

TECHNICAL REPORT

RAPPORT TECHNIQUE



**Effects of current on human beings and livestock –
Part 4: Effects of lightning strokes**

**Effets du courant sur le corps humain et sur les animaux domestiques –
Partie 4: Effets de la foudre**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2011 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 la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: 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.

- Catalogue of IEC publications: www.iec.ch/searchpub

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 It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

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

- Electropedia: www.electropedia.org

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

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) 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 CEI

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

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

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

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00

TECHNICAL REPORT

RAPPORT TECHNIQUE



**Effects of current on human beings and livestock –
Part 4: Effects of lightning strokes**

**Effets du courant sur le corps humain et sur les animaux domestiques –
Partie 4: Effets de la foudre**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

ICS 13.200; 29.020

ISBN 978-2-88912-694-1

CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope and object.....	6
2 Normative references	6
3 Terms and definitions	6
4 Physics of lightning	9
5 Interaction of strokes with human beings and livestock.....	10
5.1 General.....	10
5.2 Description of direct strike.....	10
5.3 Description of contact voltage	11
5.4 Description of side flash	12
5.5 Description of step voltage.....	13
5.6 Description of streamer shock	15
5.7 Description of flashover.....	16
6 Effects of lightning strokes on the body of human beings and livestock	16
6.1 General.....	16
6.2 Physiological effects.....	16
6.3 Pathophysiological effects.....	17
6.4 Thermal effects	17
6.5 Comparison between effects of electric shock derived from electrical systems and lightning.....	17
6.6 Percentage occurrence	17
Bibliography.....	20
Figure 1 – Categorization of lightning [4].....	10
Figure 2 – Direct stroke	11
Figure 3 – Contact voltage.....	12
Figure 4 – Side flash.....	13
Figure 5 – Step voltage.....	14
Figure 6 – Step voltage on quadrupeds.....	14
Figure 7 – Step voltage with side flash.....	15
Figure 8 – Upward streamer current.....	16
Table 1 – Causes of lightning death and most typical reported consequent disorders [11-16], [20]	18
Table 2 – Differences between low voltage and high voltage injuries from electrical systems, and lightning injuries [1], [11-16], [20]	19

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –**Part 4: Effects of lightning strokes**

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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC/TR 60479-4, which is a technical report, has been prepared by technical committee No.64: Electrical installations and protection against electric shock.

This second edition cancels and replaces the first edition, published in 2004 and constitutes a technical revision.

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

- the report has been completed with additional information on the influences and effects of natural electricity in the form of lightning strokes during thunderstorms;
- the definitions and technical terms have been updated;

- the explanation of the basic physical mechanisms for the dynamics of lightning where specified;
- the references to the relevant literature and the list of bibliography are updated;
- figures showing the current path during different interactions of lightning with the victim's body are updated.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
64/1772/DTR	64/1804/RVC

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

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

A list of all the parts in the IEC 60479 series, under the general title *Effects of current on human beings and livestock*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

INTRODUCTION

IEC 60479-1, IEC 60479-2 and IEC 60479-3 deal with the effect of electric shock derived from electrical systems on the bodies of human beings and livestock. This part of IEC 60479, which is a technical report, describes the influence and effect of natural electricity in the form of lightning strokes during thunderstorms. Lightning current can consist of several uni-polar and/or bi-polar impulses with different peak values and durations; Clause 6 of IEC/TS 60479-2:2007[24]¹ does not cover these effects.

The interaction of a lightning stroke with the victim's body is quite different from the usual experience with electric shock derived from electrical systems. The pathway often includes the head in lightning accidents. The importance of the cranial orifices as points of entry of lightning current has been noted, and from these the proximity of the pathway to the brainstem. The brain stem includes the respiratory centre, in contrast with pathways of shock current arising from electrical systems. In particular it should be pointed out that differences exist between accidents caused by a direct flash compared with those interactions which are caused by step voltages. Even very short single impulses of lightning can cause cardiopulmonary arrest [5], [6], [15] and [16].

The intense electric interactions with living organisms are very dangerous but, surprisingly in many cases, not always lethal. It is accepted that more than 90 % of lightning accidents involving humans are not fatal [1], [12]. Corresponding reliable data for livestock is not known. There is a large variation in outcome due to different environments, different activities of people and knowledge of first aid and quality of medical care [1], [5].

It has been necessary, therefore, to create a separate standard concerning the special effects of lightning strokes. The physical behaviour of lightning is shown as a basis. The interaction with a living body is then described, followed by the consequences for the life of the victim.

¹ References in square brackets refer to the bibliography.

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 4: Effects of lightning strokes

1 Scope and object

This part of IEC 60479, which is a technical report, summarizes the basic parameters for lightning and their variability insofar as they apply to human beings and livestock.

The possible direct and indirect interactions of strikes with bodies of living beings are indicated and the resulting effects caused by lightning currents for the organism are described.

The object of this report is to show the differences of effects on human beings and livestock due to lightning strokes versus those effects of electric shocks derived from electrical systems.

2 Normative references

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC/TS 60479-1, in addition to the following definitions, apply.

3.1 Definitions of technical terms

3.1.1

lightning flash

atmospheric discharge consisting of one or more strokes

3.1.2

lightning stroke

single electrical discharge in a lightning flash

3.1.3

lightning channel

conducting path of the lightning current

3.1.4

stepped and connecting leader

stepped leader stepping down from a cloud and a connecting leader stepping up from points of field concentration beneath, noting that they are low current non-luminous processes leading to the return stroke when the two connect