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COMMENTED VERSION

INTERNATIONAL STANDARD



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD	4
INTRODUCTION	7
1 Scope	8
2 Normative references	8
3 Terms, definitions and symbols	9
3.1 Terms and definitions	9
3.2 Symbols	9
4 Calculation of thermal resistances	12
4.1 Thermal resistance of the constituent parts of a cable, T_1 , T_2 and T_3	12
4.1.1 General	12
4.1.2 Thermal resistance between one conductor and sheath T_1	12
4.1.3 Thermal resistance of any generic annular layer	16
4.1.4 Thermal resistance between sheath and armour T_2	17
4.1.5 Thermal resistance of outer covering (serving) T_3	17
4.1.6 Pipe-type cables	18
4.2 External thermal resistance T_4	18
4.2.1 Cables laid in free air	18
4.2.2 Single isolated buried cable	20
4.2.3 Groups of buried cables (not touching)	21
4.2.4 Groups of buried cables (touching) equally loaded	24
4.2.5 Buried pipes	26
4.2.5 Cables in buried troughs	26
4.2.6 Cables in ducts or pipes	27
4.2.7 Cables or conduits laid in a medium of different thermal resistivity	28
5 Digital calculation of quantities given graphically	30
5.1 General	30
5.2 Geometric factor G for two-core belted cables with circular conductors	30
5.3 Geometric factor G for three-core belted cables with circular conductors	32
5.4 Thermal resistance of three-core screened cables with circular conductors compared to that of a corresponding unscreened cable	33
5.5 Thermal resistance of three-core screened cables with sector-shaped conductors compared to that of a corresponding unscreened cable	35
5.6 Curve for \bar{G} for obtaining the thermal resistance of the filling material between the sheaths and armour of SL and SA type cables	36
5.7 Calculation of $\Delta\theta_s$ by means of a diagram	37
Annex A (informative) Correction factor for increased lengths of individual cores within multicore cables	52
Bibliography	53
List of comments	54
Figure 1 – Diagram showing a group of q cables and their reflection in the ground-air surface	42

Figure 2 – Geometric factor G for two-core belted cables with circular conductors (see 4.1.2.2.2)	43
Figure 3 – Geometric factor G for three-core belted cables with circular conductors (see 4.1.2.2.4)	44
Figure 4 – Thermal resistance of three-core screened cables with circular conductors compared to that of a corresponding unscreened cable (see 4.1.2.3.1)	45
Figure 5 – Thermal resistance of three-core screened cables with sector-shaped conductors compared to that of a corresponding unscreened cable (see 4.1.2.3.3).....	46
Figure 6 – Geometric factor \bar{G} for obtaining the thermal resistances of the filling material between the sheaths and armour of SL and SA type cables (see 4.1.2.5).....	47
Figure 7 – Heat dissipation coefficient for black surfaces of cables in free air, laying conditions 1 to 4.....	48
Figure 8 – Heat dissipation coefficient for black surfaces of cables in free air, laying conditions 5 to 8.....	49
Figure 9 – Heat dissipation coefficient for black surfaces of cables in free air, laying conditions 9 and 10	50
Figure 10 – Graph for the calculation of external thermal resistance of cables in air	51
Table 1 – Thermal resistivities of materials	39
Table 2 – Extended values of the geometric factor for duct banks and backfills	40
Table 3 – Values for constants Z , E and ϵC_g for black surfaces of cables in free air.....	40
Table 4 – Absorption coefficient of solar radiation for cable surfaces	41
Table 5 – Values of constants U , V and Y	42
Table A.1 – Values of C_{fL} for different cases	52

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

Part 2-1: Thermal resistance – Calculation of thermal resistance

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.
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- 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 60287-2-1:2023 edition 3.0 allows the user to identify the changes made to the previous IEC 60287-2-1:2015 edition 2.0. 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 60287-2-1 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 2015. 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) improvement in the identification of tabulated materials and introduction of new materials in the tables;
- c) introduction of generic annular layers to improve thermal modelling of existing and future cables designs;
- d) improved calculation of T_4 in the case of directly buried cables;
- e) 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);
- f) improved description and formulation for the case of cables in pipe and backfill;
- g) redefinition of the calculation method of T_4 for duct banks where $y/x > 3$, the new table based method eliminates errors, extends the usability of the new formulation while keeping a suitable conservative margin in the calculation.

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

Draft	Report on voting
20/2099/FDIS	20/2106/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

The IEC 60287 series has been divided into three parts so that revisions of, and additions to the document can be carried out more conveniently.

Each part is subdivided into subparts which are published as separate standards.

Part 1: Formulae of ratings and power losses;

Part 2: Formulae for thermal resistance;

Part 3: Operating conditions.

This part of IEC 60287-2 contains methods for calculating the internal thermal resistance of cables and the external thermal resistance for cables laid in free air, ducts and buried.

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 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 2-1: Thermal resistance – Calculation of thermal resistance

1 Scope

This part of IEC 60287 is solely 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, in 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 thermal resistance.

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).

Equations given in this document for calculating the external thermal resistance of a cable buried directly in the ground or in a buried duct are for a limited number of installation conditions. Where analytical methods are not available for calculation of external thermal resistance finite element methods ~~may~~ can be used. Guidance on the use of finite element methods for calculating cable current ratings is given in IEC TR 62095.

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 60287-1-1:2006/2023, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*
~~IEC 60287-1-1:2006/AMD1:2014~~

IEC 60853-2, *Calculation of the cyclic and emergency current rating of cables – Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages*

INTERNATIONAL STANDARD

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



CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms, definitions and symbols	8
3.1 Terms and definitions.....	8
3.2 Symbols.....	8
4 Calculation of thermal resistances	11
4.1 Thermal resistance of the constituent parts of a cable, T_1 , T_2 and T_3	11
4.1.1 General	11
4.1.2 Thermal resistance between one conductor and sheath T_1	11
4.1.3 Thermal resistance of any generic annular layer	15
4.1.4 Thermal resistance between sheath and armour T_2	15
4.1.5 Thermal resistance of outer covering (serving) T_3	16
4.1.6 Pipe-type cables	17
4.2 External thermal resistance T_4	17
4.2.1 Cables laid in free air.....	17
4.2.2 Single isolated buried cable	19
4.2.3 Groups of buried cables (not touching)	19
4.2.4 Groups of buried cables (touching) equally loaded.....	22
4.2.5 Cables in buried troughs.....	24
4.2.6 Cables in ducts or pipes	24
4.2.7 Cables or conduits laid in a medium of different thermal resistivity	26
5 Digital calculation of quantities given graphically	27
5.1 General.....	27
5.2 Geometric factor G for two-core belted cables with circular conductors	27
5.3 Geometric factor G for three-core belted cables with circular conductors	28
5.4 Thermal resistance of three-core screened cables with circular conductors compared to that of a corresponding unscreened cable	29
5.5 Thermal resistance of three-core screened cables with sector-shaped conductors compared to that of a corresponding unscreened cable.....	30
5.6 Curve for \bar{G} for obtaining the thermal resistance of the filling material between the sheaths and armour of SL and SA type cables	31
5.7 Calculation of $\Delta\theta_S$ by means of a diagram.....	32
Annex A (informative) Correction factor for increased lengths of individual cores within multicore cables.....	46
Bibliography.....	47
Figure 1 – Diagram showing a group of q cables and their reflection in the ground-air surface	36
Figure 2 – Geometric factor G for two-core belted cables with circular conductors (see 4.1.2.2.2)	37
Figure 3 – Geometric factor G for three-core belted cables with circular conductors (see 4.1.2.2.4)	38
Figure 4 – Thermal resistance of three-core screened cables with circular conductors compared to that of a corresponding unscreened cable (see 4.1.2.3.1).....	39

Figure 5 – Thermal resistance of three-core screened cables with sector-shaped conductors compared to that of a corresponding unscreened cable (see 4.1.2.3.3).....	40
Figure 6 – Geometric factor \bar{G} for obtaining the thermal resistances of the filling material between the sheaths and armour of SL and SA type cables (see 4.1.2.5).....	41
Figure 7 – Heat dissipation coefficient for black surfaces of cables in free air, laying conditions 1 to 4	42
Figure 8 – Heat dissipation coefficient for black surfaces of cables in free air, laying conditions 5 to 8	43
Figure 9 – Heat dissipation coefficient for black surfaces of cables in free air, laying conditions 9 and 10.....	44
Figure 10 – Graph for the calculation of external thermal resistance of cables in air	45
Table 1 – Thermal resistivities of materials	33
Table 2 – Extended values of the geometric factor for duct banks and backfills.....	34
Table 3 – Values for constants Z , E and C_g for black surfaces of cables in free air	35
Table 4 – Absorption coefficient of solar radiation for cable surfaces	36
Table 5 – Values of constants U , V and Y	36
Table A.1 – Values of C_{fL} for different cases	46

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

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- c) introduction of generic annular layers to improve thermal modelling of existing and future cables designs;
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Part 2: Formulae for thermal resistance;

Part 3: Operating conditions.

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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 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 2-1: Thermal resistance – Calculation of thermal resistance

1 Scope

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This document provides formulae for thermal resistance.

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).

Equations given in this document for calculating the external thermal resistance of a cable buried directly in the ground or in a buried duct are for a limited number of installation conditions. Where analytical methods are not available for calculation of external thermal resistance finite element methods can be used. Guidance on the use of finite element methods for calculating cable current ratings is given in IEC TR 62095.

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 60287-1-1:2023, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*

IEC 60853-2, *Calculation of the cyclic and emergency current rating of cables – Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages*