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Electrical Equipment For Measurement, Control, and Laboratory Use; Part 1: General Requirements

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, 61010-1

Second Edition, Dated July 12, 2004

Summary of Topics

This new edition of the Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1, is harmonized with CSA and ISA and is a result of UL's Bulletins on this subject dated March 28, 2003 and January 16, 2004. The title page reflects the July 12, 2004 ANSI recognition of this new edition of the Standard.

The new requirements are substantially in accordance with UL's Bulletin(s) on this subject dated March 28, 2003 and January 16, 2004. The bulletin(s) is now obsolete and may be discarded.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-160.....	July 12, 2004



Canadian Standards Association
CAN/CSA-C22.2 No. 61010-1
Second Edition
(IEC 61010-1:2001, Mod)



ISA – The Instrumentation, Systems, and Automation Society
ISA-82.02.01 (IEC 61010-1 Mod)
Second Edition



Underwriters Laboratories Inc.
UL 61010-1
Second Edition

Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements

July 12, 2004

This standard is based on IEC 61010-1, Second Edition (2001).



ANSI/UL 61010-1-2004

Approved
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Standards Council
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Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

The most recent designation of ANSI/UL 61010-1 and ANSI/ISA-82.02.01 (IEC 61010-1 Mod) as an American National Standard (ANSI) occurred on July 12, 2004.

This ANSI/UL Standard for Safety, which consists of the Second Edition is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to the UL-Northbrook Standards Department, 333 Pfingsten Road, Northbrook, IL 60062.

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Preface

This is the common CSA, ISA, and UL standard for *Electrical Equipment for Measurement, Control, and Laboratory Use*. It is the second edition of CAN/CSA-C22.2 No. 61010-1, the second edition of ISA-82.02.01 (IEC 61010-1 Mod), and the second edition of UL 61010-1. This edition of CAN/CSA-C22.2 No. 61010-1 supersedes the previous edition published as CAN/CSA-C22.2 No. 1010-1 in 1992. This edition of ISA-82.02.01 (IEC 61010-1 Mod) supersedes the previous edition of ISA-82.02.01 published in 1999. This edition of UL 61010-1 will supersede the first edition of UL 61010A-1 published in 2002, UL 61010B-1 published in 2003, and UL 61010C-1 published in 2002. This standard is based on IEC 61010-1, second edition.

CAN/CSA-C22.2 No. 61010-1, ISA-82.02.01 (IEC 61010-1 Mod), and UL 61010-1 contain identical requirements and identical publication dates. The presentation and format of the standards material may differ between the three published standards.

This common standard was prepared by the Canadian Standards Association (CSA), The Instrumentation, Systems, and Automation Society (ISA), and Underwriters Laboratories Inc. (UL).

This standard was reviewed by the CSA Subcommittee on Safety Requirements for Electric 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 approved as a National Standard of Canada by the Standards Council of Canada (SCC).

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

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.

The requirements are presented in different formats. The ISA version of the standard illustrates the national differences from the IEC text through the use of legislative text (strike-out and underline). The CSA and UL versions of the standard illustrates national differences immediately following the IEC text. National differences between the CSA and UL version and the ISA version shall be word for word except for editorial changes.

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 literal interpretation 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.

CSA Effective Date

The effective date for CSA International will be announced through CSA Informs or a CSA Certification notice.

ISA Effective Date

The effective date for ISA is the date of publication.

UL Effective Date

The effective date for UL is the date of publication. However, the first editions of UL 61010A-1, UL 61010B-1, and UL 61010C-1 will also be effective until January 1, 2014.

A UL effective date is one established by Underwriters Laboratories Inc. and is not part of the ANSI approved standard.

Foreword (ISA)

The suffix "Mod" indicates the document is a modification of the IEC document and includes national differences encompassing both additions and deletions of information.

All text of IEC 61010-1:2001 is included. National Deviations are shown by ~~strikeout~~ through text deleted and underline under text added. Tables, or portions of tables, that are to be deleted are shown as shaded; figures to be deleted are marked with the overlay "X." There are eleven annexes in this standard. Annexes G, H, DVA, and DVB are informative and are not considered part of this Standard. The remaining Annexes are normative and are considered part of this standard.

The standards referenced within this document may contain provisions which, through reference in this text, constitute requirements of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated within this document. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintains registers of currently valid U.S. National Standards.

This document has been prepared as part of the service of ISA - The Instrumentation, Systems, and Automation Society - toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA; 67 Alexander Drive; P. O. Box 12277; Research Triangle Park, NC 27709; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: standards@isa.org.

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Foreword (CSA)

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Products in substantial accord with this Standard but which exhibit a minor difference or a new feature may be deemed to meet the Standard providing the feature or difference is found acceptable utilizing appropriate CSA International Operating Procedures. Products that comply with this Standard shall not be certified if they are found to have additional features which are inconsistent with the intent of this Standard. Products shall not be certifiable if they are discovered to contravene applicable laws or regulations.

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Manufacturers should note that, in the event of the failure of CSA International to resolve an issue arising from the interpretation of requirements, there is an appeal procedure: the complainant should submit the matter, in writing, to the Secretary of the Canadian Standards Association.

If this Standard is to be used in obtaining CSA Certification please remember, when making application for certification, to request all current Amendments, Bulletins, Notices, and Technical Information Letters that may be applicable and for which there may be a nominal charge. For such information or for further information concerning CSA Certification, please address your inquiry to Applications and Customer Service, CSA International, 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3.

Foreword (UL)

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

NATIONAL DIFFERENCES

In the CSA and UL publications of this standard, National Differences from the text of International Electrotechnical Commission (IEC) Publication 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements copyright 2001 are indicated by notations (differences) and are presented in bold text. The national difference type is included in the body.

In the ISA publication of this standard, National Differences are presented using legislative text (strike-out and underline). The national difference type is identified in an informative annex.

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.

Note: The CSA and UL printed standards include the national difference types within the body of the text. The ISA printed standard includes the national difference types in an annex at the back of the standard.

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 based on **safety practices**. These are differences for IEC requirements that may be acceptable, but adopting the IEC requirements would require considerable retesting or redesign on the manufacturer's part.

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**.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE – Part 1: General requirements

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

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

International Standard IEC 61010-1 has been prepared by IEC technical committee 66: Safety of measuring, control and laboratory equipment.

It has the status of a group safety publication, as specified in IEC Guide 104.

This second edition cancels and replaces the first edition published in 1990, amendment 1 (1992) and amendment 2 (1995). It constitutes a technical revision.

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

FDIS	Report on Voting
66/233/FDIS	66/244/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 3.

Annexes A to H form an integral part of this standard.

In this standard, the following print types are used:

- requirements and definitions: in roman type;
- NOTES: in smaller roman type;
- *conformity: 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 2002. 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 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.

INTRODUCTION

This part 1 specifies the safety requirements that are generally applicable to all equipment within its scope. For certain types of equipment, these requirements will be supplemented or modified by the special requirements of one, or more than one, particular part 2 of the standard which must be read in conjunction with the part 1 requirements.

SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE – Part 1: General requirements

1 Scope and object

1.1 Scope

1.1.1 Equipment included in scope

This part of IEC 61010 specifies general safety requirements for electrical equipment intended for professional, industrial process, and educational use, any of which may incorporate computing devices, as defined in a) to d) below, when used under the environmental conditions of 1.4.

a) Electrical test and measurement equipment

This is equipment which by electrical means tests, measures, indicates or records one or more electrical or non-electrical quantities, also non-measuring equipment such as signal generators, measurement standards, power supplies, transducers, transmitters, etc.

NOTE All indicating and recording electrical measuring instruments (except those excluded in 1.1.2) fall within the scope of IEC 61010 unless they are panel meters designed only for building-in to other equipment. Built-in panel meters are considered to be components and only need to meet the relevant requirements of IEC 61010, or other standards, as part of the equipment into which they are built.

b) Electrical control equipment

This is equipment which controls one or more output quantities to specific values, with each value determined by manual setting, by local or remote programming, or by one or more input variables.

c) Electrical laboratory equipment

This is equipment which measures, indicates, monitors or analyses substances, or is used to prepare materials, and includes in vitro diagnostic (IVD) equipment

This equipment may also be used in areas other than laboratories, for example self-test IVD equipment may be used in the home.

d) Accessories intended for use with the above (for example, sample handling equipment).

1.1.1DV.1 DE *Modification of item (a) by adding the following:*

This Part 1 applies to test equipment integrated into manufacturing facilities intended for testing electronic devices, including silicon wafers and other semiconductor devices.

NOTE This equipment is likely to be installed adjacent to and interconnected with industrial machinery in this application.

1.1.2 Equipment excluded from scope

This standard does not apply to equipment within the scope of

- a) IEC 60065 (Safety requirements for audio, video and similar electronic apparatus);
- b) IEC 60204 (Controls for electrical machines);
- c) IEC 60335 (Safety of household and similar electrical appliances);
- d) IEC 60364 (Electrical installations of buildings);
- e) IEC 60439-1 (Low-voltage switchgear and controlgear assemblies);
- f) IEC 60521 (Class 0,5; 1 and 2 alternating current watt-hour meters);
- g) IEC 60601 (Medical electrical equipment);
- h) IEC 60950 (Safety of information technology equipment including electrical business equipment, except as specified in 1.1.3);
- i) IEC 61558 (Power transformers, power supply units and similar).

1.1.3 Computing equipment

This standard applies only to computers, processors, etc. which form part of equipment within the scope of this standard or are designed for use exclusively with the equipment.

NOTE Computing devices and similar equipment within the scope of IEC 60950 and conforming to its requirements are considered to be suitable for use with equipment within the scope of this standard. However, some of the requirements of IEC 60950 for resistance to moisture and liquids are less stringent than those in this standard. If **HAZARDS** from moisture or liquids could affect equipment that conforms to IEC 60950 and is used with equipment which conforms with this standard, the instructions for use should specify any additional precautions required.

1.1.3ADV DR Addition of the following referencing the National Electrical Code and the Canadian Electrical Code:

This standard applies to equipment to be employed in accordance with ANSI/NFPA 70, National Electrical Code® (NEC); designed to be installed in accordance with the Canadian Electrical Code (CEC), Part I, CSA C22.1, and CSA C22.2 No. 0; or designed to comply with both the NEC and CEC.

1.2 Object

1.2.1 Aspects included in scope

The purpose of the requirements of this part 1 is to ensure that the design and methods of construction used provide adequate protection for the OPERATOR and the surrounding area against

- a) electric shock or burn (see clause 6);
- b) mechanical HAZARDS (see clauses 7 and 8);
- c) excessive temperature (see clauses 9 and 10);
- d) spread of fire from the equipment (see clause 9);
- e) effects of fluids and fluid pressure (see clause 11).
- f) effects of radiation, including lasers sources, sonic and ultrasonic pressure (see clause 12);
- g) liberated gases, explosion and implosion (see clause 13).

NOTE Attention is drawn to the existence of additional requirements which may be specified by national authorities responsible for 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 equipment not related to safety;
- b) effectiveness of transport packaging;
- c) EMC requirements, which are covered by IEC 61326;
- d) protective measures for explosive atmospheres (see IEC 60079);
- e) servicing (repair);
- f) protection of servicing (repair) personnel.

NOTE Servicing personnel are expected to be reasonably careful in dealing with obvious HAZARDS, but the design should protect against mishap by the use of warning labels, shields for hazardous voltage TERMINALS, segregation of low-voltage circuits from hazardous voltages, etc. More important, servicing personnel should be trained to recognize unexpected HAZARDS and to react accordingly.

1.3 Verification

This standard also specifies methods of verifying, through inspection and type testing, that the equipment meets the requirements of this standard.

NOTE Requirements for ROUTINE TESTS are given in annex F.

1.4 Environmental conditions

1.4.1 Normal environmental conditions

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

- a) indoor use;
- b) altitude up to 2 000 m;
- c) temperature 5 °C to 40 °C;
- d) maximum relative humidity 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;
- e) MAINS supply voltage fluctuations up to ± 10 % of the nominal voltage;
- f) transient overvoltages typically present on the MAINS supply.

NOTE The normal level of transient overvoltages is impulse withstand (overvoltage) category II of IEC 60364-4-443.

- g) applicable RATED POLLUTION degree.

1.4.2 Extended environmental conditions

This standard applies to equipment designed to be safe not only in the environmental conditions specified in 1.4.1, but also in any of the following conditions for which the equipment is RATED by the manufacturer:

- a) outdoor use;
- b) altitude above 2 000 m;
- c) ambient temperatures below 5 °C or above 40 °C;
- d) relative humidity above the levels specified in 1.4.1;
- e) MAINS supply voltage fluctuations exceeding ± 10 % of the nominal voltage.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61010. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61010

are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60027,
Letter symbols to be used in electrical technology

IEC 60060,
High-voltage test techniques

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

IEC 60085,
Thermal evaluation and classification of electrical insulation

IEC 60227,
Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V

IEC 60245,
Rubber insulated cables – Rated voltages up to and including 450/750 V

IEC 60309,
Plugs, socket-outlets and couplers for industrial purposes

IEC 60335,
Safety of household and similar electrical appliances

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

IEC 60651,
Sound level meters

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

IEC 60707,
Flammability of solid non-metallic materials when exposed to flame sources – List of test methods

IEC 60799,
Electrical accessories – Cord sets and interconnection cord sets

IEC 60804,
Integrating-averaging sound level meters

IEC 60825-1,
Safety of laser products – Part 1: Equipment classification, requirements and user's guide

IEC 60947-1,
Low-voltage switchgear and controlgear – Part 1: General rules.

IEC 60947-3,
Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units.

ISO 306: 1994,
Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)

ISO 3746,
Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane

ISO 4126-1,
Safety valves – Part 1: General requirements

ISO 9614-1,
Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points.

2DV DC Addition of the following:

ANSI/NFPA 70,
National Electrical Code

ANSI/UL 94,
Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

ANSI/UL 498,
Attachment Plugs and Receptacles

ANSI/UL 746C,
Polymeric Materials – Use in Electrical Equipment Evaluations

ANSI/UL 817,
Cord Sets and Power Supply Cords

ANSI/UL 1310,
Class 2 Power Units

CSA C22.1,
Canadian Electrical Code, Part I

CAN/CSA C22.2 No. 0.17,
Evaluation of Properties of Polymeric Materials

CSA C22.2 No. 21,
Cord Sets and Power Supply Cords.

CSA C22.2 No. 42,
Attachment Plugs and Receptacles General Use Receptacles, Attachment Plugs, and Similar Wiring Devices

CSA C22.2 No. 182.1,
Industrial Type, Special Use Attachment Plugs, Receptacles, and Connectors

**CSA C22.2 No. 182.2,
*Industrial Locking Type, Special Use Attachment Plugs, Receptacles, and Connectors***

**CSA C22.2 No. 182.3,
*Special Use Attachment Plugs, Receptacles, and Connectors***

**CAN/CSA C22.2 No. 223,
*Power Supplies With Extra-Low Voltage Class 2 Outputs***

3 Terms and definitions

For the purpose of this part of IEC 61010 the following definitions apply.

Unless otherwise specified, the values of "voltage" and "current" are the r.m.s. values of an alternating, direct or composite voltage or current.

NOTE An index of defined terms is given in annex H.

3.1 Equipment and states of equipment

3.1.1 FIXED EQUIPMENT: equipment fastened to a support, or otherwise secured in a specific location [IEV 826-07-07]

3.1.2 PERMANENTLY CONNECTED EQUIPMENT: equipment that is electrically connected to a supply by means of a permanent connection which can be detached only by the use of a TOOL

3.1.3 PORTABLE EQUIPMENT: equipment intended to be carried by hand

3.1.4 HAND-HELD EQUIPMENT: PORTABLE EQUIPMENT intended to be supported by one hand during NORMAL USE

3.1.5 TOOL: an external device, including keys and coins, used to aid a person to perform a mechanical function.

3.2 Parts and accessories

3.2.1 TERMINAL: a component provided for the connection of a device (equipment) to external conductors [IEV 151-01-03, modified]

NOTE TERMINALS can contain one or several contacts and the term therefore includes sockets, connectors, etc.

3.2.2 FUNCTIONAL EARTH TERMINAL: TERMINAL by which electrical connection is made direct to a point of a measuring or control circuit or to a screening part and which is intended to be earthed for any functional purpose other than safety

NOTE For measuring equipment, this TERMINAL is often termed measuring earth TERMINAL

3.2.3 PROTECTIVE CONDUCTOR TERMINAL: TERMINAL which is bonded to conductive parts of an equipment for safety purposes and is intended to be connected to an external protective earthing system

3.2.4 ENCLOSURE: part providing protection of equipment against certain external influences and, in any direction, protection against direct contact

3.2.5 BARRIER: part providing protection against direct contact from any usual direction of access

NOTE ENCLOSURES and BARRIERS may provide protection against the spread of fire (see 9.2.1 b)).

3.3 Electrical quantities

3.3.1 **RATED** (value): quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment [IEV 151-04-03]

3.3.2 **RATING**: set of **RATED** values and operating conditions [IEV 151-04-04]

3.3.3 **WORKING VOLTAGE**: highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at **RATED** voltage

NOTE 1 Transients are disregarded.

NOTE 2 Both open-circuit conditions and normal operating conditions are taken into account.

3.4 Tests

3.4.1 **TYPE TEST**: test of one or more samples of equipment (or parts of equipment) made to a particular design, to show that the design and construction meet one or more requirements of this standard [IEV 151-04-15, modified]

NOTE This is an amplification of the IEV 151-04-15 definition to cover both design and construction requirements.

3.4.2 **ROUTINE TEST**: test to which each individual device (equipment) is subjected during or after manufacture to ascertain whether it complies with certain criteria [IEV 151-04-16, modified] (See annex F)

3.5 Safety terms

3.5.1 **ACCESSIBLE** (of a part): able to be touched with a standard test finger or test pin, when used as specified in 6.2

3.5.2 **HAZARD**: potential source of harm

3.5.3 **HAZARDOUS LIVE**: capable of rendering an electric shock or electric burn in **NORMAL CONDITION** or **SINGLE FAULT CONDITION**

NOTE See 6.3.1 for values applicable to **NORMAL CONDITION** and 6.3.2 for the higher values deemed to be appropriate in **SINGLE FAULT CONDITION**.

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

3.5.5 **MAINS**: low-voltage electricity supply system (above the values of 6.3.2 a)) to which the equipment concerned is designed to be connected for the purpose of powering the equipment

NOTE Some measuring circuits may also be connected to the **MAINS** for measuring purposes.

3.5.6 **MAINS CIRCUIT**: circuit which is intended to be conductively connected to the **MAINS** for the purpose of powering the equipment

NOTE Measuring circuits and circuits that are inductively derived from **MAINS CIRCUITS** are not **MAINS CIRCUITS**.

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

3.5.8 PROTECTIVE BONDING: electrical connection of ACCESSIBLE conductive parts or of protective screening to provide electrical continuity to the means for connection of an external protective conductor

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

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

3.5.10 NORMAL CONDITION: condition in which all means for protection against HAZARDS are intact

3.5.11 SINGLE FAULT CONDITION: condition in which one means for protection against HAZARD is defective or one fault is present which could cause a HAZARD

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

3.5.12 OPERATOR: person operating equipment for its intended purpose

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

3.5.13 RESPONSIBLE BODY: individual or group responsible for the use and maintenance of equipment and for ensuring that OPERATORS are adequately trained

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

3.6 Insulation

3.6.1 BASIC INSULATION: insulation, the failure of which could cause a risk of electric shock

NOTE BASIC INSULATION may serve also for functional purposes.

3.6.2 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

3.6.3 DOUBLE INSULATION: insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION

3.6.4 REINFORCED INSULATION: insulation which provides protection against electric shock not less than that provided by DOUBLE INSULATION. It may comprise several layers which cannot be tested singly as SUPPLEMENTARY INSULATION OR BASIC INSULATION

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

3.6.6 POLLUTION DEGREE: for the purpose of evaluating spacings, the following degrees of POLLUTION in the micro-environment are defined

3.6.6.1 POLLUTION DEGREE 1: no POLLUTION or only dry, non-conductive POLLUTION occurs. The POLLUTION has no influence

3.6.6.2 POLLUTION DEGREE 2: normally only non-conductive POLLUTION occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

3.6.6.3 POLLUTION DEGREE 3: conductive POLLUTION occurs, or dry, non-conductive POLLUTION occurs which becomes conductive which is expected

NOTE In such conditions, equipment is normally protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity is controlled.

3.6.7 CLEARANCE: shortest distance in air between two conductive parts

3.6.8 CREEPAGE DISTANCE: shortest distance along the surface of the insulating material between two conductive parts [IEV 151-03-37]

4 Tests

4.1 General

Tests in this standard are TYPE TESTS to be carried out on samples of equipment or parts. Their only purpose is to check that the design and construction ensure conformity with this standard. In addition, manufacturers shall perform the ROUTINE TESTS of annex F on 100 % of equipment produced which has both HAZARDOUS LIVE parts and ACCESSIBLE conductive parts.

Tests on subassemblies of the equipment 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 equipment.

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 equipment demonstrates conclusively that the equipment would pass the test. Tests are carried out under

a) reference test conditions (see 4.3);

b) fault conditions (see 4.4).

NOTE 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:

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

4.2 Sequence of tests

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

4.3 Reference test conditions

4.3.1 Environmental conditions

Unless otherwise specified in this standard, the following environmental conditions shall exist in the test location:

- a) a temperature of 15 °C to 35 °C;
- b) a relative humidity of not more than 75 %, but not exceeding the limits of 1.4.1 d);
- c) an air pressure of 75 kPa to 106 kPa;
- d) no hoar-frost, dew, percolating water, rain, solar irradiation, etc.

4.3.2 State of equipment

Unless otherwise specified, tests shall be carried out on the equipment assembled for NORMAL USE and under the least favourable combination of the conditions given in 4.3.2.1 to 4.3.2.13.

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

Equipment intended to be built into a wall, recess, cabinet, etc., shall be installed as specified in the manufacturer's instructions.

4.3.2.1 Position of equipment

The equipment shall be in any position of NORMAL USE and with any ventilation unimpeded.

4.3.2.2 Accessories

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

4.3.2.3 Covers and removable parts

Covers or parts which can be removed without using a TOOL shall be removed or not removed.

4.3.2.4 MAINS supply

The following requirements apply:

- a) The supply voltage shall be between 90 % and 110 % of any RATED supply voltage for which the equipment can be set or, if the equipment is RATED for a greater fluctuation, at any supply voltage within the fluctuation range.
- b) The frequency shall be any RATED frequency.
- c) Equipment for both a.c. and d.c. shall be connected to an a.c. or d.c. supply.
- d) Equipment for d.c. or single-phase supply shall be connected both with normal and reverse polarity.
- e) Unless the equipment is specified for use only on a non-earthed MAINS supply, one pole of the reference test supply shall be at or near earth potential.
- f) If the means of connection permits reversal, battery operated equipment shall be connected with both reverse and normal polarity.

4.3.2.5 Input and output voltages

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

4.3.2.6 Earth TERMINALS

PROTECTIVE CONDUCTOR TERMINALS, if any, shall be connected to earth. FUNCTIONAL EARTH TERMINALS shall be connected or not connected to earth.

4.3.2.7 Controls

Controls which the OPERATOR can adjust by hand shall be set to any position except that

- a) MAINS selection devices shall be set to the correct value;
- b) combinations of settings shall not be made if they are prohibited by the manufacturer's marking on the equipment.

4.3.2.8 Connections

The equipment shall be connected for its intended purpose, or not connected.

4.3.2.9 Load on motors

Load conditions of motor-driven parts of equipment shall be in accordance with the intended purpose.

4.3.2.10 Output

For equipment giving an electrical output:

- a) the equipment shall be operated in such a way as to provide the RATED output power to the RATED load;
- b) the RATED load impedance of any output shall be connected or not connected.

4.3.2.11 Duty cycle

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

4.3.2.12 Loading and filling

Equipment intended to be loaded with specified material in NORMAL USE shall be loaded with the least favourable quantity of the materials specified in the instructions for use, including not loaded (empty) if the instructions for use permit this in NORMAL USE.

NOTE 1 In case of doubt, tests should be performed in more than one loading condition.

NOTE 2 If the specified material would cause a HAZARD during test, another material may be used provided that it can be shown that the result of the test is not affected.

4.3.2.13 Heating equipment

When measuring temperatures to evaluate the spread of fire, heating equipment shall be tested in a test corner as required by 10.4.1.

4.4 Testing in SINGLE FAULT CONDITION

4.4.1 General

The following requirements apply.

- a) Examination of the equipment 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 unless it can be demonstrated that no HAZARD could arise from a particular fault condition, or specified alternative methods of checking conformity are chosen in place of fault testing (see clause 9 b) and c)).
- c) The equipment shall be operated under the least favourable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they should be recorded for each test.

4.4.2 Application of fault conditions

Fault conditions shall include those specified in 4.4.2.1 to 4.4.2.12. They shall be applied only one at a time and shall be applied in turn in any 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 equipment or part shall pass the applicable tests of 4.4.4.

4.4.2.1 PROTECTIVE IMPEDANCE

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

b) If a PROTECTIVE IMPEDANCE is formed by the combination of BASIC INSULATION and a current- or voltage-limiting device, both the BASIC INSULATION and the current- or voltage-limiting device shall be subjected to single faults, applied one at a time. BASIC INSULATION shall be bridged and the current- or voltage-limiting device shall be short-circuited or disconnected, whichever is less favourable.

Parts of PROTECTIVE IMPEDANCE which are HIGH-INTEGRITY components need not be short-circuited or disconnected (see 6.5.3 and 14.6).

4.4.2.2 Protective conductor

The protective conductor shall be interrupted, except for PERMANENTLY CONNECTED EQUIPMENT or equipment utilizing a connector in accordance with IEC 60309.

4.4.2.3 Equipment or parts for short-term or intermittent operation

These shall be operated continuously if continuous operation could occur in a SINGLE FAULT CONDITION. Individual parts may include motors, relays, other electromagnetic devices and heaters.

4.4.2.4 Motors

Motors shall be stopped while fully energized or prevented from starting, whichever is less favourable.

4.4.2.5 Capacitors

Capacitors (except for self-healing capacitors) in the auxiliary winding circuits of motors shall be short-circuited.

4.4.2.6 MAINS transformers

The secondary windings of MAINS transformers shall be short-circuited as specified in 4.4.2.6.1, and overloaded as specified in 4.4.2.6.2.

A transformer damaged during one test may be repaired or replaced before the next test.

Tests for MAINS transformers tested as separate components are specified in 14.7.

4.4.2.6.1 Short circuit

Each untapped output winding, and each section of a tapped output winding, which is loaded in NORMAL USE, shall be tested in turn, one at a time, to simulate short circuits in the load. Overcurrent protection devices remain fitted during the test. All other windings are loaded or not loaded, whichever load condition of NORMAL USE is less favourable.

4.4.2.6.2 Overload

Each untapped output winding, and each section of tapped output winding, is overloaded in turn one at a time. The other windings are loaded or not loaded, whichever load condition of NORMAL USE is less favourable. If any overloads arise from testing in the fault conditions of 4.4, secondary windings shall be subjected to those overloads.

Overloading is carried out by connecting a variable resistor across the winding. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 min to maintain the applicable overload. No further readjustments are then permitted.

If overcurrent protection is provided by a current-breaking device, the overload test current is the maximum current which the overcurrent protection device is just capable of passing for 1 h. Before the test, the device is replaced by a link with negligible impedance. If this value cannot be derived from the specification, it is to be established by test.

For equipment in which the output voltage is designed to collapse when a specified overload current is reached, the overload is slowly increased to a point just before the point which causes the output voltage to collapse.

In all other cases, the loading is the maximum power output obtainable from the transformer.

Transformers with overtemperature protection which meets the requirements of 14.3 during the short-circuit test of 4.4.2.6.1 need not be subjected to overload tests.

4.4.2.7 Outputs

Outputs shall be short-circuited one at a time.

4.4.2.8 Equipment for more than one supply

Equipment which is designed to be operated from more than one type of supply shall be simultaneously connected to these supplies, unless this is prevented by the construction.

4.4.2.9 Cooling

Equipment cooling shall be restricted as follows, one fault at a time:

- a) air-holes with filters shall be closed;
- b) forced cooling by motor-driven fans shall be stopped;
- c) cooling by circulation of water or other coolant shall be stopped.

4.4.2.10 Heating devices

In equipment incorporating heating devices, the following faults shall be applied one at a time:

- a) timers which limit the heating period shall be overridden to energize the heating circuit continuously;
- b) temperature controllers, except for overtemperature protection devices meeting the requirements of 14.3, shall be overridden to energize the heating circuit continuously;
- c) loss of cooling liquid shall be simulated.

4.4.2.11 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.

NOTE See clause 9 a) and b) for alternative methods of checking protection against spread of fire.

4.4.2.12 Interlocks

Each part of an interlock system for the protection of OPERATORS shall be short-circuited or open-circuited in turn if the system prevents access to HAZARDS when a cover, etc. is removed without the use of a TOOL.

HIGH INTEGRITY components of interlock systems (see 14.6 and 15.3) need not be short-circuited or open-circuited.

4.4.3 Duration of tests

4.4.3.1 The equipment 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 risk of electric shock, spread of fire or injury to persons may eventually occur, the test shall be continued until one of these HAZARDS does occur or for a maximum period of 4 h, unless a HAZARD occurs before then.

4.4.3.2 Where a device which interrupts or limits the current during operation is included to limit the temperature of parts which can easily be touched, the maximum temperature attained by the equipment shall be measured, whether the device operates or not.

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

If the minimum operating current of the fuse is not reached in the test, the equipment shall be operated for a period corresponding to the maximum fusing time or continuously for the duration specified in 4.4.3.1.

4.4.4 Conformity after application of fault conditions

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

- a) – by making the measurements of 6.3.2 to check that no ACCESSIBLE conductive parts have become HAZARDOUS LIVE;*
- b) by performing a voltage test on DOUBLE INSULATION OR REINFORCED INSULATION to check that there is still one level of protection by insulation. The voltage test is made as specified in 6.8 (without conformity preconditioning) with the test voltage for BASIC INSULATION.*
- c) by measuring the temperature of transformer windings if the protection against electrical HAZARDS is achieved by DOUBLE INSULATION OR REINFORCED INSULATION within the transformer. The temperatures of table 16 shall not be exceeded.*

4.4.4.1DV D2 Modification of item (b) in Clause 4.4.4.1:

Replace the word "conformity" with "humidity" in the second sentence.

4.4.4.2 *Conformity with requirements for temperature protection is checked by determining the temperature of the outer surface of the ENCLOSURE and of parts which can easily be touched.*

Except for heated surfaces of heating equipment, the temperature of these parts shall not exceed 105 °C in an ambient temperature of 40 °C or the maximum RATED ambient temperature if higher.

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

4.4.4.3 Conformity with requirements for protection against the spread of fire is checked by placing the equipment on white tissue-paper covering a softwood surface and covering the equipment with cheesecloth. No molten metal, burning insulation, flaming particles, etc. shall fall on the surface on which the equipment 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 Conformity with the requirements for protection against other HAZARDS is checked as specified in clauses 7 and 8, and 11 to 16.

5 Marking and documentation

5.1 Marking

5.1.1 General

Equipment shall bear markings as specified in 5.1.2 to 5.2. Except for marking of internal parts, these markings shall be visible from the exterior, or be visible after removing a cover or opening a door without the aid of a TOOL, if the cover or door is intended to be removed or opened by an OPERATOR. Markings applying to the equipment as a whole shall not be put on parts which can be removed by an OPERATOR without the use of a TOOL.

For rack- or panel-mounted equipment, markings are permitted to be on any surface that becomes visible after removal of the equipment from the rack or panel.

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 colour requirements for symbols. Graphic symbols shall be explained in the documentation.

NOTE 1 IEC or ISO symbols should be used if available.

NOTE 2 Markings should not be on the bottom of the equipment, except on HAND-HELD EQUIPMENT or where space is limited.

Conformity is checked by inspection.

5.1.2 Identification

The equipment shall, as a minimum, be marked with

- a) the name or trade mark of the manufacturer or supplier;
- b) a model number, name or other means to identify the equipment. If equipment bearing the same distinctive designation (model number) is manufactured at more than one location, equipment from each manufacturing location shall be marked so that the location can be identified.

NOTE The marking of factory location may be in code and need not be on the equipment exterior.

Conformity is checked by inspection.

5.1.3 MAINS supply

The equipment shall be marked with the following information:

- a) nature of supply:
 - 1) a.c.: RATED MAINS frequency or range of frequencies;
 - 2) d.c.: with symbol 1 of table 1.

NOTE 1 For information purposes it may be useful to mark

- equipment intended for a.c. with symbol 2 of table 1;
- equipment suitable for both a.c. and d.c. with symbol 3 of table 1;
- equipment for three-phase supply with symbol 4 of table 1.

- b) the RATED value(s) of the supply voltage(s) or the RATED range of the supply voltages;

NOTE 2 RATED voltage fluctuations may also be marked.

- c) the maximum RATED power in watts (active power) or volt-amperes (apparent power), or the maximum RATED input current, with all accessories or plug-in modules connected. If the equipment can be used on more than one voltage range, separate values shall be marked for each voltage range unless the maximum and minimum values do not differ by more than 20 % of the mean value;

- d) equipment which the OPERATOR can set for different RATED supply voltages shall be provided with means for the indication of the voltage for which the equipment is set. For PORTABLE EQUIPMENT the indication shall be visible from the exterior. If the equipment is so constructed that the supply voltage setting can be altered without the use of a TOOL, the action of changing the setting shall also change the indication;

e) accessory MAINS socket-outlets accepting standard MAINS plugs shall be marked with the voltage if it is different from the MAINS supply voltage. If the outlet is for use only with specific equipment, it shall be marked to identify the equipment for which it is intended. If not, the maximum RATED current or power shall be marked, or symbol 14 of table 1 placed beside the outlet with the full details included in the documentation.

Conformity is checked by inspection and by measurement of power or input current to check the marking of 5.1.3 c). The measurement is made after the current has reached a stationary stage (usually after 1 min) so as to exclude any initial inrush current. The equipment shall be in the condition of maximum power consumption. Transients are ignored. The measured value shall not exceed the marked value by more than 10 %.

Table 1 – Symbols

Number	Symbol	Publication	Description
1		IEC 60417 – 5031	Direct current
2		IEC 60417 – 5032	Alternating current
3		IEC 60417 – 5033	Both direct and alternating current
4			Three-phase alternating current
5		IEC 60417 – 5017	Earth (ground) TERMINAL
6		IEC 60417 – 5019	PROTECTIVE CONDUCTOR TERMINAL
7		IEC 60417 – 5020	Frame or chassis TERMINAL
8		IEC 60417 – 5021	Equipotentiality
9		IEC 60417 – 5007	On (Supply)
10		IEC 60417 – 5008	Off (Supply)
11		IEC 60417 – 5172	Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION
12			Caution, risk of electric shock
13		IEC 60417 – 5041	Caution, hot surface
14		ISO 7000 – 0434	Caution, risk of danger (See note.)
15		IEC 60417 – 5268	In position of a bi-stable push control
16		IEC 60417 – 5269	Out-position of a bi-stable push control
NOTE 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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5.1.4 Fuses

For any fuse which may be replaced by an OPERATOR, there shall be a marking beside the fuseholder, which will enable the OPERATOR to identify the correct replacement fuse (see 5.4.5).

Conformity is checked by inspection.

5.1.5 TERMINALS, connections and operating devices

If necessary for safety, an indication shall be given of the purpose of TERMINALS, connectors, controls, and indicators, including any connections for fluids such as gas, water and drainage. Where there is insufficient space, symbol 14 of table 1 may be used.

NOTE 1 For additional information, see IEC 60445 and IEC 60447.

NOTE 2 Individual pins of multi-pin connectors need not be marked.

5.1.5.1 TERMINALS

TERMINALS for connection to the MAINS supply shall be identifiable.

The following TERMINALS shall be marked as follows:

- a) FUNCTIONAL EARTH TERMINALS with symbol 5 of table 1;
- b) PROTECTIVE CONDUCTOR TERMINALS with symbol 6 of table 1, except when the PROTECTIVE CONDUCTOR TERMINAL is part of an approved MAINS appliance inlet. The symbol shall be placed close to, or on, the TERMINAL;
- c) TERMINALS of measuring and control circuits which are permitted by 6.6.3 to be connected to ACCESSIBLE conductive parts with symbol 7 of table 1 if this connection is not self-evident;

NOTE This symbol may also be considered as a warning symbol in that it indicates that a HAZARDOUS LIVE voltage must not be connected to the TERMINAL. The symbol should also be used if it is likely that the OPERATOR could make such a connection inadvertently.

- d) TERMINALS supplied from the interior of the equipment and which are HAZARDOUS LIVE, with the voltage, current, charge or energy value or range, or with symbol 14 of table 1. This requirement does not apply to MAINS supply outlets where a standard MAINS socket outlet is used;
- e) ACCESSIBLE FUNCTIONAL EARTH TERMINALS connected to ACCESSIBLE conductive parts, with an indication that this is the case, unless it is self-evident. Symbol 8 of table 1 is acceptable for this marking.

Conformity is checked by inspection.

5.1.5.2 Measuring circuit TERMINALS

Unless a clear indication (see note below) is provided on a measuring instrument that voltage and current measuring circuit TERMINALS are not intended to be connected to voltages to earth above 50 V a.c. or 120 V d.c., the TERMINALS shall be marked as follows.

- a) Measuring circuit TERMINALS for measurements within measurement category I (see 6.7.4) shall be marked with the RATED voltage or current as applicable and with symbol 14 of table 1 (see also 5.4.1 f) and g)).
- b) Measuring circuit TERMINALS for measurements within measurement categories II, III and IV (see 6.7.4) shall be marked with the RATED voltage or current as applicable and the relevant measurement category. The measurement category markings shall be "CAT II", "CAT III" or "CAT IV" as applicable.

NOTE Examples of acceptable indications that the inputs in all cases are intended to be less than 50 V a.c. or 120 V d.c. to earth include

- a) the full-scale deflection marking of a single-range indicating voltmeter or maximum marking of a multi-range voltmeter;
- b) the maximum range marking of a voltage selector switch;
- c) the marked intended function of the instrument (for example, millivoltmeter).

Voltage and current measuring circuit TERMINALS that are permanently connected and not ACCESSIBLE need not be marked (see 5.4.3 i)). The measurement category and the RATED maximum WORKING VOLTAGE OR RATED maximum current for such TERMINALS shall be stated in the equipment installation instructions (see 5.4.3).

An exception is also permitted for circuit TERMINALS (connectors) which are dedicated only for connection to specific TERMINALS of other equipment, provided that there is a means for identifying these TERMINALS.

Markings shall be placed adjacent to the TERMINALS. However, if there is insufficient space (as in multi-input equipment), it is permissible for the marking to be on the RATING plate or scale plate, or for the TERMINAL to be marked with symbol 14 of table 1.

Conformity is checked by inspection.

5.1.6 Switches and circuit-breakers

If the power supply switch or circuit-breaker is used as the disconnecting device, the on- position or the off-position shall be clearly marked. Symbols 9 and 10 of table 1 can, in some cases, also be suitable as the device identification (see 6.11.2.5). A lamp alone is not considered to be a satisfactory marking. Symbols 9 and 10 shall not be used for switches other than the power supply switch.

If a push-button switch is used as the power supply switch, symbols 9 and 15 of table 1 may be used to indicate the on-position, or symbols 10 and 16 to indicate the off-position, with the pair of symbols (9 and 15, or 10 and 16) close together.

Conformity is checked by inspection.

5.1.6DV D2 Modification:

Replace the reference to Clause "6.11.2.5" with "6.11.3.1" in the first paragraph.

5.1.7 Equipment protected by DOUBLE INSULATION OR REINFORCED INSULATION

Equipment protected throughout by DOUBLE INSULATION OR REINFORCED INSULATION shall be marked with symbol 11 of table 1 unless it is provided with a PROTECTIVE CONDUCTOR TERMINAL.

Equipment which is only partially protected by DOUBLE INSULATION OR REINFORCED INSULATION shall not bear symbol 11 of table 1.

Conformity is checked by inspection.

5.1.8 Field-wiring TERMINAL boxes

If the temperature of the TERMINALS or the ENCLOSURE of a field-wiring TERMINAL box or compartment exceeds 60 °C in NORMAL CONDITION at an ambient temperature of 40 °C, or the maximum RATED ambient temperature if higher, there shall be a marking of the minimum temperature RATING of the cable to be connected to the TERMINALS. The marking shall be visible before and during connection, or be beside the TERMINALS.

Conformity, in case of doubt, is checked by measurement as specified in 10.3 a) and, if applicable, by inspection of markings.

5.2 Warning markings

Warning markings shall be visible when the equipment is ready for NORMAL USE. If a warning applies to a particular part of the equipment, the marking shall be placed on, or near to, this part.

The size of warning markings shall be as follows.

- a) Symbols shall be at least 2,75 mm high. Text shall be at least 1,5 mm high and contrast in colour with the background.
- b) Symbols or text moulded, stamped or engraved in a material shall be at least 2,0 mm high. If not contrasting in colour, they shall have a depth or raised height of at least 0,5 mm.

If it is necessary for the RESPONSIBLE BODY OR OPERATOR to refer to the instruction manual to preserve the protection afforded by the equipment, the equipment shall be marked with symbol 14 of table 1. Symbol 14 is not required to be used with symbols which are explained in the manual.

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 equipment must be isolated or disconnected from the HAZARDOUS LIVE voltage before access.

Warning markings are specified in 5.1.5.1 c); 6.1.2 b), 6.5.1.2 g), 6.6.2, 7.2 c), 7.3, 10.1, 13.2.2.

Conformity is checked by inspection.

5.3 Durability of markings

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

Conformity is checked by inspection and by performing the following test for durability of markings on the outside of the equipment. The markings are rubbed by hand, without undue pressure, for 30 s with a cloth soaked with the specified cleaning agent (or, if not specified, with isopropyl alcohol).

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

5.4 Documentation

5.4.1 General

Equipment shall be accompanied by documentation for safety purposes as follows:

- a) intended use of the equipment;
- b) technical specification;
- c) instructions for use;
- d) name and address of manufacturer or supplier from whom technical assistance may be obtained;
- e) the information specified in 5.4.2 to 5.4.5.
- f) definition of the relevant measurement category if marking of TERMINALS is required on the equipment (see 5.1.5.2).
- g) for equipment marked with measurement category I, a warning shall be given not to use the equipment for measurements within measurement categories II, III and IV, and a detailed RATING including the RATED transient overvoltages is given in the documentation.

If applicable, warning statements and a clear explanation of warning symbols marked on the equipment shall be provided in the documentation or shall be durably and legibly marked on the equipment. In particular, there shall be a statement that documentation needs to be consulted in all cases where symbol 14 of table 1 is used, in order to find out the nature of the potential HAZARD and any actions which have to be taken.

NOTE If NORMAL USE involves the handling of hazardous substances, instruction should be given on correct use and safety provisions. If any hazardous substance is specified or supplied by the equipment manufacturer, the necessary information on its constituents and the correct disposal procedure should also be given.

Conformity is checked by inspection.

5.4.1DV D2 Modification by adding items (h) and (i) to Clause 5.4.1:

- h) for equipment which for safety reasons requires specific probe assemblies, or probe assemblies with specific characteristics, the documentation shall indicate that probe assemblies which meet the manufacturer's specifications shall be used.
- i) for equipment intended to detect the presence of a hazardous voltage, the instructions shall provide guidance on how to determine that the equipment is functioning correctly.

5.4.2 Equipment RATINGS

Documentation shall include the following:

- a) the supply voltage or voltage range, frequency or frequency range, and power or current RATING;
- b) a description of all input and output connections;
- c) the RATING of the insulation of external circuits, appropriate for SINGLE FAULT CONDITIONS, if such circuits are nowhere ACCESSIBLE (see 6.6.2);
- d) a statement of the range of environmental conditions for which the equipment is designed (see 1.4);
- e) a statement of the degree of protection, if the equipment is RATED according to IEC 60529.

Conformity is checked by inspection.

5.4.3 Equipment installation

The documentation shall include installation and specific commissioning instructions (examples are listed below) and, if necessary for safety, warnings against HAZARDS which could arise during installation or commissioning of the equipment:

- a) assembly, location and mounting requirements;
- b) instruction for protective earthing;
- c) connections to the supply;
- d) for PERMANENTLY CONNECTED EQUIPMENT:
 - 1) supply wiring requirements;
 - 2) requirements for any external switch or circuit-breaker (see 6.11.2.1) and external overcurrent protection devices (see 9.5.1) and a recommendation that the switch or circuit-breaker be near the equipment;
- e) ventilation requirements;
- f) requirements for special services, for example air, cooling liquid;
- g) the maximum sound power level produced by equipment which emits sound, if measurement is required by 12.5.1;
- h) instructions relating to sound pressure level (see 12.5.1);
- i) for voltage- and current-measuring circuit TERMINALS that are permanently connected and not ACCESSIBLE, information regarding the measurement category, RATED maximum WORKING VOLTAGE OR RATED maximum current (See 5.1.5.2).

Conformity is checked by inspection.

5.4.4 Equipment operation

Instructions for use shall include, if applicable:

- a) identification of operating controls and their use in all operating modes;
- b) an instruction not to position the equipment so that it is difficult to operate the disconnecting device;
- c) instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts and any special materials;
- d) specification of limits for intermittent operation;
- e) an explanation of symbols related to safety which are used on the equipment;
- f) instructions for replacement of consumable materials;
- g) instructions for cleaning and decontamination;
- h) a statement listing any potentially poisonous or injurious gases that can be liberated from the equipment, and possible quantities;
- i) detailed instructions about risk-reduction procedures relating to flammable liquids (see 9.4 c)).

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

Conformity is checked by inspection.

5.4.5 Equipment maintenance

Instructions for the RESPONSIBLE BODY concerning preventive maintenance and inspection necessary for safety shall be given in sufficient detail. These shall include the inspection and replacement, if necessary, of any hoses or other parts containing liquids, if their failure could cause a HAZARD (see 11.7).

NOTE Instructions should advise the RESPONSIBLE BODY of any tests necessary to check that equipment is still in a safe condition. They should also warn against the repetition of any tests of this standard which could damage the equipment and reduce protection against HAZARDS.

For equipment using replaceable batteries, the specific battery type shall be stated.

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 replaceable fuses shall be stated.

Conformity is checked by inspection.

6 Protection against electric shock

6.1 General

6.1.1 Requirements

Protection against electric shock shall be maintained in NORMAL CONDITION (see 6.4) and SINGLE FAULT CONDITION (see 6.5). ACCESSIBLE parts of equipment shall not be HAZARDOUS LIVE (see 6.3).

Conformity is checked by the determination of ACCESSIBLE parts as specified in 6.2 and the measurements of the levels of 6.3, followed by the tests of 6.4 to 6.11.

6.1.2 Exceptions

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

- a) parts of lamps and lamp sockets after lamp removal;
- b) parts intended to be replaced by the OPERATOR (for example, batteries) and which may be HAZARDOUS LIVE during the replacement or other OPERATOR action, but only if they are ACCESSIBLE only by means of a TOOL and have a warning marking (see 5.2);
- c) locking and screw-held type measuring TERMINALS, including TERMINALS which do not require the use of a TOOL.

If any of these parts in a) and b) receive a charge from an internal capacitor, they shall not be HAZARDOUS LIVE 10 s after interruption of the supply.

If a charge is received from an internal capacitor, conformity is checked by the measurements of 6.3 to establish that the levels of 6.3.1 c) are not exceeded.

6.2 Determination of ACCESSIBLE parts

Unless obvious, determination of whether a part is ACCESSIBLE shall be made as specified in 6.2.1 to 6.2.3. Test fingers (see annex B) and pins shall be applied without force unless a force is specified. Parts are considered to be ACCESSIBLE if they can be touched with 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 6.9.1). For HAZARDOUS LIVE parts at a voltage to earth exceeding 1 kV r.m.s or 1,5 kV d.c., a part is considered to be ACCESSIBLE if the test finger or pin reaches a point nearer to the HAZARDOUS LIVE part than the applicable CLEARANCE for BASIC INSULATION for the working voltage.

If the OPERATOR is intended to perform any actions in NORMAL USE (with or without a TOOL) which will increase the accessibility of parts, such actions shall be taken before performing the examinations of 6.2.1 to 6.2.3. Examples include:

- a) removing covers;
- b) opening doors;
- c) adjusting controls;
- d) replacing consumable material;