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Câbles électriques –
Calcul du courant admissible –
Partie 2:
Résistance thermique –

Section 2: Méthode de calcul des coefficients de réduction de l'intensité de courant admissible pour des groupes de câbles posés à l'air libre et protégés du rayonnement solaire direct

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

Section 2: A method for calculating reduction factors for groups of cables in free air, protected from solar radiation

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. 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. The 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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3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

International Standard IEC 287-2-2 has been prepared by sub-committee 20A: High-voltage cables, of IEC technical committee 20: Electric cables.

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

Six months' Rule	Report on voting
20A(CO)125	20A(CO)135

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 section was published initially as IEC 1042.

INTRODUCTION

This section provides a method and data for calculating group reduction factors for cables in groups running horizontally in free air. Dielectric losses are neglected. It should be read in conjunction with part 2, section 1.

ELECTRIC CABLES –

CALCULATION OF THE CURRENT RATING –

Part 2: Thermal resistance –

Section 2: A method for calculating reduction factors for groups of cables in free air, protected from solar radiation

1 Scope

The method described in this International Standard is applicable to any type of cable and group running horizontally, provided that the cables are of equal diameter and emit equal losses.

Information is provided on the reduction in permissible current when cables are mounted adjacent to each other. It is limited to the following cases:

a) a maximum of nine cables in a square formation, see figure 1, and

b) a maximum of six circuits each comprised of three cables mounted in trefoil, with up to three circuits placed side by side or two circuits placed one above the other, see figure 2.

Caution is advised where air flow around the cables may be restricted by proximity to neighbouring objects.

NOTE – Further work is to be done to extend and refine the data and to include the effect of dielectric loss.

Information is provided for the following situations:

- Where a rating for one cable or circuit assumed to be isolated exists, group reduction factors can be derived for the same type of cable, see 4.1.
- Where previously calculated ratings are not available, the data provided can be used to calculate permissible currents for groups of cables, using the formulae in parts 1 and 2, see 4.2.
- Where adequate clearances can be provided between cables to avoid a reduction in permissible current, see clause 5.

2 Normative references

IEC 287-1-1: 1994, *Electric cables – Calculation of the current rating – Part 1: Current rating equations (100 % load factor) and calculation of losses – Section 1: General*

IEC 287-2-1: 1994, *Electric cables – Calculation of the current rating – Part 2: Thermal resistance – Section 1: Calculation of thermal resistance*

3 List of symbols

D_e	=	external diameter of a multi-core cable or of one single-core cable mounted in trefoil	mm
F_g	=	group reduction factor	
I_g	=	rating of the hottest cable in a group	A
I_t	=	rating for one cable or circuit, assumed to be isolated	A
T_{4I}	=	external thermal resistance of one cable, assumed to be isolated, used for calculating I_t	K.m/W
T_{4g}	=	external thermal resistance of the hottest cable in a group	K.m/W
W	=	power loss from one multi-core cable or one single-core cable mounted in trefoil, assumed to be isolated, when carrying the current I_t	W/m
e	=	clearance between adjacent cables in a group (note, this is measured between cable surfaces, not between cable axes as in IEC287-1-1 and IEC 287-2-1	mm
h_I	=	heat dissipation coefficient of one multicore cable or of one single-core cable mounted in trefoil, assumed to be isolated, in free air	$W/m^2.K^{5/4}$
h_g	=	heat dissipation coefficient of the hottest cable in a group	$W/m^2.K^{5/4}$
k_I	=	cable surface temperature rise factor of one multicore cable or of one single-core cable mounted in trefoil, assumed to be isolated, in free air	
	=	$\dfrac{\text{cable surface temperature rise}}{\text{conductor temperature rise}}$	
θ_a	=	ambient temperature used for calculating I_t	°C
θ_c	=	conductor temperature used for calculating I_t	°C

4 Method

4.1 *When group reduction factors can be applied to existing ratings*

When the permissible current for an isolated cable or circuit is known and it is desired to calculate the reduction factor for a group of cables, the calculation is made for the hottest cable in the group using:

$$F_g = \sqrt{\frac{1}{1 - k_I + k_I\,(T_{4g}/T_{4I})}} \qquad (1)$$

The current-carrying capacity of the hottest cable is then given by:

$$I_g = F_g \cdot I_t \qquad (2)$$

The surface temperature rise factor k_l is calculated from:

$$k_l = \frac{W \cdot T_{4l}}{(\theta_c - \theta_a)} \qquad (3)$$

NOTE – The quantities W and T_{4l} are available from the calculation used for I_t and it is convenient to calculate k_l at the same time as I_t.

The term (T_{4g}/T_{4l}) shall be calculated from the ratio (h_l/h_g) by the use of the iterative relationship:

$$(T_{4g}/T_{4l})_{n+1} = (h_l/h_g) \left[\frac{1 - k_l}{(T_{4g}/T_{4l})_n} + k_l \right]^{0,25} \qquad (4)$$

starting with $(T_{4g}/T_{4l})_1 = (h_l/h_g)$.

NOTE – Equation (4) converges quickly, one evaluation with $(T_{4g}/T_{4l})_1 = (h_l/h_g)$ is usually sufficient.

Alternatively, when (h_l/h_g) is less than 1,4, it is sufficient to substitute (h_l/h_g) for (T_{4g}/T_{4l}) in equation (1).

Values for the ratio (h_l/h_g) are given in table 1 and in figures 3 to 5 for groups of multicore cables and for groups of single-core cables in trefoil formation.

NOTE – Values for other arrangements of cables should be determined by experiment.

4.2 *Where there are previously calculated ratings*

The current-carrying capacity of the hottest cable in a group shall be calculated using the formulae given in part 2, section 1 for cables in free air, but with h_g substituted for the heat emission coefficient h given in part 2, section 1.

For the group configurations covered in table 1 and in figures 3 to 5, values of the heat emission coefficient h_g are derived from:

$$h_g = \frac{h}{(h_l/h_g)} \qquad (5)$$

where the parameter h is given in part 2, section 1, for one multicore cable or for one cable mounted in a trefoil group, assumed to be isolated, and the ratio (h_l/h_g) is obtained from table 1 or figures 3 to 5 of this standard.

4.3 *Groups of cables installed in more than one plane*

Factors and current-carrying capacities for the hottest cable in a group where cables are arranged in both the horizontal and vertical directions shall be evaluated by using the appropriate value of (h_l/h_g) for the vertical clearance and ensuring that the horizontal clearance between cables, e, is not less than the appropriate value given in table 1 for neglecting side by side thermal proximity effect.

5 Values of clearance to avoid a reduction in current-carrying capacity

Minimum clearances between the outside surfaces of neighbouring cables, necessary to avoid a reduction in current-carrying capacity from the value for one cable or circuit, assumed to be isolated, are given in column 2 of table 1 for various arrangements of cables.

The minima have been selected taking into account that it is not practicable to maintain small clearances precisely. Care shall be taken to provide supports adequate to ensure the desired spacing.

If a clearance not less than the appropriate minimum value given in column 2 of table 1 cannot be maintained over the entire length of the cable, one of the procedures given in clause 6 shall be applied.

6 Procedures to derive the reduction coefficient for grouped cables

If a clearance not less than the appropriate value given in column 2 of table 1 cannot be maintained with confidence throughout the length of the cable, the reduction coefficient shall be determined as follows:

- For horizontal clearances it shall be assumed that the cables are touching each other or the vertical surface. Appropriate values of (h_l/h_g) are given in column 4 of table 1 for calculating the reduction coefficient using one of the methods given in clause 4.

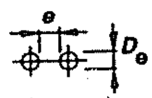
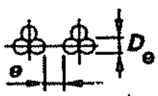
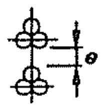
- For vertical clearances the reduction coefficient due to grouping shall be derived according to the value of the expected clearance:

  a) where the clearance is less than the appropriate value given in column 2 of table 1, but can be maintained at a value not less than the minimum given in column 3, a reduction coefficient shall be derived using one of the methods of clause 4 with an appropriate value of (h_l/h_g) obtained either from the formula in column 4 of table 1 or from one of the curves in figures 3 to 5;

  b) where the clearance cannot be maintained at a value not less than the minimum given in column 3 of table 1, is shall be assumed that the cables are touching each other. Suitable values of (h_l/h_g) are provided in column 4 of table 1 for calculating the reduction coefficient using a method in clause 4.

NOTE – The formulae in table 1 and the curves in figures 3 to 5 are valid only for the range of clearances indicated in the footnotes to the table and must not be extrapolated.

Table 1 – Data for calculating reduction coefficients for grouped cables

Arrangement of cables		Thermal proximity effect is negligible if e/D_e is greater than or equal to:	Thermal proximity effect is not negligible	
			If e/D_e is less than:	Average value of h_l/h_g [1), 2)]
1		2	3	4
Side by side				
2 multicore		0,5	0,5	1,41
3 multicore		0,75	0,75	1,65
2 trefoils		1,0	1,0	1,2
3 trefoils		1,5	1,5	1,25
One above the other				
2 multicore		2	2 or 0,5	$1{,}085\,(e/D_e)^{-0.128}$ or 1,35
3 multicore		4	4 or 0,5	$1{,}19\,(e/D_e)^{-0.135}$ or 1,57
2 trefoils		4	4 or 0,5	$1{,}106\,(e/D_e)^{-0.078}$ or 1,39
Near to a vertical surface or to a horizontal surface below the cable		0,5	0,5	1,23

1) The formulae for (h_l/h_g) given in column 4 of this table and the curves of figures 3 to 5, shall not be used for values of (e/D_e) less than 0,5 or greater than the appropriate values given in column 2.

2) Average values for cables having diameters from 13 mm to 76 mm. More precise values of (h_l/h_g) for multicore cables may be evaluated for a specific cable diameter, both inside and outside this range, by consulting table 2 of part 2, section 1.

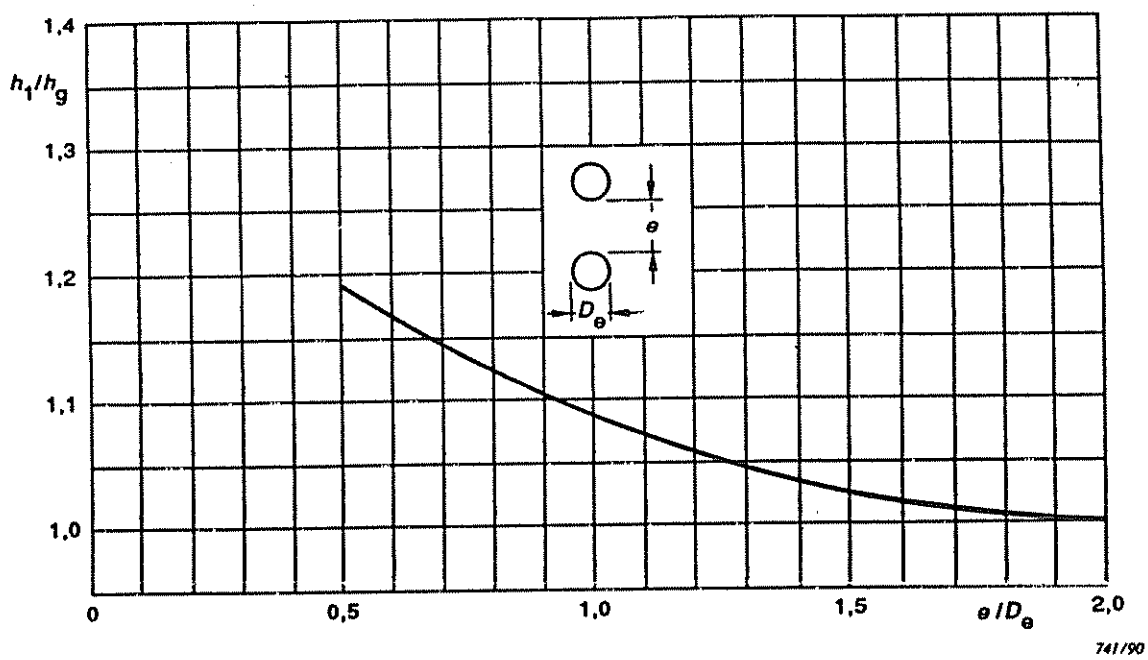


Figure 3 – Valeurs de (h_l/h_g) pour deux câbles disposés dans un plan vertical
Values of (h_l/h_g) for two cables in a vertical plane

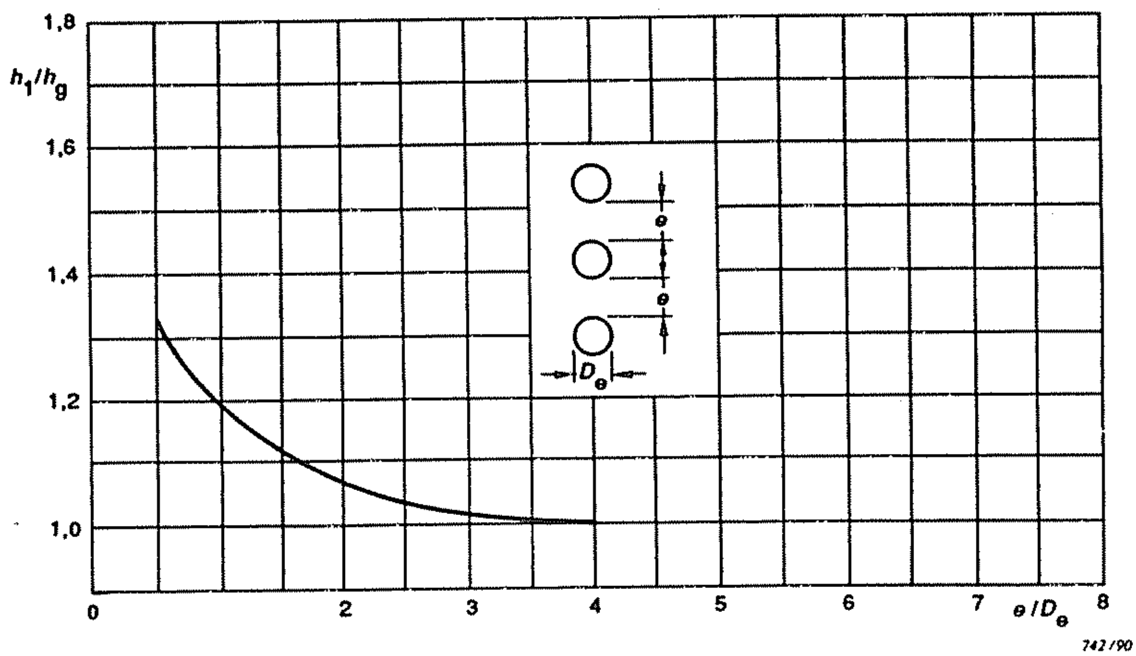


Figure 4 – Valeurs de (h_l/h_g) pour trois câbles disposés dans un plan vertical
Values of (h_l/h_g) for three cables in a vertical plane