

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Protection against electric shock – Common aspects for installations and equipment

Protection contre les chocs électriques – Aspects communs aux installations et aux matériels



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Protection against electric shock – Common aspects for installations and equipment

Protection contre les chocs électriques – Aspects communs aux installations et aux matériels

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 13.260; 29.020; 91.140.50

ISBN 978-2-8322-3103-6

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

FOREWORD	5
1 Scope	7
2 Normative references	7
3 Terms and definitions	8
4 Fundamental rule of protection against electric shock	18
4.1 General	18
4.2 Normal conditions	19
4.3 Single-fault conditions	20
4.3.1 General	20
4.3.2 Protection by independent protective provisions	20
4.3.3 Protection by an enhanced protective provision	20
4.4 Additional protection	20
4.5 Protection against electric burns	21
4.6 Protection against physiological effects without adverse health effect	21
4.6.1 General	21
4.6.2 Muscular reaction	21
4.6.3 Effects of touch current of discharge of electrostatic charges	22
4.6.4 Thermal effects	22
5 Protective provisions (elements of protective measures)	22
5.1 General	22
5.2 Provisions for basic protection	22
5.2.1 General	22
5.2.2 Basic insulation	22
5.2.3 Protective barriers or enclosures	23
5.2.4 Obstacles	23
5.2.5 Placing out of arm's reach	23
5.2.6 Limitation of voltage	24
5.2.7 Limitation of steady-state touch current and energy	24
5.2.8 Potential grading	25
5.2.9 Other provisions for basic protection	25
5.3 Provisions for fault protection	25
5.3.1 General	25
5.3.2 Supplementary insulation	25
5.3.3 Protective-equipotential-bonding	25
5.3.4 Protective screening	27
5.3.5 Indication and disconnection in high-voltage installations and systems	27
5.3.6 Automatic disconnection of supply	27
5.3.7 Simple separation (between circuits)	28
5.3.8 Non-conducting environment	28
5.3.9 Potential grading	28
5.3.10 Other provisions for fault protection	28
5.4 Enhanced protective provisions	28
5.4.1 General	28
5.4.2 Reinforced insulation	29
5.4.3 Protective separation between circuits	29
5.4.4 Limited current source	29

5.4.5	Protective impedance device	29
5.4.6	Other provisions for enhanced protection.....	30
5.5	Provisions for additional protection	30
5.5.1	Additional protection by residual current protective device (RCD) $I_{\Delta n} \leq 30 \text{ mA}$	30
5.5.2	Additional protection by supplementary equipotential bonding	30
6	Protective measures	30
6.1	General.....	30
6.2	Protection by automatic disconnection of supply	31
6.3	Protection by double or reinforced insulation.....	31
6.4	Protection by protective equipotential bonding	31
6.5	Protection by electrical separation	31
6.6	Protection by non-conducting environment (low-voltage).....	31
6.7	Protection by SELV system.....	32
6.8	Protection by PELV system.....	32
6.9	Protection by limitation of steady-state touch current and charge	32
6.10	Additional protection	32
6.10.1	Additional protection by residual current protective device (RCD) $I_{\Delta n} \leq 30 \text{ mA}$	32
6.10.2	Additional protection by supplementary protective equipotential bonding	32
6.11	Protection by other measures	33
7	Co-ordination between electrical equipment and protective provisions within an electrical installation	33
7.1	General.....	33
7.2	Class 0 equipment	33
7.3	Class I equipment	34
7.3.1	General	34
7.3.2	Insulation.....	34
7.3.3	Connection to the protective conductor	34
7.3.4	Accessible surfaces of parts of insulating material	34
7.3.5	Connection of a protective conductor	35
7.4	Class II equipment	35
7.4.1	General	35
7.4.2	Insulation.....	35
7.4.3	Protective bonding.....	36
7.4.4	Marking	36
7.5	Class III equipment	36
7.5.1	General	36
7.5.2	Voltages	36
7.5.3	Protective bonding.....	37
7.5.4	Marking	37
7.6	Touch currents, protective conductor currents.....	37
7.6.1	General	37
7.6.2	Touch currents	37
7.6.3	Protective conductor currents	37
7.6.4	Other requirements.....	39
7.6.5	Other effects.....	39
7.7	Safety and boundary clearances and hazard marking for high-voltage installations	39

7.8	Functional earthing	40
8	Special operating and servicing conditions	40
8.1	General.....	40
8.2	Devices to be operated manually and components intended to be replaced manually	40
8.2.1	General	40
8.2.2	Devices to be operated or components intended to be replaced by ordinary persons in low-voltage installations, systems and equipment	40
8.2.3	Devices to be operated or components intended to be replaced by skilled or instructed persons	41
8.3	Electrical values after isolation.....	41
8.4	Devices for isolation.....	42
8.4.1	General	42
8.4.2	Devices for isolation for low voltage.....	42
8.4.3	Devices for isolation for high voltage	43
Annex A (informative) Survey of protective measures as implemented by protective provisions		45
Annex B (informative) Index of terms		48
Annex C (informative) List of notes concerning certain countries		53
Bibliography.....		54
Figure A.1 – Protective measures with basic and fault protection		45
Figure A.2 – Protective measures with limited values of electrical quantities		46
Figure A.3 – Protective measure: additional protection (in addition to basic and/or fault protection)		47
Table 1 – Limits for voltage bands		19
Table 2 – Touch voltage thresholds for reaction		21
Table 3 – Application of equipment in a low-voltage installation		33
Table 4 – Maximum protective conductor current for frequencies up to 1 kHz		38
Table 5 – Maximum protective conductor current for DC		38
Table 6 – Minimum impulse withstand voltage of devices for isolation related to the nominal voltage		43

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PROTECTION AGAINST ELECTRIC SHOCK –
COMMON ASPECTS FOR INSTALLATION AND EQUIPMENT****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 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 61140 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition cancels and replaces the third edition published in 2001 and Amendment 1:2004. This edition constitutes a technical revision.

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

- a) Introduction of the content of IEC 60449
- b) Better distinction between provisions and measures
- c) Consideration of effects other than ventricular fibrillation
- d) Additional protection was introduced
- e) ELV defined as part of LV
- f) Devices suitable for isolation required for automatic disconnection of supply (LV)

- g) Requirements relating to current in the protective conductor were moved to the main body of the standard

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

FDIS	Report on voting
64/2076/FDIS	64/2091/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.

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

The reader's attention is drawn to the fact that Annex C lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this standard.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

PROTECTION AGAINST ELECTRIC SHOCK – COMMON ASPECTS FOR INSTALLATIONS AND EQUIPMENT

1 Scope

This International Standard is a basic safety publication primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

It is not intended to be used as a stand-alone standard.

According to IEC Guide 104, technical committees, when preparing, amending, or revising their publications, are required to make use of any basic safety publication such as IEC 61140.

This International Standard applies to the protection of persons and livestock against electric shock. The intent is to give fundamental principles and requirements which are common to electrical installations, systems and equipment or necessary for their coordination, without limitations with regard to the magnitude of the voltage or current, or the type of current, and for frequencies up to 1 000 Hz.

Some clauses in this standard refer to low-voltage and high-voltage systems, installations and equipment. For the purposes of this standard, low-voltage is any rated voltage up to and including 1 000 V a.c. or 1 500 V d.c.. High voltage is any rated voltage exceeding 1 000 V a.c. or 1 500 V d.c..

It should be noted that, for an efficient design and selection of protective measures, the type of voltage that may occur and its waveform needs to be considered, i.e. a.c. or d.c. voltage, sinusoidal, transient, phase controlled, superimposed d.c., as well as a possible mixture of these forms. The installations or equipment may influence the waveform of the voltage, e.g. by inverters or converters. The currents flowing under normal operating conditions and under fault conditions depend on the described voltage.

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 60038, *IEC standard voltages*

IEC 60068 (all parts), *Environmental testing*

IEC 60071-1, *Insulation coordination – Part 1: Definitions, principles and rules*

IEC 60071-2, *Insulation coordination – Part 2: Application guide*

IEC 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

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

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC TS 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TR 60479-5, *Effects of current on human beings and livestock – Part 5: Touch voltage threshold values for physiological effects*

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

IEC 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60721 (all parts), *Classification of environmental conditions*

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

IEC TS 61201:2007, *Use of conventional touch voltage limits – Application guide*

IEC 62271-102, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

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

ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

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

NOTE An index of definitions is given in Annex B.

3.1

electric shock

physiological effect resulting from an electric current through a human body or livestock

Note 1 to entry: Physiological effects include, for example, perception, muscular contractions and tetany, difficulty in breathing, disturbances of heart function, immobilization, cardiac arrest, breathing arrest, burns or other cellular damage.

Note 2 to entry: Physiological effects resulting from EMF are not considered in this standard.

[SOURCE: IEC 60050-195:1998, 195-01-04, modified – "through a human body or livestock" replaces "passing through a human or animal body"; addition of 2 Notes to entry]

3.1.1

basic protection

protection against electric shock under fault-free conditions

[SOURCE: IEC 60050-195:1998, 195-06-01]