IEC 60287-1-1

Edition 3.0 2023-05
COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-7059-2

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General

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.

This commented version (CMV) of the official standard IEC 60287-1-1:2023 edition 3.0 allows the user to identify the changes made to the previous IEC 60287-1-1:2006+ AMD1:2014 edition 2.1. Furthermore, comments from IEC TC 20 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

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

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

IEC 60287-1-1 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This third edition cancels and replaces the second edition published in 2006 and Amendment 1:2014. This edition constitutes a technical revision.

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

a) thorough redefinition of symbols used across the IEC 60287 and IEC 60853 series to realign and unify definitions, eliminate inconsistencies and to improve cross-use of the different parts of both IEC 60287 and IEC 60853 series; **1**

b) introduction of corrective factors on relevant calculated physical characteristics to take into account the effect of multicore lay-lengths; a dedicated annex to highlight correction factors for different number of cores has been introduced (Annex A).

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

Draft	Report on voting
20/2096/FDIS	20/2103/RVD

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

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

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

A list of all parts in the IEC 60287 series, published under the general title *Electric cables – Calculation of the current rating*, can be found on the IEC website.

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

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

IMPORTANT – The "colour inside" logo on the cover page of this document 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

This part of IEC 60287 contains formulae for the quantities ~~*R*~~ R_C, W_d, λ_1 and λ_2.

It contains methods for calculating the permissible current rating of cables from details of the permissible temperature rise, conductor resistance, losses and thermal resistivities.

Formulae for the calculation of losses are also given.

The formulae in this document contain quantities which vary with cable design and materials used. The values given in the tables are either internationally agreed, for example, electrical resistivities and resistance temperature coefficients, or are those which are generally accepted in practice, for example, thermal resistivities and permittivities of materials. In this latter category, some of the values given are not characteristic of the quality of new cables but are considered to apply to cables after a long period of use. In order that uniform and comparable results ~~may~~ can be obtained, the current ratings should be calculated with the values given in this document. However, where it is known with certainty that other values are more appropriate to the materials and design, then these may be used, and the corresponding current rating declared in addition, provided that the different values are quoted.

Quantities related to the operating conditions of cables are liable to vary considerably from one country to another. For instance, with respect to the ambient temperature and soil thermal resistivity, the values are governed in various countries by different considerations. Superficial comparisons between the values used in the various countries ~~may~~ can lead to erroneous conclusions if they are not based on common criteria: for example, there ~~may~~ can be different expectations for the life of the cables, and in some countries design is based on maximum values of soil thermal resistivity, whereas in others average values are used. Particularly, in the case of soil thermal resistivity, it is well known that this quantity is very sensitive to soil moisture content and ~~may~~ can vary significantly with time, depending on the soil type, the topographical and meteorological conditions, and the cable loading.

The following procedure for choosing the values for the various parameters should, therefore, be adopted.

Numerical values should preferably be based on results of suitable measurements. Often such results are already included in national specifications as recommended values, so that the calculation ~~may~~ can be based on these values generally used in the country in question; a survey of such values is given in IEC 60287-3-1.

A suggested list of the information required to select the appropriate type of cable is given in IEC 60287-3-1.

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General

~~1 General~~

1 Scope

This part of IEC 60287 is applicable to the conditions of steady-state operation of cables at all alternating voltages, and direct voltages up to 5 kV, buried directly in the ground, in ducts, troughs or in steel pipes, both with and without partial drying-out of the soil, as well as cables in air. The term "steady state" is intended to mean a continuous constant current (100 % load factor) just sufficient to produce asymptotically the maximum conductor temperature, the surrounding ambient conditions being assumed constant.

This document provides formulae for current ratings and losses.

The formulae given are essentially literal and designedly leave open the selection of certain important parameters. These ~~may~~ can be divided into three groups:

– parameters related to construction of a cable (for example, thermal resistivity of insulating material) for which representative values have been selected based on published work;
– parameters related to the surrounding conditions, which ~~may~~ can vary widely, the selection of which depends on the country in which the cables are used or ~~are to~~ will be used;
– parameters which result from an agreement between manufacturer and user and which involve a margin for security of service (for example, maximum conductor temperature).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60027-3, *Letter symbols to be used in electrical technology – Part 3: Logarithmic and related quantities, and their units*~~

~~IEC 60028:1925, *International standard of resistance for copper*~~

~~IEC 60141 (all parts), *Tests on oil-filled and gas-pressure cables and their accessories*~~

IEC 60228, *Conductors of insulated cables*

IEC 60287-1-3, *Electric cables – Calculation of the current rating – Part 1-3: Current rating equations (100 % load factor) and calculation of losses – Current sharing between parallel single-core cables and calculation of circulating current losses*

IEC 60287-2-1:2023, *Electric cables – Calculation of the current rating – Part 2-1: Thermal resistance – Calculation of the thermal resistance*

~~IEC 60502-1, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)*~~

~~IEC 60502-2, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)*~~

~~IEC 60889, *Hard-drawn aluminium wire for overhead line conductors*~~

IEC 60287-1-1

Edition 3.0 2023-05

INTERNATIONAL STANDARD

Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General

IEC 60287-1-1:2023-05(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General

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.

IEC 60287-1-1 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This third edition cancels and replaces the second edition published in 2006 and Amendment 1:2014. This edition constitutes a technical revision.

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

a) thorough redefinition of symbols used across the IEC 60287 and IEC 60853 series to realign and unify definitions, eliminate inconsistencies and to improve cross-use of the different parts of both IEC 60287 and IEC 60853 series;
b) introduction of corrective factors on relevant calculated physical characteristics to take into account the effect of multicore lay-lengths; a dedicated annex to highlight correction factors for different number of cores has been introduced (Annex A).

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

Draft	Report on voting
20/2096/FDIS	20/2103/RVD

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

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

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

A list of all parts in the IEC 60287 series, published under the general title *Electric cables – Calculation of the current rating*, can be found on the IEC website.

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

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

INTRODUCTION

This part of IEC 60287 contains formulae for the quantities R_C, W_d, λ_1 and λ_2.

It contains methods for calculating the permissible current rating of cables from details of the permissible temperature rise, conductor resistance, losses and thermal resistivities.

Formulae for the calculation of losses are also given.

The formulae in this document contain quantities which vary with cable design and materials used. The values given in the tables are either internationally agreed, for example, electrical resistivities and resistance temperature coefficients, or are those which are generally accepted in practice, for example, thermal resistivities and permittivities of materials. In this latter category, some of the values given are not characteristic of the quality of new cables but are considered to apply to cables after a long period of use. In order that uniform and comparable results can be obtained, the current ratings should be calculated with the values given in this document. However, where it is known with certainty that other values are more appropriate to the materials and design, then these may be used, and the corresponding current rating declared in addition, provided that the different values are quoted.

Quantities related to the operating conditions of cables are liable to vary considerably from one country to another. For instance, with respect to the ambient temperature and soil thermal resistivity, the values are governed in various countries by different considerations. Superficial comparisons between the values used in the various countries can lead to erroneous conclusions if they are not based on common criteria: for example, there can be different expectations for the life of the cables, and in some countries design is based on maximum values of soil thermal resistivity, whereas in others average values are used. Particularly, in the case of soil thermal resistivity, it is well known that this quantity is very sensitive to soil moisture content and can vary significantly with time, depending on the soil type, the topographical and meteorological conditions, and the cable loading.

The following procedure for choosing the values for the various parameters should, therefore, be adopted.

Numerical values should preferably be based on results of suitable measurements. Often such results are already included in national specifications as recommended values, so that the calculation can be based on these values generally used in the country in question; a survey of such values is given in IEC 60287-3-1.

A suggested list of the information required to select the appropriate type of cable is given in IEC 60287-3-1.

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General

1 Scope

This part of IEC 60287 is applicable to the conditions of steady-state operation of cables at all alternating voltages, and direct voltages up to 5 kV, buried directly in the ground, in ducts, troughs or in steel pipes, both with and without partial drying-out of the soil, as well as cables in air. The term "steady state" is intended to mean a continuous constant current (100 % load factor) just sufficient to produce asymptotically the maximum conductor temperature, the surrounding ambient conditions being assumed constant.

This document provides formulae for current ratings and losses.

The formulae given are essentially literal and designedly leave open the selection of certain important parameters. These can be divided into three groups:

– parameters related to construction of a cable (for example, thermal resistivity of insulating material) for which representative values have been selected based on published work;
– parameters related to the surrounding conditions, which can vary widely, the selection of which depends on the country in which the cables are used or will be used;
– parameters which result from an agreement between manufacturer and user and which involve a margin for security of service (for example, maximum conductor temperature).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60228, *Conductors of insulated cables*

IEC 60287-1-3, *Electric cables – Calculation of the current rating – Part 1-3: Current rating equations (100 % load factor) and calculation of losses – Current sharing between parallel single-core cables and calculation of circulating current losses*

IEC 60287-2-1:2023, *Electric cables – Calculation of the current rating – Part 2-1: Thermal resistance – Calculation of the thermal resistance*