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

INTERNATIONAL
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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.
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This Redline version is not an official IEC Standard and is intended only to provide the user with an indication of what changes have been made to the previous version. Only the current version of the standard is to be considered the official document.

This Redline version provides you with a quick and easy way to compare all the changes between this standard and its previous edition. A vertical bar appears in the margin wherever a change has been made. Additions and deletions are displayed in red, with deletions being struck through.

This is a preview of "S+ IEC 60287-2-1 Ed...". Click here to purchase the full version from the ANSI store.

International Standard IEC 60287-2-1 has been prepared by IEC technical committee 20: Electric cables.

This second edition of IEC 60287-2-1 cancels and replaces the first edition, published in 1994, Amendment 1:2001, Amendment 2:2006 and Corrigendum 1:2008. The document 20/1448/CDV, circulated to the National Committees as Amendment 3, led to the publication of this new edition. This edition constitutes a technical revision.

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

- a) inclusion of a reference to the use of finite element methods where analytical methods are not available for the calculation of external thermal resistance;
- b) explanation about SL and SA type cables;
- c) calculation method for T3 for unarmoured three-core cables with extruded insulation and individual copper tape screens on each core;
- d) change of condition for X in 5.4;
- e) inclusion of constants or installation conditions for water filled ducts in Table 4.

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

FDIS	Report on voting
20/1561/FDIS	20/1588/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.

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 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.

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 publication using a colour printer.

INTRODUCTION

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

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

Part 1: Formulae of ratings and power losses

Part 2: Formulae for thermal resistance

Part 3: ~~Sections on~~ 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 standard 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 be obtained, the current ratings should be calculated with the values given in this standard. 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 lead to erroneous conclusions if they are not based on common criteria: for example, there may 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 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—General

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 part of IEC 60287 provides formulae for thermal resistance.

The formulae given are essentially literal and designedly leave open the selection of certain important parameters. These may 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 vary widely, the selection of which depends on the country in which the cables are used or are to 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 part of IEC 60287 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 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, 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 60287-1-1:2006, *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*

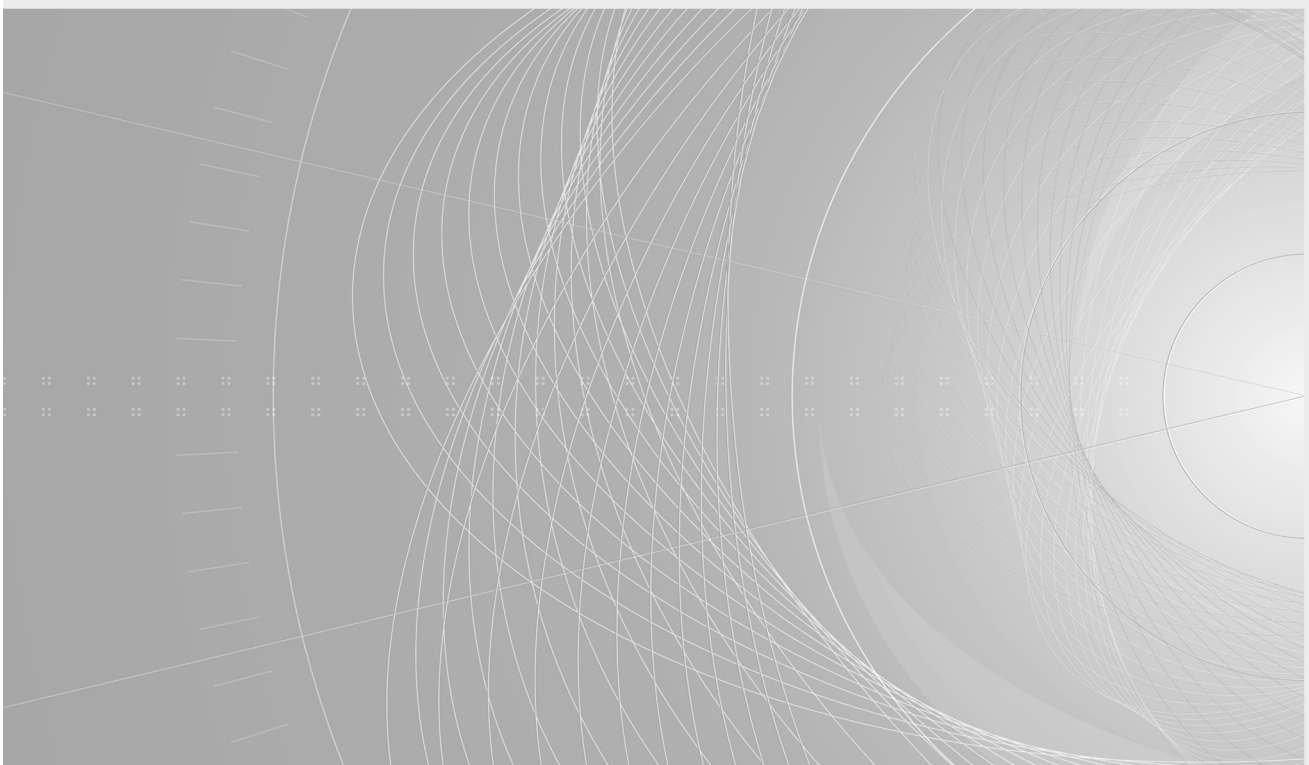


INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Câbles électriques – Calcul du courant admissible –
Partie 2-1: Résistance thermique – Calcul de la résistance thermique**



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ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

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

1 Scope

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- parameters related to the surrounding conditions which may vary widely, the selection of which depends on the country in which the cables are used or are to 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 part of IEC 60287 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 be used. Guidance on the use of finite element methods for calculating cable current ratings is given in IEC TR 62095.

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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*

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

CÂBLES ÉLECTRIQUES – CALCUL DU COURANT ADMISSIBLE –

Partie 2-1: Résistance thermique – Calcul de la résistance thermique

AVANT-PROPOS

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La présente Norme internationale IEC 60287-2-1 a été établie par le comité d'études 20 de l'IEC: Câbles électriques.

Cette seconde édition de l'IEC 60287-2-1 annule et remplace la première édition, publiée en 1994, l'Amendement 1:2001, l'Amendement 2:2006 et le Corrigendum 1:2008. Le document 20/1448/CDV, circulé comme Amendement 3 auprès des Comités nationaux de l'IEC, a conduit à la publication de cette nouvelle édition.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

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- a) ajout d'une référence à l'utilisation des méthodes des éléments finis dans le cas où des méthodes analytiques ne sont pas disponibles pour le calcul de la résistance thermique externe;
- b) explication sur les câbles triplombs et sous gaines d'aluminium individuelles;
- c) méthode de calcul de T3 pour les câbles tripolaires non armés à isolation extrudée et écrans individuels constitués de bandes en cuivre disposés sur chaque conducteur;
- d) changement de condition de X en 5.4;
- e) ajout des valeurs des constantes ou conditions d'installation des fourreaux remplis d'eau au Tableau 4.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
20/1561/FDIS	20/1588/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60287, publiées sous le titre général *Câbles électriques – Calcul du courant admissible*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "<http://webstore.iec.ch>" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

INTRODUCTION

L'IEC 60287 a été divisée en trois parties de manière à faciliter les révisions et les adjonctions au document.

Chaque partie est subdivisée en sous-parties qui sont publiées en tant que normes séparées.

Partie 1: Formules de l'intensité du courant admissible et pertes de puissance

Partie 2: Formules relatives à la résistance thermique

Partie 3: Conditions de fonctionnement

La présente partie de l'IEC 60287-2 contient des méthodes de calcul de la résistance thermique interne des câbles, et de la résistance thermique externe des câbles posés à l'air libre, des câbles enterrés et des canaux.

Les formules de cette norme contiennent des paramètres variant avec la spécification du câble et les matériaux utilisés. Les valeurs données dans les tableaux sont soit approuvées au niveau international, comme les résistivités électriques et les coefficients de température à résistance, soit les valeurs généralement acceptées dans la pratique, comme les résistivités thermiques et les permittivités des matériaux. Certaines des valeurs de la dernière catégorie ne sont pas caractéristiques de la qualité des câbles neufs, mais de celles des câbles ayant déjà subi une longue période d'utilisation. Dans le but d'obtenir des résultats comparables et reproductibles, il convient de calculer les caractéristiques assignées du courant avec les valeurs indiquées dans la présente norme. Toutefois, lorsqu'on sait avec certitude que d'autres valeurs sont plus appropriées aux matériaux et à leur conception, ces dernières peuvent alors être utilisées en déclarant les caractéristiques assignées correspondantes du courant, à condition que les différentes valeurs soient indiquées.

Les grandeurs relatives aux conditions de fonctionnement des câbles sont susceptibles de varier considérablement d'un pays à l'autre. Par exemple, pour ce qui est de la température ambiante et de la résistivité thermique du sol, les valeurs sont régies dans les différents pays par diverses considérations. Des comparaisons hâtives entre les valeurs utilisées dans les différents pays peuvent donner lieu à des conclusions erronées, si elles ne reposent pas sur des critères communs; par exemple, on peut prévoir différentes valeurs d'espérance de vie des câbles; de même, dans certains pays, la conception est fondée sur la valeur maximale de la résistivité thermique du sol, tandis que dans d'autres c'est la valeur moyenne qui est utilisée. En particulier, dans le cas de la résistivité thermique du sol, il est bien connu que celle-ci est très sensible au taux d'humidité et peut varier sensiblement dans le temps suivant le type de sol, les conditions topographiques et météorologiques et la charge du câble.

Il convient dès lors d'effectuer le choix des valeurs des différents paramètres de la façon suivante:

Les valeurs numériques devront, de préférence, être basées sur des résultats de mesures valables. De tels résultats sont déjà souvent inclus dans les spécifications nationales sous forme de valeurs recommandées, de telle sorte que le calcul peut être exécuté sur la base de ces valeurs généralement utilisées dans le pays en question; un examen de ces valeurs figure dans l'IEC 60287-3-1.

On trouvera un choix d'informations nécessaires pour sélectionner le type de câble approprié dans l'IEC 60287-3-1.

CABLES ÉLECTRIQUES – CALCUL DU COURANT ADMISSIBLE –

Partie 2-1: Résistance thermique – Calcul de la résistance thermique

1 Domaine d'application

La présente partie de l'IEC 60287 s'applique uniquement au fonctionnement en régime permanent des câbles de toutes tensions alternatives et de tensions continues jusqu'à 5 kV, enterrés directement dans le sol, placés dans des fourreaux, des caniveaux ou des tubes d'acier, avec ou sans assèchement partiel du sol, ainsi que les câbles posés à l'air libre. On entend par "régime permanent" la circulation continue d'un courant constant (facteur de charge 100 %) juste suffisant pour atteindre asymptotiquement la température maximale de l'âme en supposant que les conditions du milieu ambiant restent inchangées.

La présente partie de l'IEC 60287 fournit des formules pour la résistance thermique.

Les formules proposées sont essentiellement littérales et laissent en principe libre le choix de certains paramètres importants. Ceux-ci peuvent être divisés en trois groupes:

- les paramètres liés à la constitution du câble (par exemple résistivité thermique de l'isolant) pour lesquels des valeurs représentatives ont été recueillies, à partir des travaux publiés;
- les paramètres liés aux conditions du milieu ambiant qui peuvent varier considérablement, dont le choix dépend du pays dans lequel les câbles sont ou doivent être utilisés;
- les paramètres résultant d'un accord entre fabricant et utilisateur et qui supposent une marge de sécurité en service (par exemple température maximale du conducteur).

Les équations figurant dans cette partie de l'IEC 60287 pour le calcul de la résistance thermique externe d'un câble enterré directement dans le sol, ou dans un conduit enterré concernent un nombre limité de conditions d'installation. Dans le cas où des méthodes analytiques ne sont pas disponibles pour le calcul de la résistance thermique externe, les méthodes des éléments finis peuvent être utilisées. Les lignes directrices relatives à l'utilisation des méthodes des éléments finis pour le calcul des caractéristiques assignées du courant de câble sont fournies dans l'IEC TR 62095.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60287-1-1:2006, *Câbles électriques – Calcul du courant admissible – Partie 1-1: Equations de l'intensité du courant admissible (facteur de charge 100 %) et calcul des pertes – Généralités*

IEC 60287-1-1:2006/AMD1:2014

IEC 60853-2, *Calcul des capacités de transport des câbles pour les régimes de charge cycliques et de surcharge de secours – Partie 2: Régime cyclique pour des câbles de tensions supérieures à 18/30 (36) kV et régimes de secours pour des câbles de toutes tensions*