

# INTERNATIONAL STANDARD



Electric cables – Calculation of the current rating –  
Part 3-1: ~~Sections on~~ Operating conditions – Site reference ~~operating~~ conditions  
~~and selection of cable type~~

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INTERNATIONAL  
ELECTROTECHNICAL  
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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRIC CABLES –  
CALCULATION OF THE CURRENT RATING –****Part 3-1: ~~Sections on~~ Operating conditions –  
Site reference ~~operating conditions and selection of cable type~~**

## FOREWORD

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

This second edition cancels and replaces the first edition published in 1995 and Amendment 1:1999. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

- a) the updated list of national laying conditions is now covered in Annex A;
- b) Clause 5 about the information required from the purchaser for the selection of the appropriate type of cable has been removed.

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

FDIS	Report on voting
20/1714/FDIS	20/1730/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 reader's attention is drawn to the fact that Annex A lists all of the “in-some-country” clauses on differing practices of a less permanent nature relating to the subject of this standard.

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- withdrawn,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.

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## 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 subparts which are published as separate standards.

Part 1: Formulae for ratings (100 % load factor) and power losses

Part 2: Formulae for thermal resistance

Part 3: ~~Sections on~~ Operating conditions

This part of IEC 60287-3 contains reference ambient temperatures and thermal resistivities of soil in various countries. ~~Also in this section is an outline of the information required from the purchaser for the selection of the appropriate type of cable.~~

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 this part of IEC 60287-3.

## ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

### Part 3-1: ~~Sections on~~ Operating conditions – Site reference ~~operating conditions and selection of cable type~~

#### 1 Scope

This part of IEC 60287-3 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 section concerns reference operating conditions and selection of cable type.~~

This document defines site reference conditions, however the general values are superseded by specific national requirements.

#### 2 Normative references

~~The following normative document contains provisions which, through reference in this text, constitute provisions of this section of IEC 60287-3. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 60287-3 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.~~

~~IEC 60183:1984, *Guide to the selection of high-voltage cables*  
Amendment 1 (1990)~~

There are no normative references in this document.

#### 3 Terms and definitions

No terms and definitions are listed in this document.

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

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

#### 4 Reference ambient temperatures and thermal resistivities of soil in various countries

##### 4.1 ~~Standard~~ Operating conditions – Site reference conditions

In order to use the formulae given in the various parts of IEC 60287, numerical values for the physical quantities should be chosen relating to the operating conditions.

It is obviously possible to compare the results of two calculations of current rating only when the assumptions made and the numerical values of the parameters are known.

In particular, the quantities related to the operating conditions of cables are ~~liable~~ likely to vary considerably from one country to another. An enquiry into this subject has been carried out and a number of countries have replied.

Annex A summarizes the operating conditions used in various countries. Attention is drawn to the fact that the information in Annex A is intended only as a guide for cable installation designers when data provided by a user is incomplete. Care ~~must~~ should be taken not to draw unjustified conclusions from comparisons of values for different countries. It should be remembered that the values adopted in any particular country are governed by many factors some of which might not be of equal importance in other countries.

Values relating to the operating conditions are given in Annex A for the following countries:

Australia	Italy	Portugal
Austria	Japan	Spain
Canada	Mexico	South Africa
China	Netherlands	Sweden
Egypt	New Zealand	Switzerland
Finland	Norway	United Kingdom
France	Oman	United States of America
Germany	Poland	

## 4.2 Procedure when values are not provided in national tables

### 4.2.1 General

It is recommended that when there is no value laid down in the national tables for the reference ambient temperature, thermal resistivity of the soil or solar radiation, the values given in 4.2.2, 4.2.3 and 4.2.4 should be adopted.

### 4.2.2 Ambient temperatures at sea level

See Table 1.

**Table 1 – Ambient temperatures at sea level**

Climate	Ambient air temperature		Ambient ground temperature at a depth of 1 m	
	Min. °C	Max. °C	Min. °C	Max. °C
Tropical	25	55	25	40
Subtropical	10	40	15	30
Temperate	0	25	10	20

It is essential that current ratings should be valid for the maximum temperatures given. The lower values are for winter ratings if required. The values correspond with the temperature limits of winter and summer, alternatively rainy and dry seasons.

When no information about the depth of laying is given, the standard depth is to be taken as 1 m.

### 4.2.3 Thermal resistivity of soil

See Table 2.

**Table 2 – Thermal resistivity of soil**

<b>Thermal resistivity</b> K·m/W	<b>Soil conditions</b>	<b>Weather conditions</b>
0,7	Very moist	Continuously moist
1,0	Moist	Regular rainfall
2,0	Dry	Seldom rains
3,0	Very dry	Little or no rain

**4.2.4 Solar radiation**

When no information about the intensity of solar radiation a value of 1 000 W/m<sup>2</sup> is adopted.

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## Annex A (informative)

### Values relating to the operating conditions in various countries

#### A.1 Australia

<i>Standard conditions</i> Thermal characteristics of the soil		
Soil Thermal resistivity, nominal	1,2	K·m/W
Soil ambient temperature, summer	25	°C
Soil ambient temperature, winter	18	°C
<b>Depth of laying of cables <sup>a</sup></b>		
<b>Voltage range 1:</b> L.V. cables		
under footways	0,5	m
under roadways	0,75	m
<b>Voltage range 2:</b> 11 kV cables		
under footways and roadways	0,8	m
<b>Voltage range 3:</b> 33 kV cables and higher voltages		
under footways and roadways	1,0	m
<b>Air ambient temperature</b>		
Maximum, summer	+40	°C
Maximum, winter	+30	°C
<sup>a</sup> Measured from the ground surface to the centre of the cable, or to the centre of a trefoil group.		

**A.2 Austria**

<b>Thermal characteristics of the soil</b>		
<i>Thermal resistivity:</i>	0,7 K.m/W	
up to 30 kV, average value	1,0 K.m/W	
30 kV, average value	(max. 1,2; min. 0,7 K.m/W)	
Thermal resistivity, nominal, season 1 (wet)	1,0	K.m/W
Thermal resistivity, dry zone, season 1 (dry)	2,5	K.m/W
<b>Temperature:</b>		
maximum value	20 °C	
minimum value	0 °C	
Temperature, season 1	20	°C
<b>Depth of laying for buried of cables</b>		
All cables up to 1 kV	700 mm	
All cables up to 10 kV	800 mm	
Paper-insulated cables 10 kV	1 000 mm	
Oil-filled cables up to 220 kV	1 200 mm	
Voltage range 1: up to 1 kV	0,7	m
Voltage range 2: > 1 kV up to 30 kV	0,8	m
Voltage range 3: > 30 kV	1,2	m
<b>Air ambient temperature</b>		
Average value	20	°C
Maximum	+40	°C
Minimum	-20	°C

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### A.3 Canada

There are no recognized Canadian national values of soil thermal resistivity and temperature, and depth of laying, however the values shown below are typical. It is recommended that, where feasible, soil tests are performed for cable installations.

<b>Thermal characteristics of the soil <del>for cables directly buried or in ducts</del></b>		
<i>Thermal resistivity:</i>		
<del>maximum value</del>	1,2 K.m/W	
<del>minimum value</del>	0,6 K.m/W	
<del>average value</del>	0,9 K.m/W	
Thermal resistivity, nominal (Critical temperature 50 °C)	0,5 to 3,0	K·m/W
Temperature, season 1 (summer)	20 25	°C
Temperature, season 2 (winter)	-5	°C
<del>average value</del>	<del>not used as a design basis</del>	
<b>Depth of laying of cables (minimum cover)</b>		
Paper insulated, solid and non-draining cables for voltages up to 69 kV	1,1	m
Solid insulation (butyl, ethylene propylene rubber, p.v.c., cross-linked polyethylene, etc.) cables for voltages up to 46 kV	0,9	m
Oil filled cables for voltages up to 345 kV	1,1	m
Pipe-type (gas or oil pressure) cables for voltages up to 345 kV	1,1	m
<b>Air ambient temperature</b>		
Maximum	5 to 40	°C
Minimum	<del>-40</del> -55 to -20	°C
<b>Cyclic ratings</b>		
Critical temperature	50	°C
Drying out is not considered for cables in concrete duct banks		

Where direct measurements of soil thermal resistivity are not available, it is usual to assume a thermal resistivity of 0,9 K·m/W. However in cases where it is foreseen that there may be a progressive deterioration of the thermal characteristics of the environment over a period of years, and in cases where the climatic conditions may give rise to significant seasonal variations, it is recommended that the current-carrying capacity be based on a thermal resistivity of 1,2 K·m/W.

Reference is not made to lower values of resistivity, during winter, as a basis for system design to any significant extent.

### A.4 China

<b>Thermal characteristics of the soil</b>		
Thermal resistivity	1,0 to 1,2	K·m/W
Temperature, summer	30	°C
Temperature, winter	5	°C
<b>Depth of laying of cables</b>		
≤1 kV	0,7	m
>1 kV up to 35 kV	0,7	m
≥110 kV up to 500 kV	1,0	m
<b>Air ambient temperature</b>		
Maximum	40	°C
Minimum	-10	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

### A.5 Egypt

<b>Thermal characteristics of the soil</b>		
Thermal resistivity	1,2	K·m/W
Temperature, summer	35	°C
Temperature, winter	0	°C
<b>Depth of laying of cables</b>		
≤1 kV	0,4	m
>1 kV up to 35 kV	0,8	m
≥110 kV up to 500 kV <sup>a</sup>	1,2	m
<b>Air ambient temperature</b>		
Maximum	47	°C
Minimum	-5	°C
<b>Solar radiation</b>		
Intensity of solar radiation	≥1 000	W/m <sup>2</sup>
<sup>a</sup> Note at soil temperature 25 °C.		

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**A.6 Finland**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity		
Average value to be used for rating calculations.	1,0	K·m/W
For submarine cables where the soil is completely saturated with water	0,4	K·m/W
Temperature		
Maximum value	15	°C
Minimum value	0	°C
(average value 5 °C to 10 °C, exceptional maximum 20 °C)		
<b>Depth of laying of cables</b>		
All cables up to 36 kV	0,7	m
All cables up to 52 kV	1,0	m
All cables up to 123 kV	1,3	m
All cables up to 245 kV	1,5	m
The actual depth depends on local conditions		
<b>Air ambient temperature</b>		
Reference value for rating calculations	25	°C
Maximum value	35	°C
Minimum value	-20	°C

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## A.7 France

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, <i>nominal</i> , summer	1,20	K·m/W
Thermal resistivity, <i>nominal</i> , winter	0,85	K·m/W
<i>(for main connections at 225 kV and 400 kV direct measurements are carried out, and an artificial backfill is used if necessary in order to obtain the rated thermal resistivity)</i>		
Thermal resistivity, dry zone <sup>a</sup> , summer	2,5	K·m/W
Thermal resistivity, dry zone <sup>a</sup> , winter	2,5	K·m/W
Temperature, summer		
20 kV cables		
63 kV, 90 kV, 225 kV, <del>255 kV</del> and 400 kV cables	20	°C
hot area	25	°C
intermediate area	22	°C
cold area	20	°C
Temperature, winter		
20 kV cables		
63 kV, 90 kV, 225 kV, <del>255 kV</del> and 400 kV cables	10	°C
hot region	17	°C
intermediate region	15	°C
cold region	13	°C
<b>Depth of laying of cables</b>		
20 kV cables		
<del>1 400 mm in Paris, 800 mm to 1 400 mm generally in the provinces.</del>		
in Paris	1,0 to 1,2	m
outside Paris city	0,8	m
63 kV, 90 kV, 225 kV, <del>255 kV</del> and 400 kV cables		
<del>1 300 mm in trenches or in ducts, 700 mm in substations.</del>		
<i>The above figures representing the distance between the ground surface and the axis of the cable in the case of flat-laid cables and between the ground surface and the centre of the trefoil in the case of cables laid in trefoil formation.</i>		
<i>(These values may vary according to local regulations.)</i>		
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	20	°C
<b>Cyclic ratings</b>		
Critical temperature, summer	55	°C
Critical temperature, winter	60	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>
<sup>a</sup> Drying out of the soil is only considered for high voltage systems.		

## A.8 Germany

The indicated values are taken as a basis as standard values for current rating calculations unless there are any requirements specified for the thermal resistivity of the soil, the temperature and the depth of laying.

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value	1,0	K·m/W
Thermal resistivity, for calculations considering a dry zone near the cable – for the dry zone	2,5	K·m/W
Temperature, maximum value	20	°C
Temperature, minimum value	0	°C
Temperature, average value	10	°C
<b>Depth of laying of cables</b>		
For cables ≥ 60 kV	1,2	m
For cables < 60 kV	0,7 <sup>a</sup>	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	-20	°C
Average value	10	°C
<sup>a</sup> In spite of being calculated for 0,7 m, often cables at 20 kV to 30 kV are laid at 0,9 m to 1,0 m depth.		

## A.9 Italy

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, maximum value	1,0	K·m/W
If the thermal characteristics of the soil are found to be poor, a suitable backfill is used and reference is made to a thermal resistivity intermediate between that of the backfill and that of the surrounding soil.		
Temperature, maximum value (to be used in calculations)	20	°C
Temperature, minimum value	5	°C
<b>Depth of laying of cables <del>for directly buried cables</del></b>		
This depth is the maximum adopted unless otherwise specified.		
Up to 12 kV	0,8	m
Up to 17,5 kV	1,0	m
Up to 24 kV	1,2	m
Up to 36 kV	1,5	m
Up to 72 kV	1,8	m
Up to 220 kV	2,2	m
<b>Air ambient temperature</b>		
Maximum value (to be used in calculations)	30	°C
Minimum value	0	°C
Maximum daily excursion	20	°C

In summer, the maximum temperature may sometimes, for a few hours daily, be higher by 5 °C (and in special cases even more) than the above-mentioned maximum value. Such an occurrence is considered to be acceptable due to its short duration.

### A.10 Japan

<b>Thermal characteristics of the soil</b>		
<del>average value 1,0 K.m/W</del> (one manufacturer uses 1,2; 0,8 and 0,4 K.m/W for dry, normal and wet soil respectively).		
Thermal resistivity, nominal	1,0	K·m/W
1,5 K·m/W, 1,0 K·m/W and 0,6 K m/W for dry, normal and wet soil respectively. No distinction for seasons		
Temperature, summer	25	°C
<del>15 °C winter</del> minimum value <del>10 °C</del>		
<b>Depth of laying of cables</b>		
Direct burial:		
<del>paper and solid insulation up to 33 kV 1 200 mm</del>		
<del>oil-filled and pipe cables 1 500 mm</del>		
1,2 m for places where the pressure of vehicle or other heavy goods may be applied. 0,6 m for other places		
In duct:		
<del>less than 66 kV 1 200 mm</del>		
<del>66 kV and over 1 500 mm</del>		
the use of duct which withstands the pressure of vehicle or other heavy goods is required (there is no regulation for the depth of duct).		
<b>Air ambient temperature</b>		
Maximum, summer	40	°C
<del>30 °C winter</del>		
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

Japanese Cable Makers' Association Standard JCS 0501, gives the calculation formulae of thermal resistance of soil for a 2-layer model having two different thermal resistivities divided by the boundary such as ground water level. Therefore, the ground water level is one parameter for variations in thermal resistivity.

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## A.11 Mexico

### Thermal characteristics of the soil

#### Thermal resistivity, nominal season 1 (summer)

Southern Mexico	0,8 to 2,4	K·m/W
Central Mexico	1,0 to 2,5	K·m/W
Northern Mexico	0,5 to 4,0	K·m/W
Coast Mexico	0,5 to 3,0	K·m/W

#### Thermal resistivity, nominal season 2 (winter)

Southern Mexico	1,0 to 2,0	K·m/W
Central Mexico	1,3 to 2,1	K·m/W
Northern Mexico	0,8 to 3,6	K·m/W
Coast Mexico	0,8 to 2,7	K·m/W

#### Thermal resistivity, dry zone season 1 (summer)

Southern Mexico	1,4 to 3,9	K·m/W
Central Mexico	1,6 to 4,0	K·m/W
Northern Mexico	1,0 to 5,5	K·m/W
Coast Mexico	0,9 to 3,5	K·m/W

#### Thermal resistivity, dry zone season 2 (winter)

Southern Mexico	1,0 to 2,8	K·m/W
Central Mexico	1,0 to 3,0	K·m/W
Northern Mexico	0,8 to 4,7	K·m/W
Coast Mexico	0,6 to 2,9	K·m/W

Where direct measurements of soil thermal resistivity are not available, it is usual to assume a thermal resistivity of 1,5 K·m/W, however it is recommended that a survey of the thermal characteristics of the soil is carried out for critical cable links.

#### Temperature, season 1 (summer)

Southern Mexico	30	°C
Central Mexico	25	°C
Northern Mexico	35	°C
Coast Mexico	30	°C

#### Temperature, season 2 (winter)

Southern Mexico	25	°C
Central Mexico	20	°C
Northern Mexico	30	°C
Coast Mexico	25	°C

(Critical temperature 50 °C)

When soil temperature measurements are not available a reference value of 25 °C is often used for rating calculations

### A.11 Mexico (continued)

<b>Depth of laying of cables <sup>a b</sup></b>		
Voltage range 1: up to 1 kV cables (maximum 2 circuits)		
Under footways	0,3	m
Under roads	0,5	m
Voltage range 2: > 1 kV up to 35 kV cables (5 kV, 15 kV, 25 kV and 35 kV, maximum 4 circuits)		
Under footways	0,3	m
Under roads	0,5	m
Voltage range 3: > 35 kV up to 138 kV cables (69 kV, 85 kV, 115 kV and 138 kV, maximum 2 circuits)		
Only under roadways (normal terrain)	1,0	m
Only under roadways (phreatic zone or rock soils)	0,5	m
Voltage range 4: > 161 kV up to 230 kV cables (161 kV and 230 kV, maximum 2 circuits)		
Only under roadways (normal terrain)	1,2	m
Only under roadways (phreatic zone or rock soils)	0,7	m
Voltage range 5: ≥ 400 kV cables (maximum 2 circuits)		
Only under roadways (normal terrain)	1,4	m
Only under roadways (phreatic zone or rock soils)	0,9	m
<b>Air ambient temperature</b>		
Maximum (annually)		
Southern Mexico	25 to 35	°C
Central Mexico	20 to 26	°C
Northern Mexico	36 to 45	°C
Coast Mexico	26 to 36	°C
Minimum (annually)		
Southern Mexico	8 to 18	°C
Central Mexico	1 to 12	°C
Northern Mexico	-5 to +10	°C
Coast Mexico	12 to 20	°C
Average (annually)		
Southern Mexico	28	°C
Central Mexico	21	°C
Northern Mexico	30	°C
Coast Mexico	29	°C
<b>Cyclic ratings</b>		
Critical temperature or temperature rise	35 to 50	°C
The critical temperature is highly dependant on the soil composition and location. It may also vary due to seasonal influences and/or cyclic loading. It is recommended to investigate the critical temperature during a soil survey, unless it can be demonstrated that no drying out of the soil will occur.		

## A.11 Mexico (concluded)

### Solar radiation <sup>c</sup>

Intensity of solar radiation

Southern Mexico	650 to 850	W/m <sup>2</sup>
Central Mexico	700 to 900	W/m <sup>2</sup>
Northern Mexico	850 to 1 100	W/m <sup>2</sup>
Coast Mexico	800 to 1 000	W/m <sup>2</sup>

The values given above for soil thermal resistivity and temperature correspond to measurements made at different locations in Mexico at different depths (0,9 m, 1,2 m and 1,5 m). It is recommended that, where feasible, soil measurements are made for cable installations.

- <sup>a</sup> Measured from the ground surface to the top of the cable ducts, or to the top of a trefoil duct group. Cables are always laid in HDPE ducts.
- <sup>b</sup> Depths may be greater depending on any underground obstacles along the cable route.
- <sup>c</sup> Direct normal irradiance or beam solar radiation value, maximum annual values present for short time periods.

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## A.12 Netherlands

<b>Thermal characteristics of the soil</b>		
sub-soil water level near to cables — 0,5 K.m/W		
eastern part of the country — 0,8 K.m/W		
Thermal resistivity, nominal	1,00	K·m/W
It is recommended that a survey of the thermal characteristics of the soil is carried out for critical cable links.		
Thermal resistivity, dry zone	2,5	K·m/W
It is recommended that a survey of the thermal characteristics of the soil is carried out for critical cable links.		
Temperature, maximum	20	°C
Temperature, winter	5	°C
Temperature, average	15	°C
<b>Depth of laying for directly buried of cables</b>		
Cables up to 10 kV — 700 mm		
Cables above 10 kV — 1 000 mm		
Up to 30 kV	0,7 to 1,0	m
Above 30 kV	1,2	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	-5 to 10	°C
Average	20	°C
<b>Cyclic ratings</b>		
Critical temperature	30	°C
The critical temperature is highly dependent on soil composition and location. It may also vary due to seasonal influences and/or cyclic loading. It is recommended to investigate the critical temperature during a soil survey, unless it can be demonstrated that no drying out of the soil will occur.		
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

The two zone model is regularly used to calculate the current rating of MV cable systems and incidentally for HV systems. The parameter used to define the boundary between wet and dry zones is the absolute temperature, isotherm at this boundary, usually in the range between 30 °C (MV cables) and 50 °C (HV cables).

Cable circuits are taken to be thermally independent if the separation is not less than 3 m. For cables installed deeper than 3 m, such as in horizontal directional drilling, the minimum separation is not less than 5 m to consider a cable circuit as thermally independent.

### A.13 New Zealand

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
Soil ambient temperature, summer	15	°C
Soil ambient temperature, winter	15	°C
<b>Depth of laying of cables <sup>a</sup></b>		
This depth is the minimum adopted unless otherwise specified		
Voltage range 1: L.V.		
under footways	0,5	m
under roadways	0,75	M
Voltage range 2: 11kV		
under footways and roadways	1,0	m
Voltage range 3: 33kV and higher		
under footways and roadways	1,0	m
<b>Air ambient temperature</b>		
Maximum summer	+30	°C
Maximum winter	+30	°C
<sup>a</sup> Measured from the ground surface to the centre of the cable, or to the centre of a trefoil group.		

### A.14 Norway

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value to be used in calculations	1,0	K·m/W
Temperature, Southern Norway max./min.	17/0	°C
Temperature, Central Norway max./min.	15/0	°C
Temperature, Northern Norway max./min.	13/-5	°C
<b>Depth of laying of cables (minimum value)</b>		
1 kV	0,5	m
above 1 kV	0,7	m
<b>Air ambient temperature</b>		
Maximum value (to be used in calculations)	25	°C

### A.15 Oman

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	2,5	K·m/W
No distinction for seasons		
Temperature, maximum	40	°C
Temperature, minimum	10	°C
<b>Depth of laying of cables</b>		
All cables up to 1 kV	0,5	m
All cables above 1 kV	0,8	m
<b>Air ambient temperature</b>		
Maximum	55	°C
Minimum	10	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 200	W/m <sup>2</sup>

### A.16 Poland

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value to be used in calculations	<del>0,8</del> 1,0	K·m/W
Thermal resistivity, nominal, season 2		
Temperature, average value to be used in calculations	<del>15</del> 20	°C
Temperature, minimum value	5	°C
<b>Depth of laying of cables <del>for directly buried cables</del></b>		
<del>Paper-insulated and solid type cables</del>		
<del>up to 1 kV — 700 mm</del>		
<del>up to 15 kV — 800 mm</del>		
<del>Paper-insulated cables at voltages</del>		
<del>higher than 15 kV — 1 000 mm</del>		
<del>Oil-filled cables up to 110 kV — 1 000 mm</del>		
up to and including 36 kV	0,7	m
above 36 kV	1,0	m
<b>Air ambient temperature</b>		
Average value to be used in calculations	25	°C

## A.17 Portugal

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, summer	1,2	K·m/W
Thermal resistivity, nominal, winter	0,85	K·m/W
Thermal resistivity, nominal, submarine cables	1,0	K·m/W
Soil ambient temperature, summer	20	°C
Soil ambient temperature, winter	10	°C
<b>Depth of laying of cables</b>		
This depth is the minimum adopted unless otherwise specified		
Voltage range up to 1 kV	0,7	m
Voltage range up to 30 kV	1,0	m
Voltage range up to 400 kV	1,2	m
<b>Air ambient temperature</b>		
Air ambient temperature, summer (at sea level)	30	°C
Air ambient temperature, winter (at sea level)	20	°C
Air ambient temperature, minimum	0	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

## A.18 Spain

There are no recognized Spanish national values of soil thermal resistivities, ambient temperatures and depth of laying, the values shown below are typical

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, Cables ≤0,6/1 kV	1	K·m/W
Thermal resistivity, Cables >0,6/1 kV and ≤18/30 kV	1,5	K·m/W
Thermal resistivity, Cables >18/30 kV	1	K·m/W
Where concrete is used for the cable installation it should be considered for the calculation a value of 0,85 K m/W for the volume occupied by the concrete	0,85	K·m/W
Temperature	25	°C
<b>Depth of laying of cables</b>		
	0,6 to 1,5	m
<b>Air ambient temperature</b>		
Maximum	40	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

## A.19 South Africa

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
No distinction for seasons		
Temperature, season 1	25	°C
No distinction for seasons		
<b>Depth of laying of cables</b>		
Voltage range 1: low voltage	0,5	m
Voltage range 2: all higher voltages	0,8	m
<b>Air ambient temperature</b>		
Nominal	30	°C
<b>Solar radiation</b>		
Intensity of solar radiation (inland)	1 250	W/m <sup>2</sup>
Intensity of solar radiation (coast)	1 000	W/m <sup>2</sup>

## A.20 Sweden

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value to be used in calculations	1,0	K·m/W
Where the soil is completely saturated with water and for submarine cables where the bottom is covered with sand	0,4	K·m/W
Maximum value for submarine cables	1,0	K·m/W
For important cables, a measurement of the resistivity and soil conditions on the sea bottom is recommended, otherwise:	0,6	K·m/W
Temperature, maximum value	15	°C
Temperature, minimum value	0	°C
(for main part of the year between 5 °C and 10 °C)		
<b>Depth of laying of cables</b>		
For directly buried cables and for short road crossings by means of ducts		
All cables up to 24 kV	0,7	m
Paper-insulated cables up to 52 kV	0,7	m
Oil-filled cables up to 420 kV	1,0 to 1,5 <sup>a</sup>	m
<sup>a</sup> The depth depends on local conditions. Less than 1 000 mm is not used.		

## A.21 Switzerland

<b>Thermal characteristics of the soil</b>		
<i>Thermal resistivity:</i>		
<del>normal value to be used in calculations — 1,0 K·m/W (1,3 K·m/W in case of rocky soil)</del>		
Thermal resistivity, nominal, summer (May – October)	1,0	K·m/W
Thermal resistivity, nominal, winter (November – April)	0,85	K·m/W
Thermal resistivity, rocky soil, summer	1,3	K·m/W
Thermal resistivity, rocky soil, winter	1,3	K·m/W
<i>Temperature:</i>		
<del>maximum value to be used in calculations — 20 °C</del>		
<del>minimum values — 10 °C in general — 15 °C in mountains</del>		
<del>NOTE — An additional condition in case of permanent load is 50 °C maximum temperature of the soil near the cable (in order to avoid soil drying).</del>		
Temperature, summer	20	°C
Temperature, winter	10	°C
<b>Depth of laying of cables</b>		
<del>Normally 1 000 mm</del>		
Voltage range 10 kV to 30 kV	0,8	m
Voltage range 50 kV to 400 kV	1,0	m
<b>Air ambient temperature</b>		
Maximum, outdoor	30	°C
Minimum, outdoor	-25	°C
<b>Solar radiation</b>		
Intensity of solar radiation, Swiss plateau (Mittelland)	1 000	W/m <sup>2</sup>
Intensity of solar radiation, Alpine region (Alpenraum)	1 200	W/m <sup>2</sup>

Cables are usually laid in HDPE pipes.

Drying out is usually not considered (otherwise, rho\_dry is 2,5 K·m/W; T\_boundary is 50 °C).

## A.22 United Kingdom

### 1) ~~Standard conditions~~

~~Soil thermal resistivity — 1,2 K.m/W~~

~~Ground ambient temperature — 15 °C~~

### 2) ~~Depth of burial~~

~~a) For 1 kV cables — depth from ground surface to centre of cable, to centre of duct or to centre of trefoil group of cables or ducts — 500 mm~~

~~b) For 3,3 kV to 33 kV cables (unless pressure assisted) — depth from ground surface to centre of cable, to centre of duct or to centre of trefoil group of cables or ducts — 800 mm~~

~~c) For 33 kV pressure assisted cables — depth from ground surface to upper-most surface of cable or duct or of group of cables or ducts — 900 mm~~

### 3) ~~Air ambient temperature~~

~~Out of doors\* — 25 °C~~

~~In buildings — 30 °C~~

~~\* This temperature is also assumed as a standard condition in tabulating ratings of cable for use in certain indoor situations such as cable basements in power stations and other industrial plants.~~

### A.22.1 HV

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, winter	1,05	K·m/W
Thermal resistivity, nominal, summer	1,2	K·m/W
Thermal resistivity, dry zone, winter	1,05	K·m/W
Thermal resistivity, dry zone, summer (critical temperature 50 °C)	3,0	K·m/W
Temperature, winter	10	°C
Temperature, summer	15	°C
<b>Depth of laying of cables</b>		
132 kV and above	0,9 min. (general)	m
	0,75 min. (substation sites)	m
	0,825 min. (Scotland)	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	10	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

**A.22.2 LV/MV**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
Thermal resistivity, nominal, season 2	No distinction for seasons	
Thermal resistivity, dry zone (critical temperature 50 °C)	1,2	K·m/W
Temperature, season 1	15	°C
Temperature, season 2	No distinction for seasons	°C
<b>Depth of laying of cables</b>		
Voltage range 1: 1 kV	0,5	m
Voltage range 2: 3 kV to 33 kV	0,8	m
<b>Air ambient temperature</b>		
Nominal	25	°C
1 kV cables in buildings	30	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

Historically a 3 m circuit separation at normal cable depths is assumed to be thermally independent – under review.

**A.23 United States of America**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	0,9	K·m/W
<del>Temperature 20 °C</del>		
Temperature, season 1	25	°C
Temperature, season 2	15	°C
<b>Depth of laying of cables</b>		
Nominal	0,9	m
<b>Air ambient temperature</b>		
<del>Design value 40 °C</del>		
<del>(including solar heating the maximum values range between 40 °C and 50 °C)</del>		
Maximum	50	°C
Minimum	2	°C

When circuits are separated 3,7 m (12 feet) or more they are considered thermally independent.

## **5— Information required from the purchaser for the selection of the appropriate type of cable**

### **5.1— Background**

The information, which is necessary to enable the selection of the appropriate type of cable to be made, has been reproduced from IEC 60183, and is given in this clause so that purchasers can provide the data needed by a cable manufacturer when he is called upon to specify the correct size and type of cable for a particular application. Purchasers should provide the manufacturer with as much information as possible, and draw attention to those questions to which they either do not know or are uncertain of the answer. In the absence of definite data, a manufacturer is obliged to make assumptions and therefore any relevant information which a purchaser can provide will be helpful.

### **5.2— Operating conditions**

- a) Nominal voltage of the system  $U$ . The rated r.m.s. power frequency voltage between any two conductors for which cables and accessories are designed.
- b) Highest voltage of the three-phase system  $U_m$ . The highest r.m.s. phase to phase voltage which occurs under normal operating conditions at any time and at any point in the system. It excludes voltage transients (such as those due to system switching) and temporary voltage variation due to abnormal system conditions (such as those due to fault conditions or sudden disconnection of large loads).
- c) Lightning overvoltage.
- d) System frequency.
- e) Type of earthing and, where the neutral is not effectively earthed, the maximum permitted duration of earth fault conditions on any one occasion and the total duration per year.
- f) Where terminals are specified, the environmental conditions shall be given, for example:
  - the altitude above sea level, if above 1 000 m;
  - indoor or outdoor installations;
  - whether excessive atmospheric pollution is expected;
  - termination in SF<sub>6</sub> switchgear;
  - design clearance and insulation used in the method for connecting cable to equipment, for example transformers, switchgear, motors, etc. For example, clearance and surrounding insulation should be specified.
- g) Maximum rated current
  - 1) For continuous operation.
  - 2) For cyclic operation.
  - 3) For emergency or overload operation, if any.

NOTE — A load curve is essential if cyclic loading is considered when determining conductor size.

- h) The expected symmetrical and asymmetrical short-circuit currents which may flow in case of short circuits, both between phases and to earth.
- j) Maximum time for which short-circuit currents may flow.

### **5.3— Installation data**

#### **5.3.1— General**

- a) Length and profile of route.
- b) Details of laying arrangements (e.g. flat or trefoil arrangement) and how the metallic coverings are connected to each other and to earth.
- c) Special laying conditions, for example cables in water. Individual installations require special consideration.

### **5.3.2** ~~Underground cables~~

- a) ~~Details of installation conditions (e.g. direct burial, in ducts, etc.) to enable decisions to be taken on composition of metallic sheath, type of armour (if required) and type of serving, for example anticorrosion, flame-retarding, or anti-termite.~~
- b) ~~Depth of laying.~~
- c) ~~Thermal resistivities and kinds of soil along the route (e.g. sand, clay, made-up ground), and whether this information is based on measurement and inspection or only assumed.~~
- d) ~~Minimum, maximum and average ground temperature at the depth of burial.~~
- e) ~~Proximity of other load-carrying cables, or of other heat sources, with details.~~
- f) ~~Lengths of troughs, ducts or pipe lines, with spacing of manholes, if any.~~
- g) ~~Number of ducts or pipes.~~
- h) ~~Internal diameter of ducts and pipes.~~
- j) ~~Spacing between individual ducts and pipes, if more than one.~~
- k) ~~Material of ducts or pipes.~~

### **5.3.3** ~~Cables in air~~

- a) ~~Minimum, maximum and average ambient air temperature to be assumed.~~
- b) ~~Type of installation (e.g. direct laying on walls, racks, etc., grouping of cables, dimensions of the tunnels, ducts, etc.).~~
- c) ~~Details of ventilation (for cables indoors, in tunnels or ducts).~~
- d) ~~Whether exposed to direct sunlight.~~
- e) ~~Special conditions for example fire risk.~~

## Bibliography

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Electric cables – Calculation of the current rating –  
Part 3-1: Operating conditions – Site reference conditions**

**Câbles électriques – Calcul du courant admissible –  
Partie 3-1: Conditions de fonctionnement – Conditions du site de référence**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRIC CABLES –  
CALCULATION OF THE CURRENT RATING –****Part 3-1: Operating conditions –  
Site reference conditions**

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

This second edition cancels and replaces the first edition published in 1995 and Amendment 1:1999. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

- a) the updated list of national laying conditions is now covered in Annex A;
- b) Clause 5 about the information required from the purchaser for the selection of the appropriate type of cable has been removed.

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

FDIS	Report on voting
20/1714/FDIS	20/1730/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 reader's attention is drawn to the fact that Annex A lists all of the “in-some-country” clauses on differing practices of a less permanent nature relating to the subject of this standard.

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.

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## INTRODUCTION

IEC 60287 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 for ratings (100 % load factor) and power losses

Part 2: Formulae for thermal resistance

Part 3: Operating conditions

This part of IEC 60287-3 contains reference ambient temperatures and thermal resistivities of soil in various countries.

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 this part of IEC 60287-3.

# ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

## Part 3-1: Operating conditions – Site reference conditions

### 1 Scope

This part of IEC 60287-3 is applicable to the conditions of steady-state operation of cables at all voltages, 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 defines site reference conditions, however the general values are superseded by specific national requirements.

### 2 Normative references

There are no normative references in this document.

### 3 Terms and definitions

No terms and definitions are listed in this document.

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

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

### 4 Reference ambient temperatures and thermal resistivities of soil in various countries

#### 4.1 Operating conditions – Site reference conditions

In order to use the formulae given in the various parts of IEC 60287, numerical values for the physical quantities should be chosen relating to the operating conditions.

It is obviously possible to compare the results of two calculations of current rating only when the assumptions made and the numerical values of the parameters are known.

In particular, the quantities related to the operating conditions of cables are likely to vary considerably from one country to another. An enquiry into this subject has been carried out and a number of countries have replied.

Annex A summarizes the operating conditions used in various countries. Attention is drawn to the fact that the information in Annex A is intended only as a guide for cable installation designers when data provided by a user is incomplete. Care should be taken not to draw unjustified conclusions from comparisons of values for different countries. It should be remembered that the values adopted in any particular country are governed by many factors some of which might not be of equal importance in other countries.

Values relating to the operating conditions are given in Annex A for the following countries:

Australia  
Austria

Italy  
Japan

Portugal  
Spain

Canada	Mexico	South Africa
China	Netherlands	Sweden
Egypt	New Zealand	Switzerland
Finland	Norway	United Kingdom
France	Oman	United States of America
Germany	Poland	

## 4.2 Procedure when values are not provided in national tables

### 4.2.1 General

It is recommended that when there is no value laid down in the national tables for the reference ambient temperature, thermal resistivity of the soil or solar radiation, the values given in 4.2.2, 4.2.3 and 4.2.4 should be adopted.

### 4.2.2 Ambient temperatures at sea level

See Table 1.

**Table 1 – Ambient temperatures at sea level**

Climate	Ambient air temperature		Ambient ground temperature at a depth of 1 m	
	Min. °C	Max. °C	Min. °C	Max. °C
Tropical	25	55	25	40
Subtropical	10	40	15	30
Temperate	0	25	10	20

It is essential that current ratings should be valid for the maximum temperatures given. The lower values are for winter ratings if required. The values correspond with the temperature limits of winter and summer, alternatively rainy and dry seasons.

When no information about the depth of laying is given, the standard depth is to be taken as 1 m.

### 4.2.3 Thermal resistivity of soil

See Table 2.

**Table 2 – Thermal resistivity of soil**

Thermal resistivity K·m/W	Soil conditions	Weather conditions
0,7	Very moist	Continuously moist
1,0	Moist	Regular rainfall
2,0	Dry	Seldom rains
3,0	Very dry	Little or no rain

### 4.2.4 Solar radiation

When no information about the intensity of solar radiation a value of 1 000 W/m<sup>2</sup> is adopted.

## Annex A (informative)

### Values relating to the operating conditions in various countries

#### A.1 Australia

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
Soil ambient temperature, summer	25	°C
Soil ambient temperature, winter	18	°C
<b>Depth of laying of cables <sup>a</sup></b>		
Voltage range 1: L.V. cables		
under footways	0,5	m
under roadways	0,75	m
Voltage range 2: 11 kV cables		
under footways and roadways	0,8	m
Voltage range 3: 33 kV cables and higher voltages		
under footways and roadways	1,0	m
<b>Air ambient temperature</b>		
Maximum, summer	+40	°C
Maximum, winter	+30	°C
<sup>a</sup> Measured from the ground surface to the centre of the cable, or to the centre of a trefoil group.		

#### A.2 Austria

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, season 1 (wet)	1,0	K·m/W
Thermal resistivity, dry zone, season 1 (dry)	2,5	K·m/W
Temperature, season 1	20	°C
<b>Depth of laying of cables</b>		
Voltage range 1: up to 1 kV	0,7	m
Voltage range 2: > 1 kV up to 30 kV	0,8	m
Voltage range 3: > 30 kV	1,2	m
<b>Air ambient temperature</b>		
Average value	20	°C
Maximum	+40	°C
Minimum	-20	°C

### A.3 Canada

There are no recognized Canadian national values of soil thermal resistivity and temperature, and depth of laying, however the values shown below are typical. It is recommended that, where feasible, soil tests are performed for cable installations.

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal (Critical temperature 50 °C)	0,5 to 3,0	K·m/W
Temperature, season 1 (summer)	25	°C
Temperature, season 2 (winter)	-5	°C
<b>Depth of laying of cables (minimum cover)</b>		
Paper insulated, solid and non-draining cables for voltages up to 69 kV	1,1	m
Solid insulation (butyl, ethylene propylene rubber, p.v.c., cross-linked polyethylene, etc.) cables for voltages up to 46 kV	0,9	m
Oil filled cables for voltages up to 345 kV	1,1	m
Pipe-type (gas or oil pressure) cables for voltages up to 345 kV	1,1	m
<b>Air ambient temperature</b>		
Maximum	5 to 40	°C
Minimum	-55 to -20	°C
<b>Cyclic ratings</b>		
Critical temperature	50	°C
Drying out is not considered for cables in concrete duct banks		

Where direct measurements of soil thermal resistivity are not available, it is usual to assume a thermal resistivity of 0,9 K·m/W. However in cases where it is foreseen that there may be a progressive deterioration of the thermal characteristics of the environment over a period of years, and in cases where the climatic conditions may give rise to significant seasonal variations, it is recommended that the current-carrying capacity be based on a thermal resistivity of 1,2 K·m/W.

Reference is not made to lower values of resistivity, during winter, as a basis for system design to any significant extent.

#### A.4 China

<b>Thermal characteristics of the soil</b>		
Thermal resistivity	1,0 to 1,2	K·m/W
Temperature, summer	30	°C
Temperature, winter	5	°C
<b>Depth of laying of cables</b>		
≤1 kV	0,7	m
>1 kV up to 35 kV	0,7	m
≥110 kV up to 500 kV	1,0	m
<b>Air ambient temperature</b>		
Maximum	40	°C
Minimum	-10	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

#### A.5 Egypt

<b>Thermal characteristics of the soil</b>		
Thermal resistivity	1,2	K·m/W
Temperature, summer	35	°C
Temperature, winter	0	°C
<b>Depth of laying of cables</b>		
≤1 kV	0,4	m
>1 kV up to 35 kV	0,8	m
≥110 kV up to 500 kV <sup>a</sup>	1,2	m
<b>Air ambient temperature</b>		
Maximum	47	°C
Minimum	-5	°C
<b>Solar radiation</b>		
Intensity of solar radiation	≥1 000	W/m <sup>2</sup>
<sup>a</sup> Note at soil temperature 25 °C.		

**A.6 Finland**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity		
Average value to be used for rating calculations.	1,0	K·m/W
For submarine cables where the soil is completely saturated with water	0,4	K·m/W
Temperature		
Maximum value	15	°C
Minimum value	0	°C
(average value 5 °C to 10 °C, exceptional maximum 20 °C)		
<b>Depth of laying of cables</b>		
All cables up to 36 kV	0,7	m
All cables up to 52 kV	1,0	m
All cables up to 123 kV	1,3	m
All cables up to 245 kV	1,5	m
The actual depth depends on local conditions		
<b>Air ambient temperature</b>		
Reference value for rating calculations	25	°C
Maximum value	35	°C
Minimum value	-20	°C

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## A.7 France

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, summer	1,20	K·m/W
Thermal resistivity, nominal, winter	0,85	K·m/W
Thermal resistivity, dry zone <sup>a</sup> , summer	2,5	K·m/W
Thermal resistivity, dry zone <sup>a</sup> , winter	2,5	K·m/W
Temperature, summer		
20 kV cables	20	°C
63 kV, 90 kV, 225 kV, 400 kV cables		
hot area	25	°C
intermediate area	22	°C
cold area	20	°C
Temperature, winter		
20 kV cables	10	°C
63 kV, 90 kV, 225 kV and 400 kV cables		
hot region	17	°C
intermediate region	15	°C
cold region	13	°C
<b>Depth of laying of cables</b>		
20 kV cables		
in Paris	1,0 to 1,2	m
outside Paris city	0,8	m
63 kV, 90 kV, 225 kV and 400 kV cables	1,3	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	20	°C
<b>Cyclic ratings</b>		
Critical temperature, summer	55	°C
Critical temperature, winter	60	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>
<sup>a</sup> Drying out of the soil is only considered for high voltage systems.		

## A.8 Germany

The indicated values are taken as a basis as standard values for current rating calculations unless there are any requirements specified for the thermal resistivity of the soil, the temperature and the depth of laying.

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value	1,0	K·m/W
Thermal resistivity, for calculations considering a dry zone near the cable – for the dry zone	2,5	K·m/W
Temperature, maximum value	20	°C
Temperature, minimum value	0	°C
Temperature, average value	10	°C
<b>Depth of laying of cables</b>		
For cables $\geq$ 60 kV	1,2	m
For cables $<$ 60 kV	0,7 <sup>a</sup>	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	-20	°C
Average value	10	°C
<sup>a</sup> In spite of being calculated for 0,7 m, often cables at 20 kV to 30 kV are laid at 0,9 m to 1,0 m depth.		

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### A.9 Italy

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, maximum value	1,0	K·m/W
If the thermal characteristics of the soil are found to be poor, a suitable backfill is used and reference is made to a thermal resistivity intermediate between that of the backfill and that of the surrounding soil.		
Temperature, maximum value (to be used in calculations)	20	°C
Temperature, minimum value	5	°C
<b>Depth of laying of cables</b>		
This depth is the maximum adopted unless otherwise specified.		
Up to 12 kV	0,8	m
Up to 17,5 kV	1,0	m
Up to 24 kV	1,2	m
Up to 36 kV	1,5	m
Up to 72 kV	1,8	m
Up to 220 kV	2,2	m
<b>Air ambient temperature</b>		
Maximum value (to be used in calculations)	30	°C
Minimum value	0	°C
Maximum daily excursion	20	°C

In summer, the maximum temperature may sometimes, for a few hours daily, be higher by 5 °C (and in special cases even more) than the above-mentioned maximum value. Such an occurrence is considered to be acceptable due to its short duration.

### A.10 Japan

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,0	K·m/W
1,5 K·m/W, 1,0 K·m/W and 0,6 K·m/W for dry, normal and wet soil respectively. No distinction for seasons		
Temperature, summer	25	°C
<b>Depth of laying of cables</b>		
Direct burial: 1,2 m for places where the pressure of vehicle or other heavy goods may be applied. 0,6 m for other places		
In duct: the use of duct which withstands the pressure of vehicle or other heavy goods is required (there is no regulation for the depth of duct).		
<b>Air ambient temperature</b>		
Maximum, summer	40	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

Japanese Cable Makers' Association Standard JCS 0501, gives the calculation formulae of thermal resistance of soil for a 2 layer model having two different thermal resistivities divided by the boundary such as ground water level. Therefore, the ground water level is one parameter for variations in thermal resistivity.

### A.11 Mexico

<b>Thermal characteristics of the soil</b>		
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## Thermal resistivity, nominal season 1 (summer)

Southern Mexico	0,8 to 2,4	K·m/W
Central Mexico	1,0 to 2,5	K·m/W
Northern Mexico	0,5 to 4,0	K·m/W
Coast Mexico	0,5 to 3,0	K·m/W

## Thermal resistivity, nominal season 2 (winter)

Southern Mexico	1,0 to 2,0	K·m/W
Central Mexico	1,3 to 2,1	K·m/W
Northern Mexico	0,8 to 3,6	K·m/W
Coast Mexico	0,8 to 2,7	K·m/W

## Thermal resistivity, dry zone season 1 (summer)

Southern Mexico	1,4 to 3,9	K·m/W
Central Mexico	1,6 to 4,0	K·m/W
Northern Mexico	1,0 to 5,5	K·m/W
Coast Mexico	0,9 to 3,5	K·m/W

## Thermal resistivity, dry zone season 2 (winter)

Southern Mexico	1,1 to 2,8	K·m/W
Central Mexico	1,0 to 3,0	K·m/W
Northern Mexico	0,8 to 4,7	K·m/W
Coast Mexico	0,6 to 2,9	K·m/W

Where direct measurements of soil thermal resistivity are not available, it is usual to assume a thermal resistivity of 1,5 K·m/W, however it is recommended that a survey of the thermal characteristics of the soil is carried out for critical cable links.

**Temperature, season 1 (summer)**

Southern Mexico	30	°C
Central Mexico	25	°C
Northern Mexico	35	°C
Coast Mexico	30	°C

**Temperature, season 2 (winter)**

Southern Mexico	25	°C
Central Mexico	20	°C
Northern Mexico	30	°C
Coast Mexico	25	°C

(Critical temperature 50 °C)

When soil temperature measurements are not available a reference value of 25 °C is often used for rating calculations

**A.11 Mexico (continued)**

<b>Depth of laying of cables <sup>a b</sup></b>		
Voltage range 1: up to 1 kV cables (maximum 2 circuits)		
Under footways	0,3	m
Under roads	0,5	m
Voltage range 2: > 1 kV up to 35 kV cables (5 kV, 15 kV, 25 kV and 35 kV, maximum 4 circuits)		
Under footways	0,3	m
Under roads	0,5	m
Voltage range 3: > 35 kV up to 138 kV cables (69 kV, 85 kV, 115 kV and 138 kV, maximum 2 circuits)		
Only under roadways (normal terrain)	1,0	m
Only under roadways (phreatic zone or rock soils)	0,5	m
Voltage range 4: > 161 kV up to 230 kV cables (161 kV and 230 kV, maximum 2 circuits)		
Only under roadways (normal terrain)	1,2	m
Only under roadways (phreatic zone or rock soils)	0,7	m
Voltage range 5: ≥ 400 kV cables (maximum 2 circuits)		
Only under roadways (normal terrain)	1,4	m
Only under roadways (phreatic zone or rock soils)	0,9	m
<b>Air ambient temperature</b>		
Maximum (annually)		
Southern Mexico	25 to 35	°C
Central Mexico	20 to 26	°C
Northern Mexico	36 to 45	°C
Coast Mexico	26 to 36	°C
Minimum (annually)		
Southern Mexico	8 to 18	°C
Central Mexico	1 to 12	°C
Northern Mexico	-5 to +10	°C
Coast Mexico	12 to 20	°C
Average (annually)		
Southern Mexico	28	°C
Central Mexico	21	°C
Northern Mexico	30	°C
Coast Mexico	29	°C
<b>Cyclic ratings</b>		
Critical temperature or temperature rise	35 to 50	°C
The critical temperature is highly dependant on the soil composition and location. It may also vary due to seasonal influences and/or cyclic loading. It is recommended to investigate the critical temperature during a soil survey, unless it can be demonstrated that no drying out of the soil will occur.		

### A.11 Mexico (concluded)

<b>Solar radiation <sup>c</sup></b>		
Intensity of solar radiation		
Southern Mexico	650 to 850	W/m <sup>2</sup>
Central Mexico	700 to 900	W/m <sup>2</sup>
Northern Mexico	850 to 1 100	W/m <sup>2</sup>
Coast Mexico	800 to 1 000	W/m <sup>2</sup>
<p>The values given above for soil thermal resistivity and temperature correspond to measurements made at different locations in Mexico at different depths (0,9 m, 1,2 m and 1,5 m). It is recommended that, where feasible, soil measurements are made for cable installations.</p> <p><sup>a</sup> Measured from the ground surface to the top of the cable ducts, or to the top of a trefoil duct group. Cables are always laid in HDPE ducts.</p> <p><sup>b</sup> Depths may be greater depending on any underground obstacles along the cable route.</p> <p><sup>c</sup> Direct normal irradiance or beam solar radiation value, maximum annual values present for short time periods.</p>		

### A.12 Netherlands

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,00	K·m/W
It is recommended that a survey of the thermal characteristics of the soil is carried out for critical cable links.		
Thermal resistivity, dry zone	2,5	K·m/W
It is recommended that a survey of the thermal characteristics of the soil is carried out for critical cable links.		
Temperature, maximum	20	°C
Temperature, winter	5	°C
Temperature, average	15	°C
<b>Depth of laying of cables</b>		
Up to 30 kV	0,7 to 1,0	m
Above 30 kV	1,2	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	-10	°C
Average	20	°C
<b>Cyclic ratings</b>		
Critical temperature	30	°C
The critical temperature is highly dependent on soil composition and location. It may also vary due to seasonal influences and/or cyclic loading. It is recommended to investigate the critical temperature during a soil survey, unless it can be demonstrated that no drying out of the soil will occur.		
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

The two zone model is regularly used to calculate the current rating of MV cable systems and incidentally for HV systems. The parameter used to define the boundary between wet and dry zones is the absolute temperature, isotherm at this boundary, usually in the range between 30 °C (MV cables) and 50 °C (HV cables).

Cable circuits are taken to be thermally independent if the separation is not less than 3 m. For cables installed deeper than 3 m, such as in horizontal directional drilling, the minimum separation is not less than 5 m to consider a cable circuit as thermally independent.

### A.13 New Zealand

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
Soil ambient temperature, summer	15	°C
Soil ambient temperature, winter	15	°C
<b>Depth of laying of cables <sup>a</sup></b>		
This depth is the minimum adopted unless otherwise specified		
Voltage range 1: L.V.		
under footways	0,5	m
under roadways	0,75	M
Voltage range 2: 11kV		
under footways and roadways	1,0	m
Voltage range 3: 33kV and higher		
under footways and roadways	1,0	m
<b>Air ambient temperature</b>		
Maximum summer	+30	°C
Maximum winter	+30	°C
<sup>a</sup> Measured from the ground surface to the centre of the cable, or to the centre of a trefoil group.		

### A.14 Norway

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value to be used in calculations	1,0	K·m/W
Temperature, Southern Norway max./min.	17/0	°C
Temperature, Central Norway max./min.	15/0	°C
Temperature, Northern Norway max./min.	13/-5	°C
<b>Depth of laying of cables (minimum value)</b>		
1 kV	0,5	m
above 1 kV	0,7	m
<b>Air ambient temperature</b>		
Maximum value (to be used in calculations)	25	°C

**A.15 Oman**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	2,5	K·m/W
No distinction for seasons		
Temperature, maximum	40	°C
Temperature, minimum	10	°C
<b>Depth of laying of cables</b>		
All cables up to 1 kV	0,5	m
All cables above 1 kV	0,8	m
<b>Air ambient temperature</b>		
Maximum	55	°C
Minimum	10	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 200	W/m <sup>2</sup>

**A.16 Poland**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value to be used in calculations	1,0	K·m/W
Thermal resistivity, nominal, season 2		
Temperature, average value to be used in calculations	20	°C
Temperature, minimum value	5	°C
<b>Depth of laying of cables</b>		
up to and including 36 kV	0,7	m
above 36 kV	1,0	m
<b>Air ambient temperature</b>		
Average value to be used in calculations	25	°C

### A.17 Portugal

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, summer	1,2	K·m/W
Thermal resistivity, nominal, winter	0,85	K·m/W
Thermal resistivity, nominal, submarine cables	1,0	K·m/W
Soil ambient temperature, summer	20	°C
Soil ambient temperature, winter	10	°C
<b>Depth of laying of cables</b>		
This depth is the minimum adopted unless otherwise specified		
Voltage range up to 1 kV	0,7	m
Voltage range up to 30 kV	1,0	m
Voltage range up to 400 kV	1,2	m
<b>Air ambient temperature</b>		
Air ambient temperature, summer (at sea level)	30	°C
Air ambient temperature, winter (at sea level)	20	°C
Air ambient temperature, minimum	0	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

### A.18 Spain

There are no recognized Spanish national values of soil thermal resistivities, ambient temperatures and depth of laying, the values shown below are typical

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, Cables ≤0,6/1 kV	1	K·m/W
Thermal resistivity, Cables >0,6/1 kV and ≤18/30 kV	1,5	K·m/W
Thermal resistivity, Cables >18/30 kV	1	K·m/W
Where concrete is used for the cable installation it should be considered for the calculation a value of 0,85 K m/W for the volume occupied by the concrete	0,85	K·m/W
Temperature	25	°C
<b>Depth of laying of cables</b>		
	0,6 to 1,5	m
<b>Air ambient temperature</b>		
Maximum	40	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

**A.19 South Africa**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
No distinction for seasons		
Temperature, season 1	25	°C
No distinction for seasons		
<b>Depth of laying of cables</b>		
Voltage range 1: low voltage	0,5	m
Voltage range 2: all higher voltages	0,8	m
<b>Air ambient temperature</b>		
Nominal	30	°C
<b>Solar radiation</b>		
Intensity of solar radiation (inland)	1 250	W/m <sup>2</sup>
Intensity of solar radiation (coast)	1 000	W/m <sup>2</sup>

**A.20 Sweden**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, average value to be used in calculations	1,0	K·m/W
Where the soil is completely saturated with water and for submarine cables where the bottom is covered with sand	0,4	K·m/W
Maximum value for submarine cables	1,0	K·m/W
For important cables, a measurement of the resistivity and soil conditions on the sea bottom is recommended, otherwise:	0,6	K·m/W
Temperature, maximum value	15	°C
Temperature, minimum value	0	°C
(for main part of the year between 5 °C and 10 °C)		
<b>Depth of laying of cables</b>		
For directly buried cables and for short road crossings by means of ducts		
All cables up to 24 kV	0,7	m
Paper-insulated cables up to 52 kV	0,7	m
Oil-filled cables up to 420 kV	1,0 to 1,5 <sup>a</sup>	m
<sup>a</sup> The depth depends on local conditions. Less than 1 000 mm is not used.		

## A.21 Switzerland

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, summer (May – October)	1,0	K·m/W
Thermal resistivity, nominal, winter (November – April)	0,85	K·m/W
Thermal resistivity, rocky soil, summer	1,3	K·m/W
Thermal resistivity, rocky soil, winter	1,3	K·m/W
Temperature, summer	20	°C
Temperature, winter	10	°C
<b>Depth of laying of cables</b>		
Voltage range 10 kV to 30 kV	0,8	m
Voltage range 50 kV to 400 kV	1,0	m
<b>Air ambient temperature</b>		
Maximum, outdoor	30	°C
Minimum, outdoor	-25	°C
<b>Solar radiation</b>		
Intensity of solar radiation, Swiss plateau (Mittelland)	1 000	W/m <sup>2</sup>
Intensity of solar radiation, Alpine region (Alpenraum)	1 200	W/m <sup>2</sup>

Cables are usually laid in HDPE pipes.

Drying out is usually not considered (otherwise,  $\rho_{dry}$  is 2,5 K·m/W;  $T_{boundary}$  is 50 °C).

## A.22 United Kingdom

### A.22.1 HV

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal, winter	1,05	K·m/W
Thermal resistivity, nominal, summer	1,2	K·m/W
Thermal resistivity, dry zone, winter	1,05	K·m/W
Thermal resistivity, dry zone, summer (critical temperature 50 °C)	3,0	K·m/W
Temperature, winter	10	°C
Temperature, summer	15	°C
<b>Depth of laying of cables</b>		
132 kV and above	0,9 min. (general)	m
	0,75 min. (substation sites)	m
	0,825 min. (Scotland)	m
<b>Air ambient temperature</b>		
Maximum	30	°C
Minimum	10	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

**A.22.2 LV/MV**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	1,2	K·m/W
Thermal resistivity, nominal, season 2	No distinction for seasons	
Thermal resistivity, dry zone (critical temperature 50 °C)	1,2	K·m/W
Temperature, season 1	15	°C
Temperature, season 2	No distinction for seasons	°C
<b>Depth of laying of cables</b>		
Voltage range 1: 1 kV	0,5	m
Voltage range 2: 3 kV to 33 kV	0,8	m
<b>Air ambient temperature</b>		
Nominal	25	°C
1 kV cables in buildings	30	°C
<b>Solar radiation</b>		
Intensity of solar radiation	1 000	W/m <sup>2</sup>

Historically a 3 m circuit separation at normal cable depths is assumed to be thermally independent – under review.

**A.23 United States of America**

<b>Thermal characteristics of the soil</b>		
Thermal resistivity, nominal	0,9	K·m/W
Temperature, season 1	25	°C
Temperature, season 2	15	°C
<b>Depth of laying of cables</b>		
Nominal	0,9	m
<b>Air ambient temperature</b>		
Maximum	50	°C
Minimum	2	°C

When circuits are separated 3,7 m (12 feet) or more they are considered thermally independent.

## Bibliography

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**CÂBLES ÉLECTRIQUES –  
CALCUL DU COURANT ADMISSIBLE –****Partie 3-1: Conditions de fonctionnement –  
Conditions du site de référence****AVANT-PROPOS**

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La Norme internationale IEC 60287-3-1 Ed.2 a été établie par le comité d'études 20 de l'IEC: Câbles électriques.

Cette deuxième édition annule et remplace la première édition publiée en 1995 et l'Amendement 1:1999. Cette édition constitue une révision technique. Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) la liste mise à jour des conditions de pose nationales est maintenant couverte par l'Annexe A;
- b) l'Article 5 relatif aux informations exigées de l'acheteur pour permettre la sélection du type approprié de câble a été supprimé.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
20/1714/FDIS	20/1730/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.

L'attention du lecteur est attirée sur le fait que l'Annexe A énumère tous les articles traitant des différences à caractère moins permanent inhérentes à certains pays, concernant le sujet de la présente norme.

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. À cette date, la publication sera

- reconduite,
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- amendée.

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## INTRODUCTION

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

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

Partie 1: Équations de l'intensité du courant admissible (facteur de charge 100 %) et calcul des pertes

Partie 2: Équations de la résistance thermique

Partie 3: Conditions de fonctionnement

La présente partie de l'IEC 60287-3 contient des valeurs des températures ambiantes de référence et des résistivités thermiques des sols dans divers pays.

Les données 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 superficielles entre les valeurs utilisées dans les différents pays peuvent conduire à des conclusions erronées, si elles ne sont pas fondées sur des critères communs: par exemple, il peut y avoir des attentes différentes pour la durée de vie des câbles, et dans certains pays, la conception est basée sur les valeurs maximales de résistivité thermique du sol, alors que dans d'autres pays, les valeurs moyennes sont utilisées. 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 par conséquent d'adopter la méthode suivante pour le choix des valeurs des différents paramètres.

Il convient que les valeurs numériques soient, de préférence, 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 est donné dans la présente partie de l'IEC60287-3.

# CÂBLES ÉLECTRIQUES – CALCUL DU COURANT ADMISSIBLE –

## Partie 3-1: Conditions de fonctionnement – Conditions du site de référence

### 1 Domaine d'application

La présente partie de l'IEC 60287-3 s'applique aux conditions de fonctionnement en régime permanent des câbles de toutes tensions enterrés directement dans le sol, placés dans des fourreaux, caniveaux ou 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 %) assez suffisant pour produire asymptotiquement la température maximale à l'âme en supposant que les conditions du milieu ambiant restent constantes.

Le présent document définit les conditions du site de référence, cependant les valeurs générales sont remplacées par les exigences spécifiques nationales.

### 2 Références normatives

Le présent document ne contient aucune référence normative.

### 3 Termes et définitions

Aucun terme n'est défini dans le présent document.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

### 4 Valeurs des températures ambiantes de référence et résistivités thermiques des sols dans divers pays

#### 4.1 Conditions de fonctionnement – Conditions du site de référence

Afin d'utiliser les formules données dans les différentes parties de l'IEC 60287, il convient de choisir les valeurs numériques des grandeurs physiques en fonction des conditions de fonctionnement.

Il n'est évidemment possible de comparer les résultats de deux calculs de courant admissible que si les hypothèses faites et les valeurs numériques des paramètres sont connues.

En particulier, les grandeurs relatives aux conditions de fonctionnement des câbles sont susceptibles de varier considérablement d'un pays à un autre. Une enquête a été effectuée à ce sujet et un certain nombre de pays a répondu.

L'Annexe A résume les conditions de fonctionnement utilisées dans divers pays. L'attention est attirée sur le fait que les renseignements contenus dans l'Annexe A sont proposés seulement comme un modèle pour les concepteurs d'installations de câbles lorsque les

données fournies par un utilisateur sont incomplètes. Il convient de se garder de tirer des conclusions erronées à partir de la comparaison des valeurs de divers pays. Il convient de rappeler que les valeurs adoptées dans un pays particulier sont fonction d'un grand nombre de facteurs dont certains pourraient ne pas avoir le même degré d'importance dans d'autres pays.

Les valeurs relatives aux conditions de fonctionnement sont données à l'Annexe A pour les pays suivants:

Australie	Italie	Portugal
Autriche	Japon	Espagne
Canada	Mexique	Afrique du Sud
Chine	Pays-Bas	Suède
Egypte	Nouvelle Zélande	Suisse
Finlande	Norvège	Royaume-Uni
France	Oman	États-Unis d'Amérique
Allemagne	Pologne	

## 4.2 Règle lorsque les valeurs ne sont pas fournies dans les tables nationales

### 4.2.1 Généralités

La recommandation est qu'il convient d'adopter les valeurs données en 4.2.2, 4.2.3 et 4.2.4 lorsqu'il n'y a pas de valeurs indiquées dans les tables nationales pour la température ambiante de référence, la résistivité thermique du sol ou le rayonnement solaire.

### 4.2.2 Températures ambiantes au niveau de la mer

Voir Tableau 1.

**Tableau 1 – Températures ambiantes au niveau de la mer**

Climat	Température ambiante de l'air		Température ambiante du sol à 1 m de profondeur	
	Min. °C	Max. °C	Min. °C	Max. °C
Tropical	25	55	25	40
Subtropical	10	40	15	30
Tempéré	0	25	10	20

L'essentiel est qu'il convient que le courant admissible soit valable pour les températures maximales indiquées. Les valeurs inférieures sont destinées au courant admissible en hiver si nécessaire. Les températures ambiantes maximales et minimales correspondent respectivement aux régimes d'été et d'hiver, ou de saison sèche et de saison pluvieuse.

Lorsque les informations relatives à la profondeur de pose ne sont pas données, la profondeur standard à prendre est de 1 m.

### 4.2.3 Résistivité thermique du sol

Voir Tableau 2.

**Tableau 2 – Résistivité thermique du sol**

Résistivité thermique K·m/W	Conditions du sol	Conditions atmosphériques
0,7	Très humide	Constamment humide
1,0	Humide	Averses régulière
2,0	Sec	Pluies peu fréquentes
3,0	Très sec	Peu ou pas de pluies

#### 4.2.4 Rayonnement solaire

Lorsqu'il n'y a pas d'informations relatives à l'intensité du rayonnement solaire, une valeur de 1 000 W/m<sup>2</sup> est adoptée.

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## Annexe A (informative)

### Valeurs relatives aux conditions de fonctionnement dans divers pays

#### A.1 Australie

<b>Caractéristiques thermiques du sol</b>		
Résistivité thermique, nominale,	1,2	K·m/W
Température ambiante du sol, l'été	25	°C
Température ambiante du sol, l'hiver	18	°C
<b>Profondeur de pose des câbles <sup>a</sup></b>		
Plage de tensions 1: câbles de basse tension		
sous trottoirs	0,5	m
sous chaussées	0,75	m
Plage de tensions 2: câbles de 11 kV		
sous trottoirs et chaussées	0,8	m
Plage de tensions 3: câbles de 33 kV et plus		
sous trottoirs et chaussées	1,0	m
<b>Température ambiante de l'air</b>		
Maximale, l'été	+ 40	°C
Maximale, l'hiver	+ 30	°C
<sup>a</sup> Mesurée de la surface du sol au centre du câble ou au centre d'un groupe de câbles en trèfle.		

#### A.2 Autriche

<b>Caractéristiques thermiques du sol</b>		
Résistivité thermique, nominale, saison 1 (humide)	1,0	K·m/W
Résistivité thermique, zone sèche, saison 1 (sèche)	2,5	K·m/W
Température, saison 1	20	°C
<b>Profondeur de pose des câbles</b>		
Plage de tensions 1: jusqu'à 1 kV	0,7	m
Plage de tensions 2: > 1kV jusqu'à 30 kV	0,8	m
Plage de tensions 3: > 30 kV	1,2	m
<b>Température ambiante de l'air</b>		
Valeur moyenne	20	°C
Maximale	+40	°C
Minimale	-20	°C

### A.3 Canada

Il n'existe pas de valeurs canadiennes nationales reconnues de résistivité thermique du sol, de température et de profondeur de pose, les chiffres donnés ci-dessous sont des valeurs typiques. Il est recommandé, lorsque cela est possible, d'effectuer des essais de sols pour les installations de câbles.

<b>Caractéristiques thermiques du sol</b>		
Résistivité thermique, nominale (Température critique 50 °C)	0,5 à 3,0	K·m/W
Température, saison 1 (été)	25	°C
Température, saison 2 (hiver)	-5	°C
<b>Profondeur de pose des câbles (couverture minimale)</b>		
Câbles isolés au papier à matière stabilisée et non migrante, pour des tensions allant jusqu'à 69 kV	1,1	m
Câbles à isolation solide (butyle, caoutchouc d'éthylène-propylène, p.v.c., polyéthylène réticulé, etc.) pour des tensions jusqu'à 46 kV	0,9	m
Câbles à huile fluide pour des tensions allant jusqu'à 345 kV	1,1	m
Câbles en tuyau (à pression de gaz ou d'huile) pour des tensions jusqu'à 345 kV	1,1	m
<b>Température ambiante de l'air</b>		
Maximale	5 à 40	°C
Minimale	-55 à -20	°C
<b>Régime cyclique</b>		
Température critique	50	°C
L'assèchement n'est pas considéré pour les câbles dans des faisceaux de fourreaux en béton		

Lorsque des mesures directes de la résistivité thermique du sol ne sont pas disponibles, il est généralement admis de prendre une résistivité thermique de 0,9 K·m/W. Cependant, dans les cas où l'on prévoit qu'il peut exister une détérioration progressive des caractéristiques thermiques de l'environnement au cours des années, et dans les cas où les conditions climatiques peuvent occasionner un accroissement sensible des variations saisonnières, il est recommandé de déterminer la capacité de transport de courant à partir d'une résistivité thermique de 1,2 K·m/W.

Ne pas se référer aux plus faibles valeurs de résistivité, pendant l'hiver, pour établir les bases d'un projet de réseau de quelque importance.

**A.4 Chine**

<b>Caractéristiques thermiques du sol</b>		
Résistivité thermique	1,0 à 1,2	K·m/W
Température, été	30	°C
Température, hiver	5	°C
<b>Profondeur de pose des câbles</b>		
≤1 kV	0,7	m
>1 kV jusqu'à 35 kV	0,7	m
≥110 kV jusqu'à 500 kV	1,0	m
<b>Température ambiante de l'air</b>		
Maximale	40	°C
Minimale	-10	°C
<b>Rayonnement solaire</b>		
Intensité du rayonnement solaire	1 000	W/m <sup>2</sup>

**A.5 Égypte**

<b>Caractéristiques thermiques du sol</b>		
Résistivité thermique	1,2	K·m/W
Température, été	35	°C
Température, hiver	0	°C
<b>Profondeur de pose des câbles</b>		
≤1 kV	0,4	m
>1 kV jusqu'à 35 kV	0,8	m
≥110 kV up to 500 kV <sup>a</sup>	1,2	m
<b>Température ambiante de l'air</b>		
Maximale	47	°C
Minimale	-5	°C
<b>Rayonnement solaire</b>		
Intensité du rayonnement solaire	≥1 000	W/m <sup>2</sup>
<sup>a</sup> Pour une température du sol de 25 °C.		