
**Road vehicles — Automotive cables —
Part 1:
Vocabulary and design guidelines**

Véhicules routiers — Cables automobiles —

Partie 1: Vocabulaire et lignes directrices pour la conception

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

A list of all parts in the ISO 19642 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document was prepared following a joint resolution to improve the general structure of the ISO automotive electric cable standards. This new structure adds more clarity and, by defining a new standard family, opens up the standard for future amendments.

Many other standards currently refer to ISO 6722-1, ISO 6722-2 and ISO 14572. These standards will stay valid at least until the next scheduled systematic review and will later be replaced by the ISO 19642 series.

For new automotive cable projects, customers and suppliers are advised to use the ISO 19642 series.

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Road vehicles — Automotive cables —

Part 1: Vocabulary and design guidelines

1 Scope

This document defines terms in the field of cables applied in road vehicle general purpose applications, for use in the other parts of the ISO 19642 series.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

3.1 Terms related to voltage rating

3.1.1

a.c. voltage

voltage in an alternating current circuit that also periodically reverses because the current has a periodic function of time

Note 1 to entry: Whenever a.c. voltage is specified in the ISO 19642 series, the a.c. r.m.s. value shall be used.

3.1.2

60 V cable

cable (3.3.8) intended for use in road vehicle applications where the nominal system voltage is less than or equal to 30 V a.c. or 60 V d.c.

3.1.3

900 V cable

cable (3.3.8) intended for use in road vehicle applications where the nominal system voltage is less than or equal to 600 V a.c. or 900 V d.c.

3.1.4

1 500 V cable

cable (3.3.8) intended for use in road vehicle applications where the nominal system voltage is less than or equal to 1 000 V a.c. or 1 500 V d.c.

3.2 Terms related to temperatures

3.2.1

temperature class rating

temperature range for safe operation of the *cable* (3.3.8) divided into eight temperature classes as defined in [Table 1](#)

Table 1 — Temperature class rating

Class	Is equivalent to Class	Temperature °C
A	T 1	-40 to 85
B	T 2	-40 to 100
C	T 3	-40 to 125
D	T 4	-40 to 150
E	T 5	-40 to 175
F	T 6	-40 to 200
G	T 7	-40 to 225
H	T 8	-40 to 250

3.2.2 room temperature

RT
situation with a temperature of (23 ± 3) °C and a relative humidity (RH) of 45 % to 75 %

3.3 Terms related to cables

3.3.1 Percentage of International Annealed Copper Standard

%IACS
percentage of the volume resistivity of a metal when compared to 100 % of pure annealed copper having a volume resistivity of $0,01724 \Omega \times \text{mm}^2/\text{m}$ at 20 °C as defined in IEC 60028

**3.3.2 bare conductor
plain conductor**

metal *cable* (3.3.8) *conductor* (3.3.12) in which the strand or strands are not coated

3.3.3 bedding layer

non-metallic covering applied (normally extruded) around the assembly of the *cores* (3.3.14) [and *fillers* (3.3.17), if any] of a *multi-conductor cable* (3.3.30) to obtain a more circular outline

3.3.4 braid

covering formed from plain or plated metallic or non-metallic material

3.3.5 braid parameter

parameter of a *braid* (3.3.4) as defined in Table 2 and Table 3

Table 2 — Braid coverage formulae

Outside diameter of the braid	Number of single strands in one direction	Coverage	Optical coverage, braid percentage
$D_G = D_S + 4 \times d$	$m = a \times \frac{n}{2}$	$B = \frac{m \times d}{h \times \cos \alpha}$	$B_0 = (2 \times B - B^2) \times 100$

Table 3 — Braid parameters

d	mm	Diameter of the single strand
D_S	mm	Diameter of the <i>core</i> (3.3.14) below the braid
D_G	mm	Outside diameter of the braid
a		Number of strands in one carrier
m		Number of single strands in one direction
n		Number of carriers
h	mm	Lay length (3.3.28)
α	°	Angle of lay, see Figure 1
B		Coverage, proportion of the covered surface by strands in one direction compared to the whole surface.
B_0	%	Optical coverage. Also called braid percentage. Proportion of the covered surface by strands in both directions compared to the whole surface.

Note 1 to entry: A braid is formed by a number of single strands which are grouped into carriers and applied to the *cable* (3.3.8) surface in two different directions (left and right or S and Z) in a form that each carrier of one direction is alternatively above and below the adjacent carrier of the other direction.

Note 2 to entry: See Figure 1.

**Figure 1 — Angle of lay**

3.3.6

bunched conductor

conductor (3.3.12) in which individual strands are assembled together in helical formation, all in the same direction and with the same length of lay

3.3.7

bunching loss

f_b

ratio of *conductor* (3.3.12) resistance before and after the bunching process of *stranded conductors* (3.3.40)

Note 1 to entry: The factor, f_b , is derived by the formula:

$$f_b = \frac{m_{\text{mean}} \times R_{\text{mean}} \times \kappa}{1000 \times \rho}$$

where

- κ is the conductivity of the used conductor material in Sm/mm²;
- ρ is the density of the conductor material in kg/dm³ = kg/l;
- m_{mean} is the mean of measured conductor mass in g/m;
- R_{mean} is the mean of measured conductor resistance at 20 °C mΩ/m.

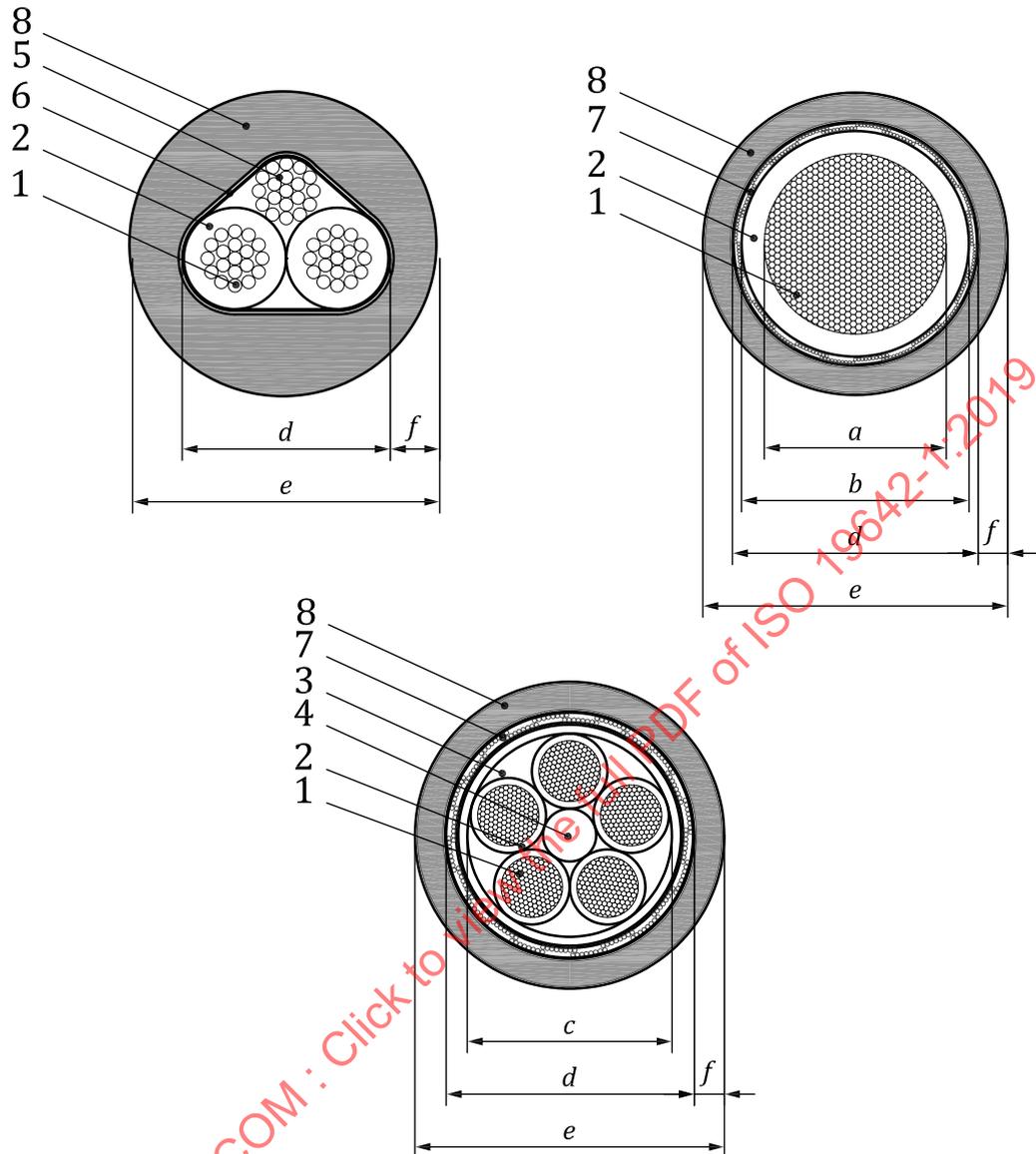
3.3.8

cable

single or multi-core *wire* ([3.3.42](#))

Note 1 to entry: Cable dimension descriptions are shown in [Figure 2](#).

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Key

- | | |
|---|---------------------------------|
| <i>a</i> conductor (3.3.12) diameter | 2 conductor insulation (3.3.13) |
| <i>b</i> core (3.3.14) diameter | 3 inner covering (3.3.22) |
| <i>c</i> twisted core diameter | 4 filler (3.3.17) |
| <i>d</i> diameter under sheath (3.3.38) | 5 drain wire (3.3.42) |
| <i>e</i> outside cable diameter | 6 foil |
| <i>f</i> wall thickness sheath | 7 screen (3.3.36) |
| 1 conductor | 8 sheath |

Figure 2 — Cable dimension descriptions

3.3.9

cable family

group with multiple conductor (3.3.12) sizes having the same conductor strand coating, insulation (3.3.25) formulation, and wall thickness type

**3.3.10
colour code**

code of a *cab*le (3.3.8) colour to make it visually distinguishable from the others

Note 1 to entry: The recommended colours are listed in Table 4.

Note 2 to entry: Annex B indicates recommended colour concentrations for the colours listed in Table 4.

Table 4 — Recommended colours

Colour	Code
Black	BK
Blue	BU
Brown	BN
Green	GN
Orange	OG
Red	RD
Violet (Purple)	VT
White	WH
Yellow	YE

NOTE Other colours can be used based on agreement between customer and supplier (see IEC 60757).

**3.3.11
compressed conductor**

stranded conductor (3.3.40) in which the interstices between the strands have been reduced by mechanical compression into a circular shape with reduced outside diameter

Note 1 to entry: See Figure 3.

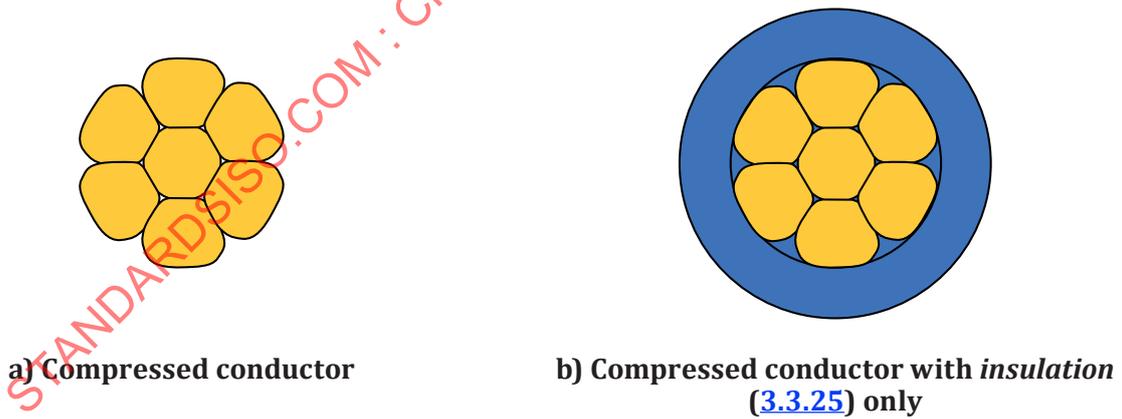


Figure 3 — Compressed conductor

**3.3.12
conductor**

one or multitude of plain, coated or cladded electrically conductive strands

**3.3.13
conductor insulation**

dielectric material applied on a *conductor* (3.3.12)

3.3.14**core**

insulated *conductor* (3.3.12) assembly comprising a conductor with its own *insulation* (3.3.25) [and *screens* (3.3.36), if any]

3.3.15**cross-sectional area**

CSA

calculated or measured area of the *conductor* (3.3.12)

3.3.16**drain wire****continuity wire**

un-insulated or conductive coated *conductor* (3.3.12) laid in contact with a *screen* (3.3.36) or a *shield* (3.3.36)

3.3.17**filler**

component used to fill the interstices between the *cores* (3.3.14) or fill a void for roundness of a *multi-conductor cable* (3.3.30)

3.3.18**flexibility**

property of a *cable* (3.3.8) that allows for bending under the influence of an outside force

3.3.19**flexible conductor**

metallic *conductor* (3.3.12) built from a multitude of single stranded *wires* (3.3.42)

3.3.20**flex life**

property of a *cable* (3.3.8) to withstand repeated bending

3.3.21**general purpose cable**

cable (3.3.8) meeting basic requirements for general automotive applications

3.3.22**inner covering**

non-metallic covering which surrounds the assembly of the *cores* (3.3.14) [and *fillers* (3.3.17), if any] of a *multi-conductor cable* (3.3.30) and over which the protective covering is applied

3.3.23**inner sheath****inner jacket**

non-metallic *sheath* (3.3.38) generally applied under a metallic sheath, reinforcement or armour

3.3.24**insulated cable**

assembly consisting of:

- one or more *cores* (3.3.14),
- their individual covering(s) (if any),
- assembly protection (if any),
- protective covering(s) (if any).

**3.3.25
insulation**

set of insulating materials incorporated on a *conductor* (3.3.12) or *screen* (3.3.36) with a specific function of insulating and/or protecting the conductive elements

**3.3.26
ISO conductor size**

nominal value (3.3.32) of the ISO *wire* (3.3.42) used as a reference in this document

**3.3.27
lay direction**

direction of rotation of a component of a *cable* (3.3.8) in relation to the longitudinal axis of the cable

Note 1 to entry: The lay is said to be right-hand when the visible portion of the helix, together with the two cross-sections limiting it, form the shape of a letter Z, and left-hand when they form the shape of a letter S. See [Figure 4](#).

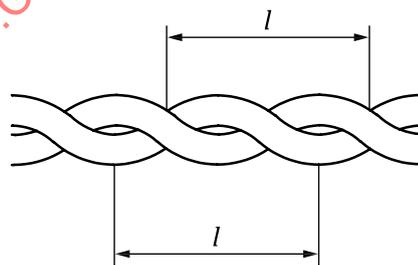


Figure 4 — Lay direction

**3.3.28
lay length**

axial length of one complete turn of the helix formed by one *cable* (3.3.8) component, for example an individual strand or *core* (3.3.14)

Note 1 to entry: See [Figure 5](#).



Key

l length where a core in the outermost layer of the bunching/twisting fulfils a full 360° turn.

Figure 5 — Lay length

**3.3.29
metal-coated conductor
plated conductor**

conductor (3.3.12) in which each individual strand is covered with a thin layer of another different metal or metal alloy

EXAMPLE An electro-chemical process.

3.3.30**multi-conductor cable**

cable (3.3.8) having more than one *conductor* (3.3.12), some of which can be un-insulated

3.3.31**multi-core cable**

cable (3.3.8) having more than one *core* (3.3.14)

Note 1 to entry: See [Figure 6](#).

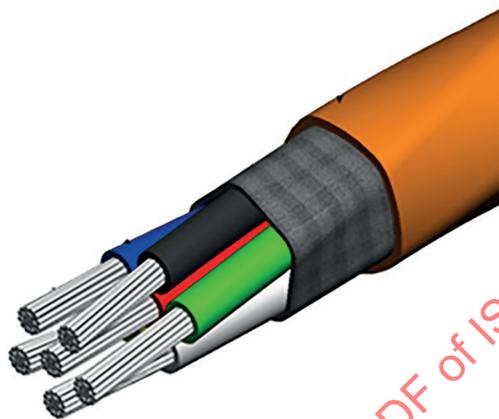


Figure 6 — Multi-core cable with screen and sheath

Note 2 to entry: [Annex A](#) provides design guidelines for calculating dimensions in multi-core cables.

3.3.32**nominal value**

suitable approximate value used to designate or identify an attribute of a component

3.3.33**nominal a.c. system voltage**

a.c. r.m.s. voltage of a *conductor* (3.3.12) to ground or to a neutral conductor in a three-phase *a.c. voltage* (3.1.1) system under nominal conditions

3.3.34**nominal d.c. system voltage**

maximum continuous positive or negative d.c. voltage of a conductor to ground under nominal conditions

3.3.35**rope-stranded conductor**

stranded conductor (3.3.40) consisting of a number of groups of strands assembled together in one or more helical layers, the *wires* (3.3.42) in each group being either bunched or stranded

Note 1 to entry: See examples in [Figure 7](#).

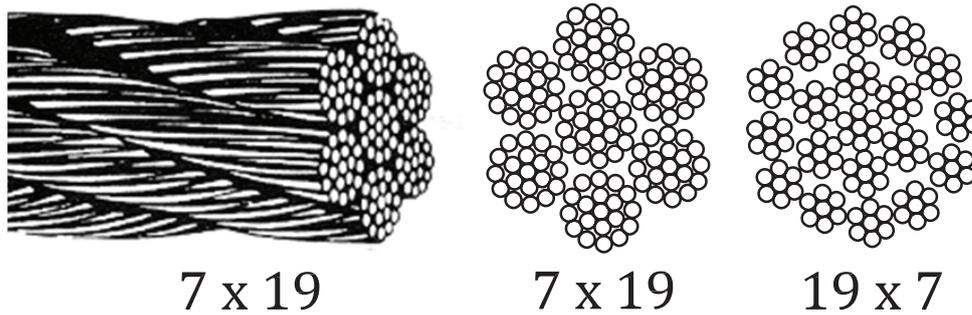


Figure 7 — Rope-stranded conductors

**3.3.36
screen
shield**

conductive material intended to reduce the penetration and/or radiation of a varying electromagnetic field

Note 1 to entry: Metallic *sheaths* (3.3.38), foils, *braids* (3.3.4), armors and earthed concentric *conductors* (3.3.12) may also serve as shields.

**3.3.37
separator**

thin layer used to facilitate the separation of, or as a barrier to prevent mutually detrimental effects between different components of a *cable* (3.3.8), such as between the *conductor* (3.3.12) and the *insulation* (3.3.25) or between the insulation and the *sheath* (3.3.38)

**3.3.38
sheath
jacket**

non-conductive, uniform and continuous covering of material, generally extruded

**3.3.39
special purpose cable**

cable (3.3.8) meeting basic requirements plus enhanced performance requirements for unique applications

Note 1 to entry: Unique requirements are as defined by the customer.

**3.3.40
stranded conductor**

conductor (3.3.12) consisting of a number of individual strands, all or some of which are wound in a helix

**3.3.41
twisting loss**

ratio of *conductor* (3.3.12) resistance before and after the twisting process of *cores* (3.3.14)

**3.3.42
wire**

stranded or solid cylindrical *conductor* (3.3.12), with or without an insulating covering

Annex A (informative)

Design guidelines for calculation of dimensions in multi-core cables

A.1 General

Due to geometric principles and the effect of subsequent production processes like twisting, braiding and sheath extrusion, the properties of the single cores in a multi-core cable are changed.

This annex provides guidelines on how these effects can be calculated.

It also gives guidelines on how to calculate the wall thicknesses of sheath and bedding layers and which tolerances should be guaranteed.

A.2 Outside diameter of twisted cores

The maximum outside diameter of twisted cores, c_{\max} , is calculated using the stranding factors in [Table A.1](#).

For certain numbers of cores (for example 5 or 6), filler cores may be used to get a stable bunching/twisting. The outside diameter of the twisted cores and the diameter of filler cores are calculated according to the following formulae:

$$c_{\max} = f_s \times d_{\max}$$

$$d_D = f_D \times d_{\max}$$

where

c_{\max} is the maximum outside diameter of twisted cores;

f_s is the stranding factor;

f_D is the filler core factor;

d_{\max} is the maximum outside diameter of single core;

d_D is the outside diameter of the filler core.

Table A.1 — Stranding factors for bunching/twisting

Number of cores	Stranding factor f_S	Filler core factor f_D	Filler core needed
2	2,000	X	X
3	2,155	X	X
4	2,414	0,414	optional
5	2,701	0,701	mandatory
6	3,000	1,000	mandatory
7	3,000	X	X
X The cable construction does not exist			

EXAMPLE For 5 thin wall cores with ISO conductor size 1,0 mm²:

- $d_{max} = 2,10$ mm, maximum outside diameter of single core;
- $f_D = 0,701$, filler core factor;
- $d_D = 1,47$ mm, outside diameter of the filler core;
- $f_S = 2,701$, stranding factor;
- $c_{max} = 2,10$ mm \times 2,701 = 5,67 mm, maximum outside diameter of twisted cores.

Although in the centre of this bunching/twisting a filler core is needed, the stranding factor already takes the dimension of the filler core into account.

No extra measurement of the diameter of the twisted cores is performed. For data sheets, the calculated value with two decimals is used.

A.3 Maximum diameter under sheath

The maximum diameter of the bunched cores and the screen is derived with the following formulae:

For an unscreened multi core cable:

$$d_{bsmax} = c_{max}$$

For a screened single core cable:

$$d_{bsmax} = c_{max} + 4 \times d_{smax} + 3 \times d_F$$

For a screened multi core cable:

$$d_{bsmax} = c_{max} + w_{bmax} + 4 \times d_{smax} + 3 \times d_F$$

where

d_{bsmax} is the maximum diameter under sheath;

c_{max} is the maximum diameter of twisted cores for multi core cables, maximum core diameter for single core cables;

w_{bmax} is the maximum wall thickness of bedding layer;

d_{smax} is the maximum diameter of screen strands;

d_F is the thickness of optional foil.

A.4 Minimum insulation wall thickness in multi-core cables

During core bunching/twisting and sheath extrusion, a certain deformation of the cores is unavoidable. This fact is taken into account when the minimum insulation wall thickness is determined.

The specified minimum insulation wall thickness of a single-core cable is reduced according [Tables A.2](#) and [A.3](#), which take into account the nominal cross-sectional area of the core, the nominal wall thickness (thick, thin) and the maximum stranded core diameter.

Table A.2 — Minimum insulation wall thickness of twisted cores with thick wall insulation

ISO conductor size mm ²	d_{max} mm	Minimum wall thickness at lay length, (s)			
		mm			
		$s > 24 \times d_{max}$	$s > 12 \times d_{max}$	$s > 6 \times d_{max}$	$s \leq 6 \times d_{max}$
0,5	2,3	0,43	0,41	0,39	0,32
0,75	2,5	0,43	0,41	0,39	0,32
1	2,7	0,43	0,41	0,39	0,32
1,25	2,95	0,43	0,41	0,39	0,32
1,5	3	0,43	0,41	0,39	0,32
2	3,3	0,43	0,41	0,39	0,32
2,5	3,6	0,50	0,48	0,46	0,38

Table A.3 — Minimum insulation wall thickness of twisted cores with thin wall insulation

ISO conductor size mm ²	d_{max} mm	Minimum wall thickness at lay length, (s)			
		mm			
		$s > 24 \times d_{max}$	$s > 12 \times d_{max}$	$s > 6 \times d_{max}$	$s \leq 6 \times d_{max}$
0,13	1,05	0,18	0,17	0,16	0,13
0,22	1,2	0,18	0,17	0,16	0,13
0,35	1,4	0,18	0,17	0,16	0,13
0,5	1,6	0,20	0,19	0,18	0,15
0,75	1,9	0,22	0,20	0,20	0,16
1	2,1	0,22	0,20	0,20	0,16
1,25	2,3	0,22	0,20	0,20	0,16
1,5	2,4	0,22	0,20	0,20	0,16
2	2,8	0,25	0,24	0,23	0,19
2,5	3	0,25	0,24	0,23	0,19

A.5 Conductor resistance increase due to bunching/twisting

A.5.1 General

The conductor resistance of cores in a multi-core cable is bigger than the resistance of a single-core cable. This effect is caused by two independent reasons and needs to be taken into account in the specified values.

A.5.2 Geometric lengthening

Due to the bunching/twisting, the conductor resistance in the finished cable is increased because the straight length of the cores is longer than the length of the finished cable.

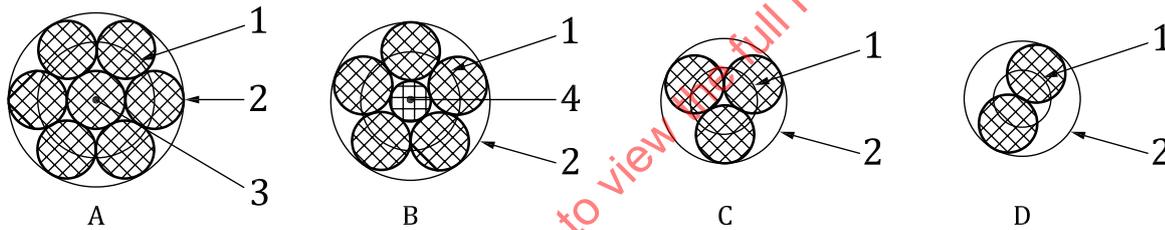
The resulting individual strand lengths are longer for shorter conductor lay lengths.

The amount of lengthening is determined by the distance of the cores to the centre of the bunching/twisting and the lay length:

A core in the centre of the bunching/twisting undergoes no lengthening.

Cores farther off the centre of the bunching/twisting suffer higher lengthening.

For the calculation, the diameter, c_L , of the circle through the centres of the cores in a layer is needed. See [Figure A.1](#).



Key

- A 7 cores
- B 5 cores
- C 3 cores
- D 2 cores
- 1 c_L
- 2 c_{max}
- 3 straight core
- 4 filler

Figure A.1 — Example of core configurations

The geometric lengthening factor, v , is calculated according to the following formulae:

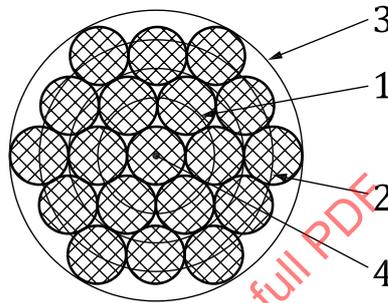
$$c_L = c_{max} - d_{max} = d_{max} \times (f_s - 1)$$

$$v = \sqrt{\left[\left(\frac{c_L \times \pi}{l} \right)^2 + 1 \right]}$$

where

- c_L is the diameter of a circle through the middle points of cores;
- c_{max} is the maximum diameter of twisted cores;
- v is the geometric lengthening factor;
- l is the lay length;
- f_s is the stranding factor;
- d_{max} is the maximum diameter of single core.

For bunching/twisting with more than one layer, the lengthening of each layer needs to be calculated separately. See [Figure A.2](#).



Key

- 1 c_{L1}
- 2 c_{L2}
- 3 c_{max}
- 4 straight core

Figure A.2 — Example of a complicated core configuration (19 cores)

A.5.3 Stress induced lengthening

Due to the unavoidable stress during the bunching/twisting process, an additional lengthening occurs. This additional lengthening is taken into account by the factor z . See [Table A.4](#) for values.

Table A.4 — Stress induced lengthening factor, z , for cable conductors

ISO conductor size mm ²	Factor z	
	Copper conductor	Aluminium conductor
≤0,35	1,020	X
0,5	1,015	1,020
0,75	1,010	1,015
≥1,0	1,005	1,010
X The cable construction does not exist		

A.5.4 Maximum conductor resistance in multi-core cables

The maximum permissible conductor resistance for multi-core cables is derived from the maximum values in the single core specification ISO 19642-3 to ISO 19642-6, using the following formula:

$$R_{\max_multi} = R_{\max_single} \times v \times z$$

where

R_{\max_multi} is the maximum permissible conductor resistance in multi core cables;

R_{\max_single} is the maximum permissible conductor resistance in single core cables;

v is the geometric lengthening factor;

z is the stress induced lengthening factor.

A.6 Wall thickness of sheath and bedding layer

Two different wall thicknesses for the sheath are recommended:

- Thick wall sheath for thick wall cores.
- Thin wall sheath for thin wall cores.

Other possible combinations are not recommended.

For screened multi-core cables a bedding layer is recommended below the screen.

The wall thickness requirements are derived from the diameter of the elements below the sheath or bedding, following [Figures A.3](#) and [A.4](#):

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