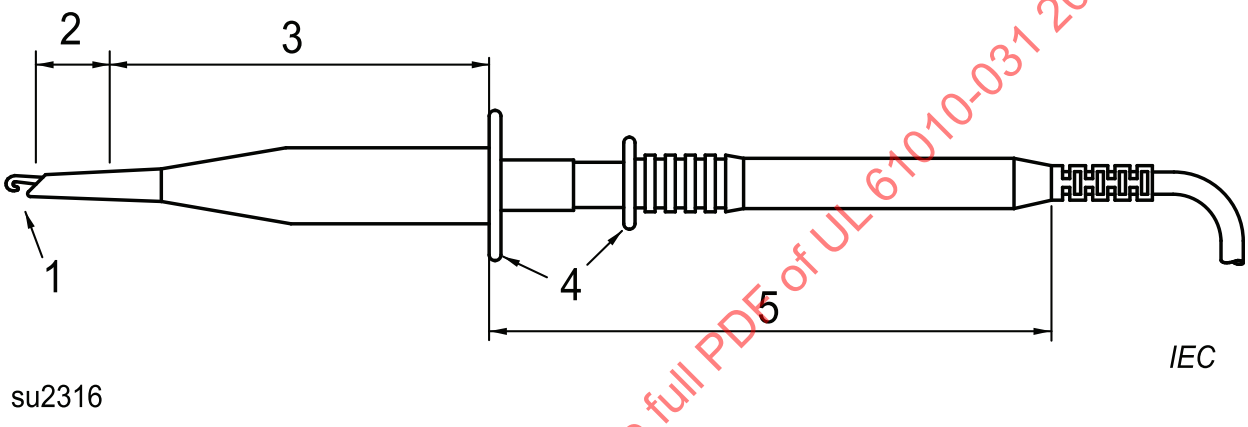
6.4.3.3 Protection by distance

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



Key

1 PROBE TIP

2 CLEARANCE and CREEPAGE DISTANCE as specified in 6.5

3 additional protective distance

4 actuating parts

5 hand-held area of the probe assembly

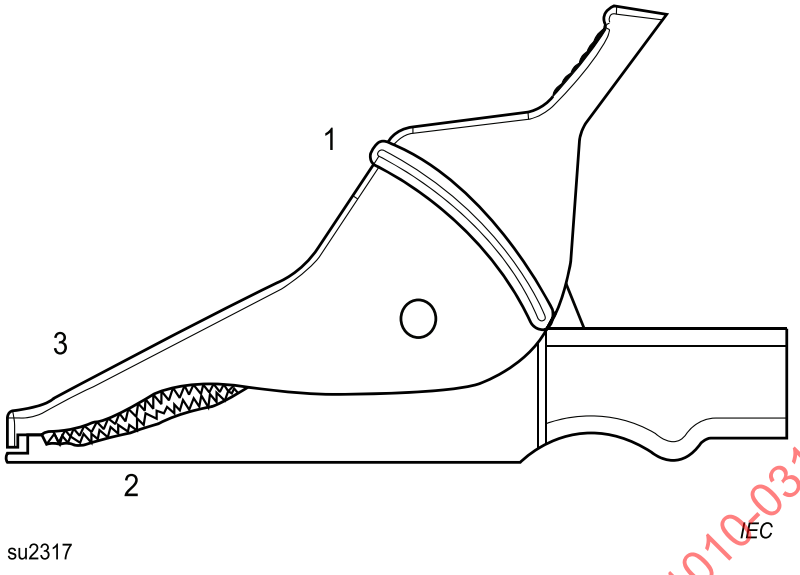
Figure 13

Protection by distance

6.4.3.4 Protection by tactile indicator

SPRING-LOADED CLIPS RATED for MEASUREMENT CATEGORY II 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.

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



Key

1 tactile indicator

2 metal jaws

3 insulated metal jaws

Figure 14

Protection by tactile indicator

6.4.3.5 PROBE TIPS used as CONNECTORS

PROBE TIPS which can be used as CONNECTORS 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 and partially-mated position (see 6.4.2 a) and b)).

6.4.4 Impedance

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

a) it shall limit the current or voltage to not more than the applicable levels of 6.3.3;

b) it shall be RATED for the WORKING VOLTAGE and for the amount of power that it will dissipate;

c) SPACINGS between terminations of the impedance shall meet the applicable requirements of 6.5 for BASIC INSULATION.

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

6.4.5 PROTECTIVE IMPEDANCE

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

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

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

a) an appropriate single component which shall be constructed, selected and tested so that safety and reliability for protection against electric shock is assured. In particular, the component shall be:

1) RATED for twice the WORKING VOLTAGE;

2) if a resistor, RATED for twice the power dissipation for the WORKING VOLTAGE;

3) if a capacitor, RATED for the maximum transient overvoltage;

b) a combination of components.

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

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

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

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

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

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

Conformity is checked as specified in 6.5.

6.5 Insulation requirements

6.5.1 The nature of insulation

6.5.1.1 General

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

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

The requirements for insulation depend on:

a) the required level of insulation (BASIC INSULATION, SUPPLEMENTARY INSULATION, or REINFORCED INSULATION);

b) the maximum transient overvoltage that may appear on the circuit, either as a result of an external event (such as a lightning strike or a switching transient), or as the result of the operation of the probe assembly;

c) the WORKING VOLTAGE;

d) the POLLUTION DEGREE of the micro-environment.

6.5.1.2 SPACINGS

6.5.1.2.1 General

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

6.5.1.2.2 CLEARANCES

CLEARANCES are specified to withstand the maximum transient overvoltage that can be present on the circuit to which the probe assembly can be connected in NORMAL USE. If transient overvoltages cannot occur, CLEARANCES are based on the WORKING VOLTAGE.

The values for CLEARANCES given in Table 6 and Table 7 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 6.6). CLEARANCES which meet the values of Table 6 and Table 7 will meet the requirements for any construction and need not be tested by a voltage test, but can be checked by measurement alone.

If the 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 m	Multiplication factor
Up to 2 000	1,00
2 001 to 3 000	1,14
3 001 to 4 000	1,29
4 001 to 5 000	1,48

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

See Annex C for details of how to measure CLEARANCES.

Conformity is checked by inspection, measurement, and in the case of more homogeneous construction by the voltage test of 6.6.

6.5.1.2.3 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.

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

6.5.1.2.3DV D2 *Modification of Clause 6.5.1.2.3, second paragraph by replacing it with the following:*

CREEPAGE DISTANCES for POLLUTION DEGREE 1 are applied to coated printed wiring boards whose coatings meet the requirements of IEC 60664-3 for type A coatings or UL 746E for conformal coatings.

For REINFORCED INSULATION, the value of the CREEPAGE DISTANCE is twice the value specified for BASIC INSULATION.

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.

Conformity is checked by inspection and measurement.

6.5.1.3 SOLID INSULATION

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 6.5.2.5 and 6.5.2.6.

6.5.2 Insulation requirements for probe assemblies

6.5.2.1 GENERAL

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.

6.5.2.2 CLEARANCES for probe assemblies of MEASUREMENT CATEGORIES II, III and IV

CLEARANCES for probe assemblies of MEASUREMENT CATEGORIES II, III and IV are specified in Table 6.

Table 6
CLEARANCES of probe assemblies RATED for MEASUREMENT CATEGORIES

Nominal a.c. r.m.s. line-to-neutral or d.c. voltage of mains to which the probe assembly is designed to be connected	CLEARANCE mm					
	BASIC INSULATION and SUPPLEMENTARY INSULATION			REINFORCED INSULATION		
V	MEASUREMENT CATEGORY II	MEASUREMENT CATEGORY III	MEASUREMENT CATEGORY IV	MEASUREMENT CATEGORY II	MEASUREMENT CATEGORY III	MEASUREMENT CATEGORY IV
≤ 50	0,04	0,1	0,5	0,10	0,32	1,4
> 50 ≤ 100	0,1	0,5	1,5	0,32	1,4	3,0
> 100 ≤ 150	0,5	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	6,0	10,4	15
> 600 ≤ 1 000	5,5	8	14	10,4	15	23,9
> 1 000 ≤ 1 500	8	11	18	16	22	36
> 1 500 ≤ 2 000	14	18	22	28	36	44
> 2 000 ≤ 3 000	18	22	25	36	44	50

Conformity is checked by inspection and measurement or 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, 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.

6.5.2.3 CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES II, III, or IV

6.5.2.3.1 General

CLEARANCES for probe assemblies which are not RATED for MEASUREMENT CATEGORIES II, III, or IV are calculated according to 6.5.2.3.2.

If they have either of the following characteristics, CLEARANCES are also determined according to 6.5.2.3.3, and the larger of the two CLEARANCE values 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.

6.5.2.3.2 CLEARANCE calculation

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

$$\text{CLEARANCE} = D_1 + F \times (D_2 - D_1)$$

where

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 7 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 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 applicable voltage from Table 10 for the required CLEARANCE.

Table 7
CLEARANCE values for the calculation of 6.5.2.3.2

Maximum voltage	CLEARANCE		Maximum voltage	CLEARANCE	
U_m	D_1	D_2	U_m	D_1	D_2
V	mm	mm	V	mm	mm
14,1 to 266	0,010	0,010	4 000	2,93	6,05
283	0,010	0,013	4 530	3,53	7,29
330	0,010	0,020	5 660	4,92	10,1
354	0,013	0,025	6 000	5,37	10,8
453	0,027	0,052	7 070	6,86	13,1
500	0,036	0,071	8 000	8,25	15,2
566	0,052	0,10	8 910	9,69	17,2
707	0,081	0,20	11 300	12,9	22,8
800	0,099	0,29	14 100	16,7	29,5
891	0,12	0,41	17 700	21,8	38,5
1 130	0,19	0,83	22 600	29,0	51,2
1 410	0,38	1,27	28 300	37,8	66,7
1 500	0,45	1,40	35 400	49,1	86,7
1 770	0,75	1,79	45 300	65,5	116
2 260	1,25	2,58	56 600	85,0	150
2 500	1,45	3,00	70 700	110	195
2 830	1,74	3,61	89 100	145	255
3 540	2,44	5,04	100 000	165	290
Linear interpolation is allowed.					

NOTE The following is an example calculation:

CLEARANCE 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 $U_m = U_w + U_t = (3\,500 + 4\,500)$ V = 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 7 at 8 000 V:

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

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

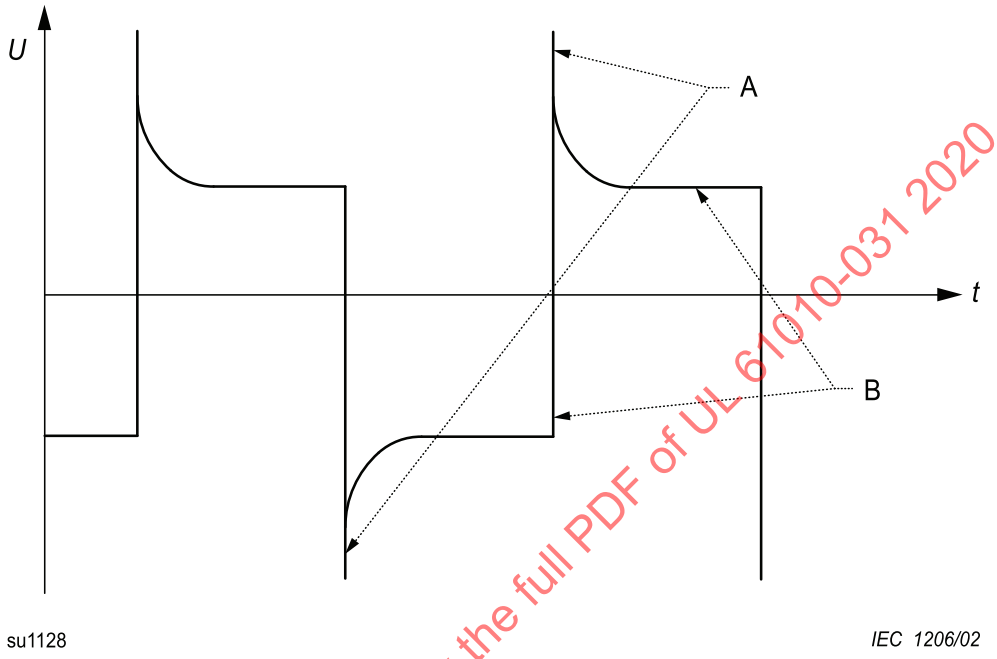
For REINFORCED INSULATION the value is doubled. CLEARANCE = 20,6 mm.

6.5.2.3.3 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 8, using the recurring peak voltage as the index (see Figure 18 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 to be 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 to be used for determining SPACINGS. For more information, see E.2 of IEC 60664-4:2005.



Key

A peak value of recurring voltage

B WORKING VOLTAGE value

Figure 18

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 8, 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 8
CLEARANCES for BASIC INSULATION in probe assemblies subjected to recurring peak voltages or WORKING VOLTAGES with frequencies above 30 kHz

Voltage peak value	CLEARANCE	
	Frequencies up to 30 kHz	Frequencies above 30 kHz
V	mm	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.		

6.5.2.4 CREEPAGE DISTANCES

CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION for probe assemblies shall meet the applicable values of Table 9, based on the WORKING VOLTAGE which stresses the insulation. Values for REINFORCED INSULATION are twice the values for BASIC INSULATION.

Conformity is checked by inspection and measurement.

Table 9
CREEPAGE DISTANCES for BASIC INSULATION or SUPPLEMENTARY INSULATION

WORKING VOLTAGE a.c. r. m.s. or d.c.	CREEPAGE DISTANCES				
	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.

6.5.2.5 Solid insulation of probe assemblies RATED for MEASUREMENT CATEGORIES

6.5.2.5.1 General

6.5.2.5.1.1 Solid insulation of 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 1.4) 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;

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.

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

Table 4
a.c. test voltages for testing electric strength of solid insulation in probe assemblies RATED for MEASUREMENT CATEGORIES

Nominal a.c. r.m.s. line-to-neutral or d.c. voltage of mains being measured V	a.c. test voltage 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	1300
> 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

Table 14
Impulse test voltages for testing electric strength of solid insulation in probe assemblies RATED for MEASUREMENT CATEGORIES

Nominal a.c. r.m.s. line-to-neutral or d.c. voltage of mains being measured	Impulse test voltage V peak					
	BASIC INSULATION and SUPPLEMENTARY INSULATION			REINFORCED INSULATION		
V	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

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

The test voltage for BASIC INSULATION and SUPPLEMENTARY INSULATION is calculated from:

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

where

U_T is the test voltage;

U_N is the nominal a.c. r.m.s. line-to-neutral or d.c. 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 $1{,}414 \times U_T$.

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

6.5.2.5.1.3 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 8;

2) for moulded and potted parts, the requirements of 6.5.2.5.2;

3) for insulating layers of printed wiring boards, the requirements of 6.5.2.5.3;

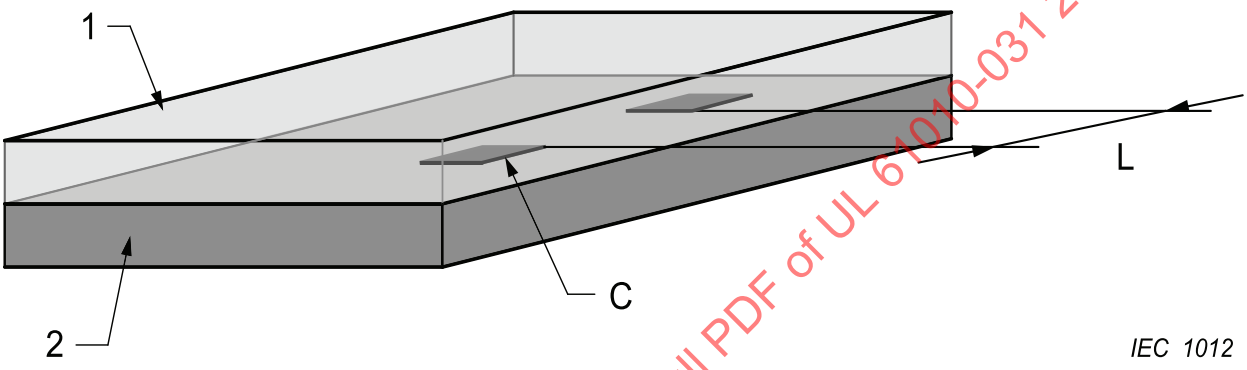
4) for thin-film insulation, the requirements of 6.5.2.5.4.

Conformity is checked as specified in 6.5.2.5.2 to 6.5.2.5.4, and in Clause 8, as applicable.

6.5.2.5.2 Moulded and potted parts

For BASIC INSULATION, SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, conductors located between the same two layers moulded together (see Figure 15, item *L*) shall be separated by at least the applicable minimum distance of Table 5 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.



su1104

Key

1 layer 1

2 layer 2

C conductor

L distance between conductors

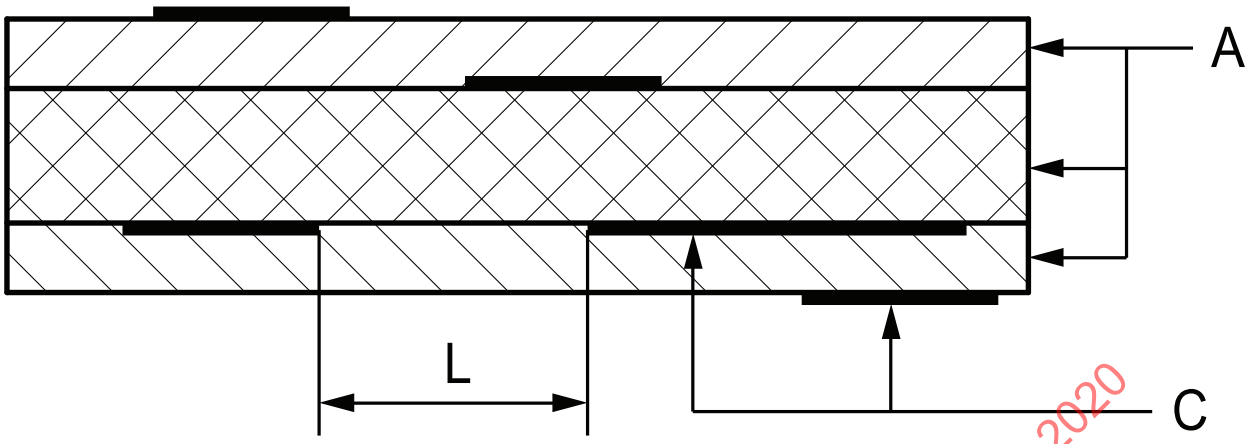
Figure 15

Distance between conductors on an interface between two layers

6.5.2.5.3 Insulating layers of printed wiring boards

For BASIC INSULATION, SUPPLEMENTARY INSULATION and REINFORCED INSULATION, conductors located between the same two layers (see Figure 16, item *L*) shall be separated by at least the applicable minimum distance of Table 5.

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

A layers

C conductors

Figure 16

Distance between adjacent conductors along an interface of two layers

Table 5
Minimum values for distance or thickness

WORKING VOLTAGE V	Minimum thickness mm	Minimum distance *L* (see Figure 16) [a] 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 voltage above 1 000 V, a partial discharge test should be used (test procedure under consideration).

REINFORCED INSULATION of insulating layers of printed wiring boards (see Figure 16, 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 of Table 5.

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.

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

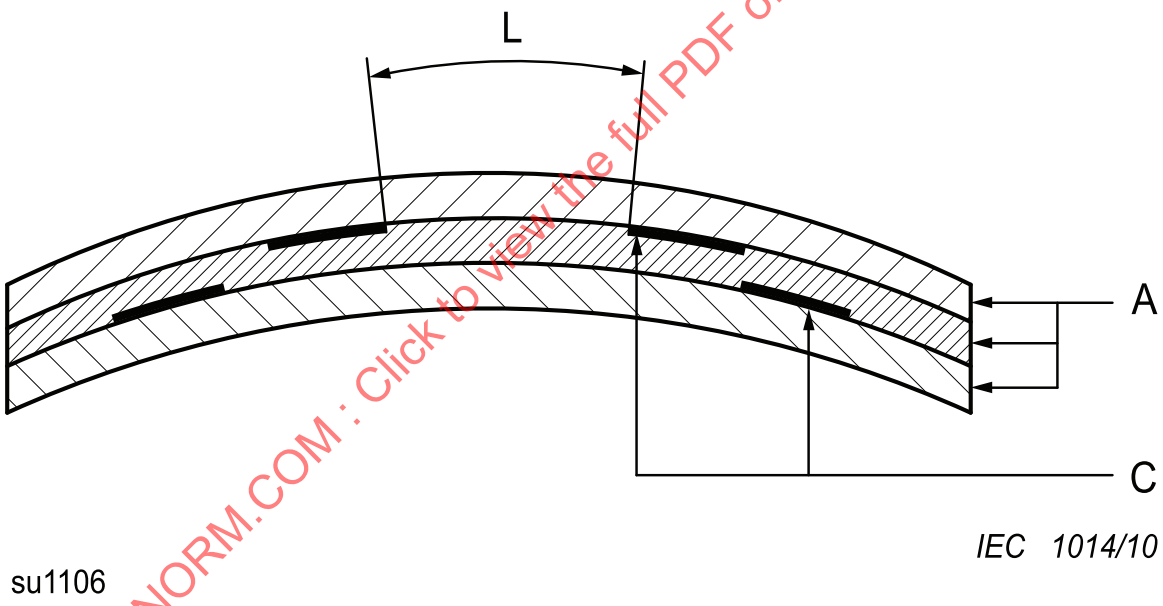
c) The insulation is assembled from at least two separate layers of printed wiring board materials, and the combination of layers is RATED by the manufacturer of the material for an electric strength of at least the value of the applicable test voltage of Table 4 or Table 14 for REINFORCED INSULATION.

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

6.5.2.5.4 Thin-film insulation

For BASIC INSULATION, SUPPLEMENTARY INSULATION, and REINFORCED INSULATION, conductors located between the same two layers (see Figure 17 , item *L*) shall be separated by at least the applicable SPACINGS of 6.5.2.2 and 6.5.2.4.

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

A layers of thin-film material such as tape and polyester film

C conductors

NOTE There might be air present between the layers.

Figure 17

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 of Table 5.

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.

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.

For the purposes of this test, a special sample can be assembled with only two layers of the material.

6.5.2.6 Solid insulation for probe assemblies which are not RATED for MEASUREMENT CATEGORIES

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 1.4) 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;

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.

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

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 8;

2) for moulded and potted parts, the requirements of 6.5.2.5.2;

3) for insulating layers of printed wiring boards, the requirements of 6.5.2.5.3, except that the applicable test voltage is determined using the procedure of 6.5.2.6 a);

4) for thin-film insulation, the requirements of 6.5.2.5.4, except that the applicable SPACINGS are from 6.5.2.3 and 6.5.2.4, and the applicable test voltage is determined using the procedure of 6.5.2.6 a).

Conformity is checked as specified in 6.5.2.5.2 to 6.5.2.5.4 with the test voltages of 6.5.2.6 a), and in Clause 8, as applicable.

6.6 Procedure for voltage tests

6.6.1 General

The following test procedures apply to type testing, and deterioration of the test specimen may occur. Further use of the test specimen may not be appropriate.

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

The reference point for the voltage tests is one or more of the following, 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 6.3.2 and any ACCESSIBLE conductive parts which are allowed to be HAZARDOUS LIVE by the exceptions of 6.1.

b) Any ACCESSIBLE insulating part of the ENCLOSURE, covered with metal foil everywhere except around CONNECTORS. For test voltages up to 10 kV a.c. peak or d.c., 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.

6.6.2 Humidity preconditioning

To ensure that the probe assembly does not become hazardous in the humidity conditions of 1.4, it is subjected to humidity preconditioning before the voltage tests. The probe assembly is not operated during preconditioning.

If wrapping in foil is required by 6.6.1, 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 4.3.1, after which parts removed (see above) are re-installed.

6.6.3 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. 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.

6.6.4 Test voltages

Voltage tests for solid insulation are applied using the values specified in 6.5.2.5 and 6.5.2.6.

Voltage tests for CLEARANCES are applied using the values specified in Table 10.

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.

The values of Table 10 apply to test sites located at 2 000 m altitude. For other test site altitudes, the correction factors of Table 11 are applied to the values of Table 10 when testing CLEARANCE but not when testing solid insulation.

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

Table 10
Test voltages based on CLEARANCES

Required CLEARANCE	Impulse 1,2/50 µs	a.c. r.m.s. 50/60 Hz	a.c. peak 50/60 Hz or d.c.	Required CLEARANCE	Impulse 1,2/50 µs	a.c. r.m.s. 50/60 Hz	a.c. peak 50/60 Hz or d.c.
mm	V peak	V	V	mm	V peak	V	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	8 200	11 600
0,2	1 140	620	880	20	16 400	9 000	12 100
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	69 300	98 000
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 10DV D2 *Modification:*

Add the following new row of values for a CLEARANCE of "1,5 mm."

Required CLEARANCE	Impulse 1,2/50 µs	a.c. r.m.s. 50/60 Hz	a.c. peak 50/60 Hz or d.c
mm	V peak	V	V
1,5	2 560	1 390	1 970

Table 11
Correction factors according to test site altitude for test voltages for CLEARANCES

	Correction factors			
Test voltage peak	≥ 327 V < 600 V	≥ 600 V < 3 500 V	≥ 3 500 V < 25 kV	≥ 25 kV
Test voltage r.m.s.	≥ 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.				

6.6.5 Test procedures

6.6.5.1 The a.c. voltage test

The voltage test equipment shall have a regulated output capable of maintaining the test voltage throughout the test. 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 r.m.s. value is $\sqrt{2}$ ± 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.

6.6.5.2 The 1 min d.c. voltage test

The voltage test equipment shall have a regulated output capable of maintaining the test voltage throughout the test. The d.c. 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 d.c. 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.

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

6.6.5.3 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 Figure 1 of IEC 61180-1:1992). The wave shape of each impulse shall be observed.

When verifying CLEARANCES within 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.

6.7 Constructional requirements for protection against electric shock

6.7.1 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.

6.7.2 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.

6.7.3 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 following means, 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 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 6.5 by loosening of parts or wires.

Conformity is checked by inspection and measurement and as specified in 6.5.

6.7.4 PROBE WIRE attachment

6.7.4.1 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 6.7.4.2 to 6.7.4.4. 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 6.5.2.2 or 6.5.2.3 and 6.5.2.4;

c) the PROBE WIRE shall pass the applicable test of 6.5.2.5.1.1 b) or 6.5.2.6 b);

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

NOTE For test purposes, it could 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.

6.7.4.2 Pull test

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

a) for probe bodies and for locking CONNECTORS, twice the pull force value from Table 12;

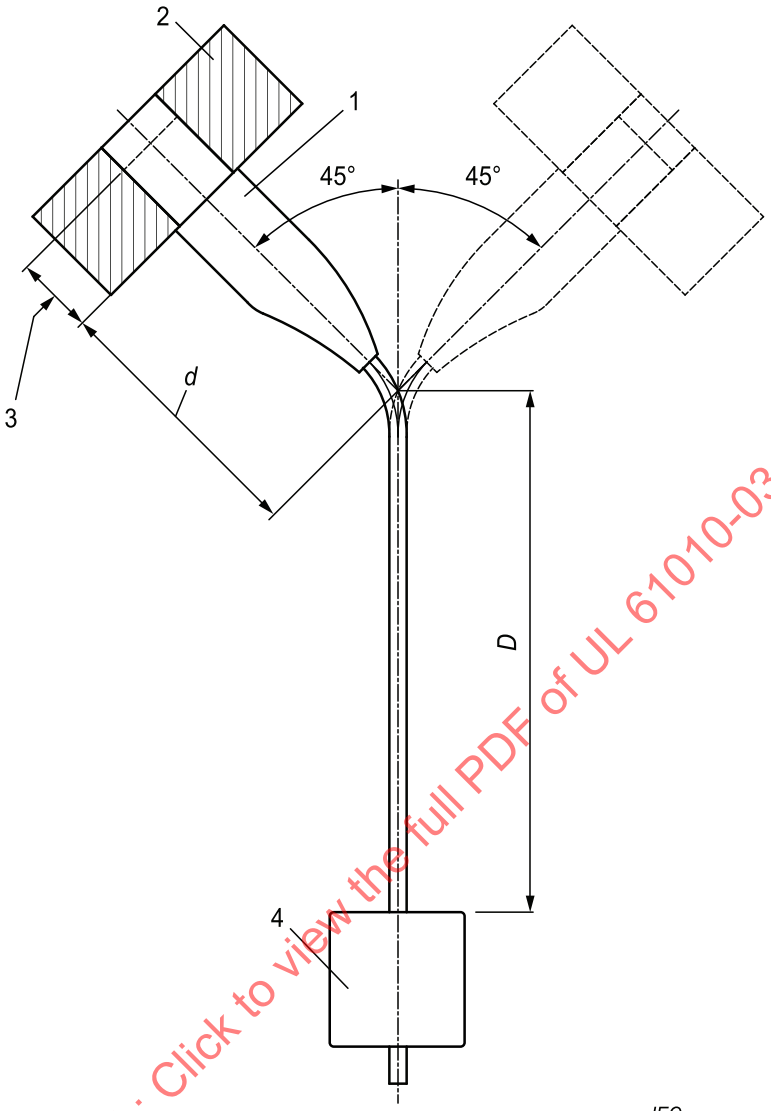
b) for non-locking CONNECTORS, twice the pull force value from Table 12 or four times the axial pull force required to disconnect the CONNECTOR, whichever is less.

6.7.4.3 Flexing/pull test

CONNECTORS shall be subjected to a flexing test in an apparatus similar to that shown in Figure 19.

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 19, 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 19

Flexing test

The PROBE WIRE is loaded with a weight such that the force from Table 12 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.

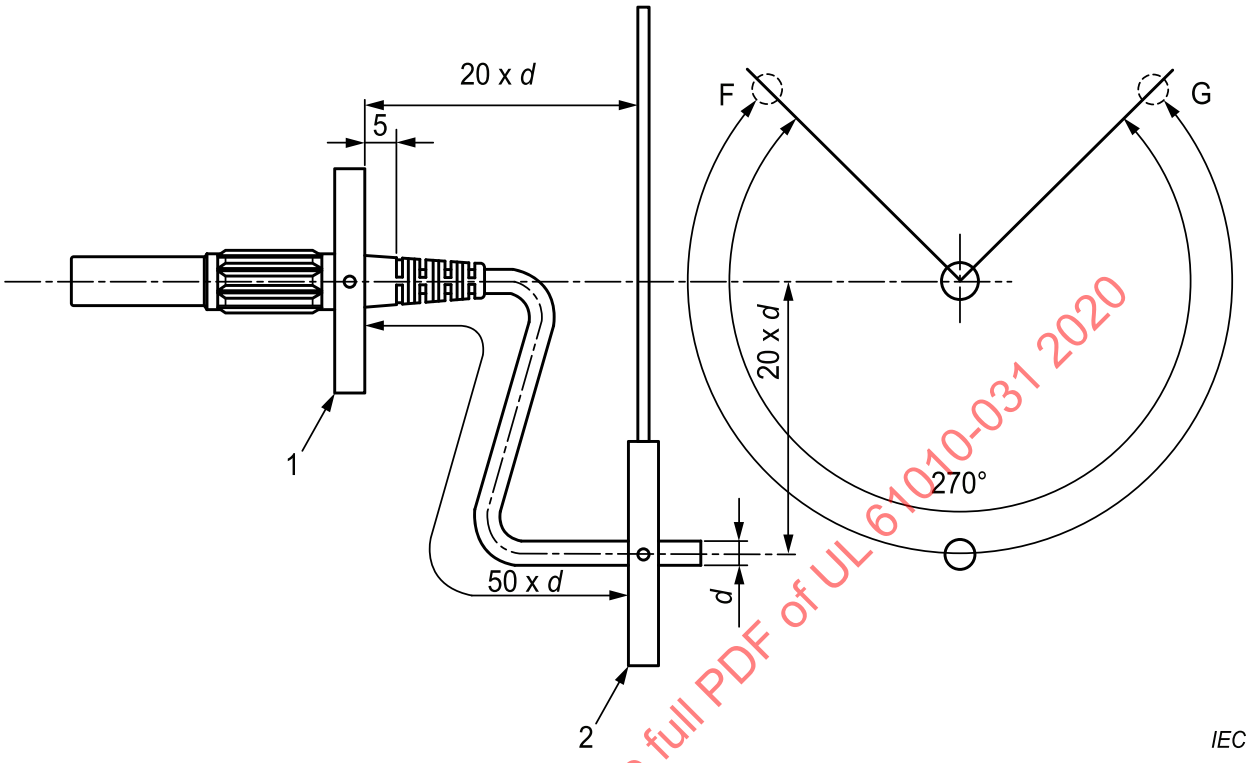
Table 12
Pull forces for PROBE WIRE attachment tests

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. 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. For the purpose of this calculation, the cross-sectional area of any shield is ignored.	

6.7.4.4 Rotational flexing test

The probe assembly is mounted in the test fixture as shown in Figure 20, 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 at a point 50 times the diameter of the PROBE WIRE, measured along the surface of the lead 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 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



su2319

Key

d diameter of PROBE WIRE

F start point, end point

G middle point (F + 270°)

1 fixed clamp

2 rotating clamp

Figure 20

Rotational flexing test

7 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.

8 Resistance to mechanical stresses

8.1 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 8.2 to 8.4. The probe assembly is not operated during the tests.

After completion of the tests, the probe assembly shall pass the applicable test of 6.5.2.5.1.1 b) or 6.5.2.6 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 values specified in 6.5, and small chips which do not adversely affect the protection against electric shock or moisture, are ignored.

8.2 Rigidity test

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.

8.3 Drop test

Three samples of the probe assembly are each dropped three times through a distance 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.

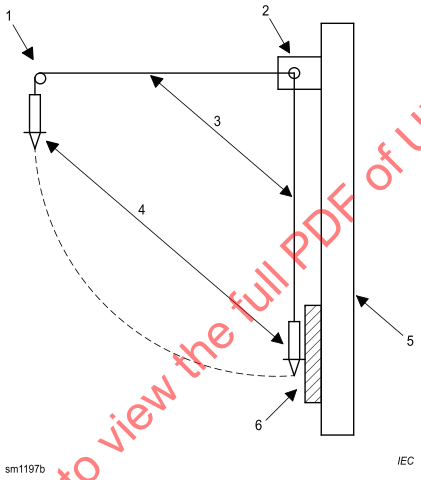
Non-metallic ENCLOSURES of probe assembly with a minimum RATED ambient temperature below 2 °C are cooled to the minimum RATED ambient temperature, then tested within 2 min.

8.4 Impact swing test

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 21). The height of the drop is 2 m, or the PROBE WIRE length if shorter.

8.4DV DE *National Difference Deleted*

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.



Key

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

Figure 21

Impact swing test

9 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 below 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 below 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 these values, but shall be recognizable as such by appearance or function, or shall be marked with Symbol 6 of Table 1 (see 5.2).

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

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.

11.2 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 5.4.3).

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 6.5.2.5.1.1 b) or 6.5.2.6 b) (without humidity preconditioning) and ACCESSIBLE parts shall not exceed the levels of 6.3.2. If a decontamination method is specified, this method is applied once.

11.3 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 6.5.2.5.1.1 b) or 6.5.2.6 b) (without humidity preconditioning) and ACCESSIBLE parts shall not exceed the levels of 6.3.2.

12 Components

12.1 General

12.1DV D2 *Modification by adding the following as the first paragraph of Clause 12.1:*

Where safety is involved, components shall comply with applicable safety requirements specified in relevant ANSI, CAN, CSA, IEC, ISO, or UL standards, as appropriate.

If safety is involved, 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) All applicable safety requirements of relevant IEC standards. Conformity with other requirements of the component standard is not required. If necessary for the application, they shall be subjected to the tests of this standard, except that it is not necessary to carry out identical or equivalent tests already performed to check conformity with the component standard.

b) The requirements of this standard and, where necessary for the application, any additional applicable safety requirements of the relevant IEC component standard.

c) If there is no relevant IEC standard, the requirements of this standard.

d) Applicable safety requirements of a non-IEC standard which are at least as high as those of the relevant IEC 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 5.1.3). If the probe assembly is RATED for both a.c. and d.c., the a.c. and d.c. 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 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 following values:

a) for type A 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;

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

d) for type D probe assemblies, 125 V.

For type B probe assemblies, Symbol 7 shall be marked on the probe assembly and a warning shall be provided in the documentation that the PROBE WIRE may not provide adequate protection if it comes into contact with the circuit under test.

Insulation of PROBE WIRES which have a wear indicator shall meet the requirements for BASIC INSULATION when the wear indicator has become visible.

A wear indicator is highly recommended (see also 5.4.3 j)).

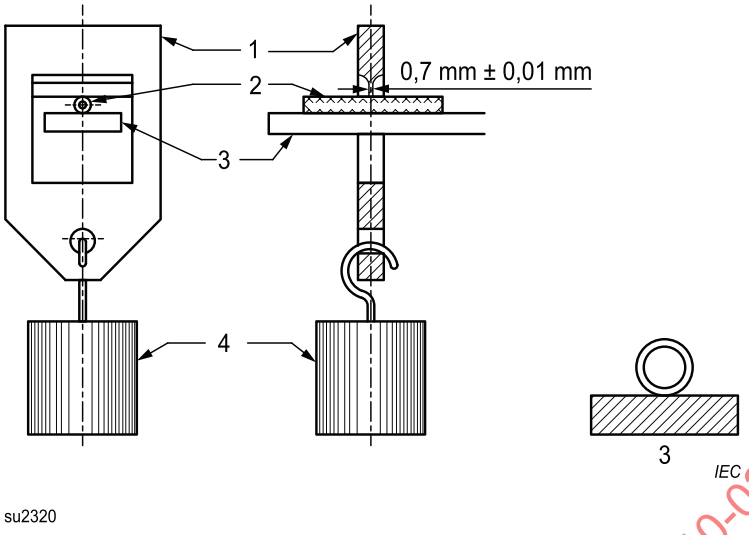
Conformity is checked by inspection, and by the applicable test of 6.5.2.5.1.1 b) or 6.5.2.6 b) for REINFORCED INSULATION. If the insulation includes a wear indicator, then the voltage test is repeated with the test voltage value for BASIC INSULATION after sufficient insulation has been removed from the cable to make the wear indicator just visible (see also 5.2 and 5.4.3 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 22, 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 22. 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 22

Indentation device

The compressing force F 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 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 6.5.2.5.1.1 b) or 6.5.2.6 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 tautly wound and fixed, at ambient temperature, on a mandrel to form a close helix. The diameter of the mandrel and the number of turns are given in Table 13.

Table 13
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

Two samples, on their mandrels, are placed in an air oven pre-heated to a temperature 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 6.5.2.5.1.1 b) or 6.5.2.6 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 6.5.2.5.1.1 b) or 6.5.2.6 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 6.5.2.5.1.2 or 6.5.2.6 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 determination of the median value of the result.

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 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 ageing treatment.

12.3.6.5 Ageing treatment

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

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 SPRINGLOADED 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 SPRINGLOADED 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 shall be constructed as follows:

a) 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.

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

1) for probe assemblies 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 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, the exposed conductive part of a PROBE TIP shall not exceed 80 mm;

3) for probe assemblies 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 shall not exceed 19 mm.

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

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

2) moving parts other than spring-loaded parts which change the RATING and the markings of the probe assembly are evaluated in each position;

3) removable parts which change the RATING and the markings of the probe assembly are removed.