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**IEC
CEI**

**NORME
INTERNATIONALE**

60287-3-3

First edition
Première édition
2007-05

**Electric cables –
Calculation of the current rating –**

**Part 3-3:
Sections on operating conditions –
Cables crossing external heat sources**

**Câbles électriques –
Calcul de la capacité de transport –**

**Partie 3-3:
Sections relatives aux conditions d'exploitation –
Câbles croisant des sources de chaleur externes**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRIC CABLES –
CALCULATION OF THE CURRENT RATING –****Part 3-3: Sections on operating conditions –
Cables crossing external heat sources**

FOREWORD

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

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

FDIS	Report on voting
20/879/FDIS	20/882/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 the parts in the IEC 60287 series, 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 maintenance result date indicated on the IEC web site 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- withdrawn,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.

INTRODUCTION

In the IEC 60287 series, Part 1 provides general formulae for ratings and power losses of electric cables.

Part 2 presents formulae for thermal resistance, with Part 2-1 providing general calculation methods for thermal resistance.

Part 2-1 provides calculation methods for dealing with groups of buried cables (see 2.2.3). These methods assume that the cables are laid in parallel and hence every cable acts as a parallel line heat source.

This Part 3-3 deals with the crossing of a cable, at right angles or obliquely with another cable, and, more generally, with any linear heat source, such as steam pipes.

When heat sources are installed in the vicinity of a cable, the permissible current-carrying capacity of the cable should be reduced to avoid overheating. But applying formulae that are valid for parallel routes would overestimate the thermal influence of the crossing heat source on the cable.

In this standard a general simplified method is provided to estimate the reduction of the permissible current-carrying capacity of a cable crossed by heat sources.

Every cable and heat source is assumed to be laid horizontally.

ELECTRIC CABLES – CALCULATION OF THE CURRENT RATING –

Part 3-3: Sections on operating conditions – Cables crossing external heat sources

1 Scope

This part of IEC 60287 describes a method for calculating the continuous current rating factor for cables of all voltages where crossings of external heat sources are involved. The method is applicable to any type of cable.

The method assumes that the entire region surrounding a cable, or cables, has uniform thermal characteristics and that the principle of superposition applies. The principle of superposition does not strictly apply to touching cables and hence the calculation method set out in this standard will produce an optimistic result if applied to touching cables.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Symbols

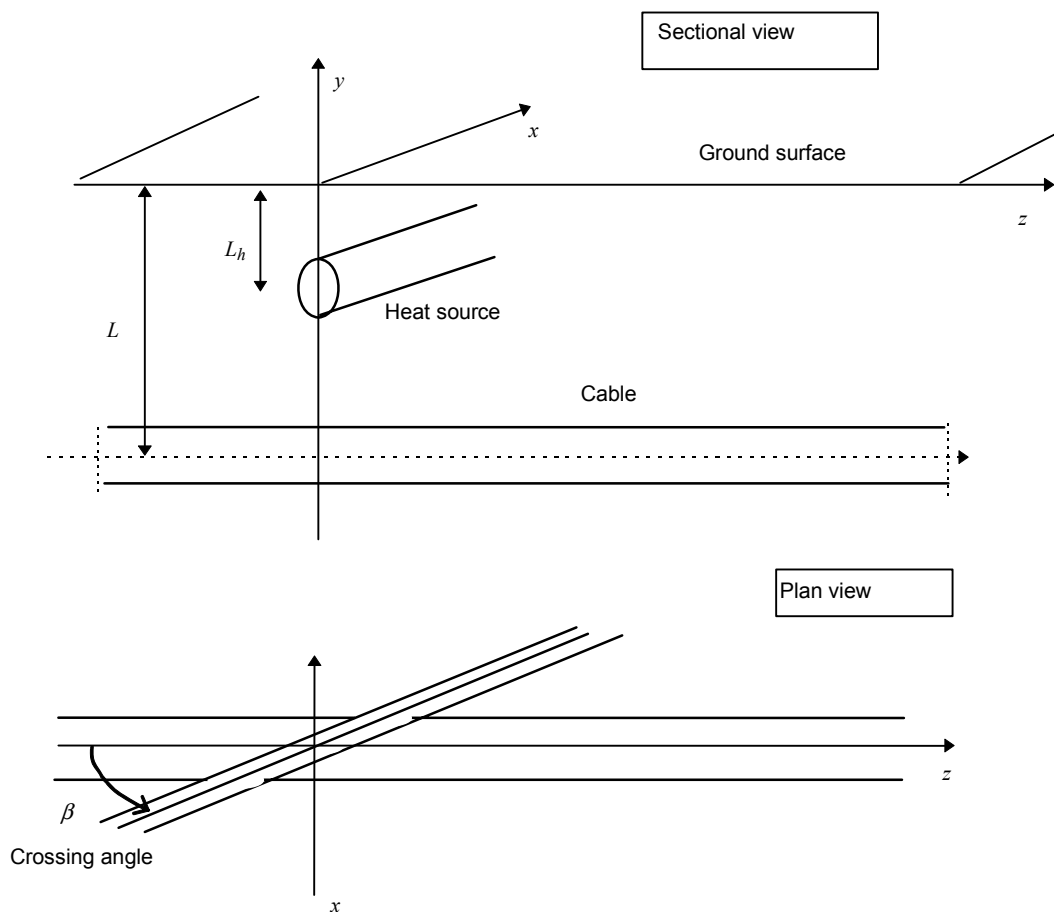
A	Conductor cross-sectional area	mm ²
DF	Ratio of the permissible current when taking into account the presence of crossing heat sources to the permissible current of the isolated cable (derating factor)	-
I	Maximum permissible current of the rated cable when isolated	A
L	Depth of laying, to cable axis, of the rated cable	m
L_h	Depth of laying of heat source h	m
N	Number of intervals in the spatial discretization for the calculations	
T_1	Thermal resistance per core between conductor and sheath	K×m/W
T_2	Thermal resistance between sheath and armour	K×m/W
T_3	Thermal resistance of external serving	K×m/W
T_4	Thermal resistance of surrounding medium (ratio of cable surface temperature rise above ambient to the losses per unit length)	K×m/W
T_{mh}	Mutual thermal resistance between cable and heat source	K×m/W
T	Equivalent thermal resistance of cable per conductor	K×m/W
T_r	Total thermal resistance of cable per conductor	K×m/W
T_L	Thermal longitudinal resistance of a conductor	K/m/W
W_d	Dielectric losses per unit length per phase	W/m

W_g	Heat generated in the rated cable, due to losses in a conductor, assuming a conductor temperature of 20 °C	W/m
W_h	Heat generated by external heat source h	W/m
k	Number of heat sources, crossing the rated cable	-
z_r	Location of the hottest point on the route of the rated cable(z co-ordinate) when several crossings are considered	m
$z_{\max}$	Distance along the cable route from the hottest point to the point where longitudinal heat flux is negligible	m
n	Number of cores	-
α_{20}	Temperature coefficient of electrical resistivity at 20 °C, per Kelvin	K ⁻¹
β	Crossing angle	Radian
γ	Attenuation factor	m ⁻¹
λ_1	Ratio of the total losses in metallic sheaths to the total conductor losses(sheath/screen loss factor)	-
λ_2	Ratio of the total losses in armour to the total conductor losses (armour loss factor)	-
ρ	Soil thermal resistivity	K×m/W
ρ_{cr}	Conductor thermal resistivity	K×m/W
$\theta_{\max}$	Maximum permissible conductor temperature	°C
$\Delta\theta_d$	Conductor temperature rise due to dielectric losses	K
$\Delta\theta_{\max}$	Maximum permissible conductor temperature rise above ambient	K
$\Delta\theta(z)$	Temperature rise of the conductor(s) of the rated cable, due to crossing heat sources, at the point z in the cable route	K
$\Delta\theta(0)$	Temperature rise of the conductor(s) of the rated cable, due to crossing heat sources, at the hottest point in the cable route	K
$\Delta\theta_{uh}(z)$	Temperature rise of the conductor(s) of the rated cable, due to the heat source, h , without taking into account longitudinal heat flux	K
ΔW	Incremental heat generated due to change of conductor resistance	W/K×m
Δz	Length of an interval used in the calculations	m

4 Description of method

4.1 General description

The conditions examined in this standard involve an external heat source crossing the route of the rated cable(s). The crossing heat source can be located either above or below the rated cable(s) with the crossing angle ranging from parallel to perpendicular. An example of such situation is shown in Figure 1.



IEC 742/07

Figure 1 – Illustration of a heat source crossing rated cable

The conductor temperature rise along the route of the rated cable, caused by the heat generated by the crossing heat source, may be calculated using Kennelly's principle. The temperature rise is maximum at the crossing point and decreases with the distance from the crossing. The distance from the crossing along the cable route, where the longitudinal heat flux is negligible, is denoted by z_{max} .

As a consequence of the varying temperature rise along the cable length, a longitudinal heat flux is generated in the conductor, which leads to a reduction in the conductor temperature rise at the crossing, compared to the case when this longitudinal flux is ignored.

The maximum permissible current in the cable to be rated, taking into account the presence of a crossing heat source, is obtained by multiplying the steady-state rating of the cable, without the crossing heat source, by a derating factor, DF , related to the heating due to the heat source:

$$DF = \sqrt{1 - \frac{\Delta\theta(0)}{\Delta\theta_{max} - \Delta\theta_d}} \quad (1)$$

where $\Delta\theta(0)$ is the temperature rise of the conductor due to the crossing heat source, at the crossing point.

4.2 Single source crossing

The value of $\Delta\theta(0)$ is obtained from the following formula by dividing the distance z_{max} into N intervals, each of length Δz :

$$\Delta\theta(0) = \frac{W_h \times \rho \times (e^{\gamma \times \Delta z} - 1)}{4\pi} \sum_{v=1}^N e^{-v \times \gamma \times \Delta z} \ln \frac{(L + L_h)^2 + (v \times \Delta z \times \sin \beta)^2}{(L - L_h)^2 + (v \times \Delta z \times \sin \beta)^2} \quad (2)$$

where

ρ is the soil thermal resistivity;

W_h is the heat generated by external heat source;

β is the crossing angle;

L is the laying depth of the rated cable;

L_h is the laying depth of the heat source.

The attenuation factor γ is expressed as

$$\gamma = \sqrt{(1 - \Delta W \times T) \times \frac{T_L}{T_r}} \quad (3)$$

with

$$T_L = \frac{\rho_{cr}}{A \cdot 10^{-6}} \quad (4)$$

$$T_r = T_1 + n \cdot (T_2 + T_3 + T_4) \quad (5)$$

$$T = T_1 + n \times [(1 + \lambda_1) \times T_2 + (1 + \lambda_1 + \lambda_2) \times (T_3 + T_4)] \quad (6)$$

$$\Delta\theta_d = W_d \times \left[\frac{T_1}{2} + n \times (T_2 + T_3 + T_4) \right] \quad (7)$$

$$\Delta W = \Delta W_0 \times \left[1 - \frac{\Delta\theta(0)}{\Delta\theta_{max} - \Delta\theta_d} \right] \quad (8)$$

$$\Delta W_0 = \frac{R \times \alpha_{20} \times I^2}{1 + \alpha_{20} \times (\theta_{max} - 20)} \quad (9)$$

where

ρ_{cr} is the conductor thermal resistivity;

For copper $\rho_{cr} = 0,0026$ Kxm/W; for aluminium $\rho_{cr} = 0,0049$ Kxm/W.

A is the conductor cross-sectional area;

α_{20} is the temperature coefficient of electrical resistivity for the conductor material;

I is the maximum permissible current of the rated cable when isolated.

The remaining variables are defined in other parts of the IEC 60287 series