

# TECHNICAL REPORT

---

## Calculation of maximum external diameter of cables for indoor installations



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Email: [inmail@iec.ch](mailto:inmail@iec.ch)  
Web: [www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: [www.iec.ch/webstore/custserv](http://www.iec.ch/webstore/custserv)

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00



# TECHNICAL REPORT

---

## Calculation of maximum external diameter of cables for indoor installations

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE

G

# INTERNATIONAL ELECTROTECHNICAL COMMISSION

## CALCULATION OF MAXIMUM EXTERNAL DIAMETER OF CABLES FOR INDOOR INSTALLATIONS

### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 60649, which is a technical report, has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories

This second edition cancels and replaces the first edition published in 1979. This edition constitutes a technical revision.

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

- a) new definitions and formulation for diameter calculation.
- b) revised values of constants used for the diameter calculation.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
46C/765/DTR	46C/799A/RVC

Full information on the voting for the approval of this technical report 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.

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.

A bilingual version of this publication may be issued at a later date.

# CALCULATION OF MAXIMUM EXTERNAL DIAMETER OF CABLES FOR INDOOR INSTALLATIONS

## 1 Scope

This Technical Report gives guidance for calculation of the overall cable diameter according to the structure and the dimensions of the cable elements.

## 2 Terms and definitions

For the purposes of this document, the following terms apply.

### 2.1 General definitions

#### 2.1.1

**single conductor**

solid conductor

#### 2.1.2

**solid conductor within the stranded conductor**

strand

#### 2.1.3

**stranded conductor**

group of assembled strands

#### 2.1.4

**cable element**

conductor, pair, triple, quad, quintuple or other structure. It may be screened or unscreened

#### 2.1.5

**solid conductor shape**

circular

#### 2.1.6

**all dimensional values are nominal**

### 2.2 Notation

#### 2.2.1

diameter of solid conductor,  $d$

#### 2.2.2

diameter of concentric-lay stranded conductor,  $d_s$

#### 2.2.3

diameter of non-concentric-lay stranded conductor,  $d_{ns}$

#### 2.2.4

total number of strands in a stranded conductor,  $N_s$

#### 2.2.5

number of lays in a concentric-lay stranded conductor,  $n$

**2.2.6****diameter coefficient for non-concentric-lay stranded conductor,  $k_{ns}$** **2.2.7****nominal insulation thickness,  $d_i$** **2.2.8****tape thickness,  $d_t$** **2.2.9****braid wire diameter,  $d_b$** **2.2.10****assembly coefficient,  $K_a$** **2.2.11****cable element diameter,  $d_a$** **2.2.12****core diameter,  $d_{core}$** **2.2.13****sheath thickness,  $d_{sh}$** **3 Equations and method for calculations****3.1 Diameter of stranded concentric-lay conductor**

Stranded concentric-lay is made up of 7, 19, 37, 61, 91 or 127 strands. Each strand has diameter  $d$ . The strands are arranged in layers.

For this case  $N_s$  can be calculated from equation (1).

$$N_s = 3n^2 + 3n + 1 \quad (1)$$

And  $d_s$  from equation (2)

$$d_s = (1+2n)d \quad (2)$$

**3.2** The diameter of stranded non concentric-lay conductor can be calculated by equation (3) and Table 1, as follows:

$$d_{ns} = k_{ns}d \quad (3)$$

**Table 1 –  $k_{ns}$  values**

$N_s$	$k_{ns}$	$N_s$	$k_{ns}$
2	2	26	6,0
3	2,15	27	6,15
4	2,41	28	6,41
5	2,7	29	6,41
6	3	30	6,41
7	3	31	6,7
8	3,31	32	6,7
9	3,62	33	6,7
10	4	34	7,0
11	4	35	7,0
12	4,15	36	7,0
13	4,41	37	7,0
14	4,41	38	7,31
15	4,7	39	7,31
16	4,7	40	7,31
17	5,0	41	7,62
18	5,0	42	7,62
19	5,0	43	7,62
20	5,31	44	8,0
21	5,31	45	8,0
22	5,62	46	8,0
23	5,62	47	8,0
24	6,0	48	8,15
25	6,0	49	8,15

**3.3** The overall diameter of insulated solid conductor,  $D$ , can be calculated by equation (4).

$$D = d + 2d_i \quad (4)$$

**3.4** Diameter of insulated concentric lay stranded conductor  $D_s$  can be calculated by equation (5).

$$D_s = d_s + 2d_i \quad (5)$$

**3.5** Diameter of insulated non-concentric-lay stranded conductor  $D_{ns}$  can be calculated by equation (6).

$$D_{ns} = d_{ns} + 2d_i \quad (6)$$

**3.6** Diameter  $D_t$  over tape wrapped with an overlap on a core can be calculated by equation (7).

$$D_t = d_{core} + 3d_t \quad (7)$$



- 3.7** Diameter  $D_t$  over tape wrapped without an overlap on a core can be calculated by equation (8).

$$D_t = d_{\text{core}} + 2d_t \quad (8)$$

- 3.8** Diameter  $D_b$  over braid screen on a core can be calculated by equation (9).

$$D_b = d_{\text{core}} + 4,75 d_b \quad (9)$$

- 3.9** Overall diameter  $D_A$  of cable elements assembly can be calculated by equation (10) and Table 2.

$$D_A = K_a d_a \quad (10)$$

**Table 2 – Assembly coefficient ( $K_a$ )**

Number of cabling elements $N$	Single conductors	Pairs	Triples	Quads	Quintuples
1	1,0	2,0	2,15	2,41	2,7
2	2,0	3,4	Note 1	Note 1	Note 1
3	2,15	3,65	4,1	4,9	5,6
4	2,41	4,1	4,6	5,5	6,3
5	2,7	4,6	5,2	6,2	7,0
6	3,0	5,1	6,0	6,9	7,8
7	3,0	5,1	6,0	6,9	7,8
8	3,4	5,5	6,5	7,6	8,7
9	3,6	6,0	7,0	8,3	9,4
10	4,0	6,4	7,5	8,8	10,0
>10	$1,20 \sqrt{N}$	$1,95 \sqrt{N}$	$2,25 \sqrt{N}$	$2,70 \sqrt{N}$	$3,10 \sqrt{N}$
NOTE 1 Since these types are rarely manufactured, no coefficient is given.					
NOTE 2 It is assumed that elements are identical.					

- 3.10** Overall sheath diameter  $D_c$  can be calculated by equation (11)

$$D_c = D_A + 2d_{\text{sh}} \quad (11)$$

NOTE The minimum value for the sheath thickness,  $d_{\text{sh}}$ , is given in the relevant IEC publications concerning indoor installations.





INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

3, rue de Varembé  
P.O. Box 131  
CH-1211 Geneva 20  
Switzerland

Tel: + 41 22 919 02 11  
Fax: + 41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)