®

Edition 2.0 2023-05

INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-6973-2

CONTENTS

FOREWORD ... 3
INTRODUCTION ... 5
1 Scope ... 6
2 Normative references ... 6
3 Terms, definitions and symbols ... 6
3.1 Terms and definitions ... 6
3.2 Symbols ... 6
4 Description of method ... 7
4.1 General ... 7
4.2 Outline of method ... 8
4.3 Matrix solution ... 11
Annex A (informative) Example calculations ... 12
A.1 Overview ... 12
A.2 Example 1 ... 12
A.2.1 General ... 12
A.2.2 Calculations ... 13
A.3 Example 2 ... 18
A.4 Example 3 ... 18
A.5 Example 4 ... 19
Annex B (informative) Example of the computation of the coefficient α for hollow core conductors ... 20
Bibliography ... 21

Figure B.1 – Representation of a hollow core conductor ... 20

Table 1 – Values of α for conductors ... 10
Table A.1 – Sheath loss factor calculation according to IEC 60287-1-1 ... 13
Table A.2 – Sheath current and sheath loss factor calculation per phase ... 15
Table A.3 – Calculated values of $d_{\mathrm{i,k}}$ ... 16
Table A.4 – Calculated values of zz ... 16
Table A.5 – Array $[Z]$ including coefficients for currents ... 17
Table A.6 – Sheath current and sheath loss factor calculation per phase ... 18
Table A.7 – Sheath current and sheath loss factor calculation per phase ... 19
Table A.8 – Sheath current and sheath loss factor calculation per phase ... 19

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

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

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 60287-1-3 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This second edition cancels and replaces the first edition published in 2002. This edition constitutes a technical revision.

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

a) Change and update of list of symbols.

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

Draft	Report on voting
20/2098/FDIS	20/2105/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

When single-core cables are installed in parallel, it is possible that the load current will not share equally between the parallel cables. The circulating currents in the sheaths of the parallel cables will also differ. This is because a significant proportion of the impedance of large conductors is due to self reactance and mutual reactance. Hence the spacing and relative location of each cable will have an effect on the current sharing and the circulating currents. The currents are also affected by phase rotation. The method described in this document can be used to calculate the current sharing between conductors as well as the circulating current losses.

There is no simple rule by which the circulating current losses of parallel cables can be estimated. Calculation for each cable configuration should be applied. The principles and impedance formulae involved are straightforward but the difficulty arises in solving the large number of simultaneous equations generated. The number of equations to be solved generally precludes the use of manual calculations and solution by computer is recommended. For n_c cables per phase having metallic sheaths in a three-phase system there are $6 \cdot n_c$ equations containing the same number of complex variables.

For simplicity the equations set out in this document assume that the parallel conductors all have the same cross-sectional area. If this is not the case, the equations should be adapted to allow for different resistances for each conductor. The effect of neutral and earth conductors can also be calculated by including these conductors in the appropriate loops. The method set out in this document does not take account of any portion of the sheath circulating currents that can flow through the earth or other extraneous paths. In this respect, the effect of earth return path has been excluded for the purposes of the methodology described in the following, as it is concluded that it can affect the magnitude of the resulting circulating currents only by a small extent on a limited number of cases, where both very low soil electrical resistivity values and low earthing conductor resistance values are simultaneously considered.

The conductor currents and sheath circulating currents in parallel single-core cables are unlikely to be equal. Because of this, the external thermal resistance for buried parallel cables should be calculated using the method set out in IEC 60287-2-1:2023, 4.2.3.2. Because the external thermal resistance and sheath temperatures are functions of the power dissipation from each cable in the group an iterative procedure to determine the circulating current losses and the external thermal resistance should be adopted.

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

1 Scope

This part of IEC 60287 provides a method for calculating the phase currents and circulating current losses in single-core cables arranged in parallel.

The method described in this document can be used for any number of cables per phase in parallel in any physical layout. The phase currents can be calculated for any arrangement of sheath bonding. For the calculation of sheath losses, it is assumed that the sheaths are bonded at both ends. A method for calculating sheath eddy current losses in two circuits in flat formation is given in IEC 60287-1-2.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and symbols

3.1 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.2 Symbols

d_{c} external diameter of the conductor, mm

d_{s} mean diameter of sheath or screen, mm

f system frequency, Hz

n_{c} number of cables per phase

D_{mn} axial spacing between conductors, mm

$[I]$ support vector used in the calculation of current in 4.3

$I_{n\text{c}}$ current in the conductor of cable n_{c}, A

$I_{\text{s}n\text{c}}$ circulating current in the sheath of cable n_{c}, A

$[Q]$ support matrix used in the calculation of current in 4.3

R resistance of a conducting element, Ω/m

R_{c} AC resistance of conductor at maximum operating temperature, Ω/m