

# INTERNATIONAL STANDARD

**IEC**  
**60092-376**

Second edition  
2003-05

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## **Electrical installations in ships –**

### **Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)**

*Installations électriques à bord des navires –*

*Partie 376:  
Câbles pour circuits de commande et d'instrumentation  
150/250 V (300 V)*



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Withdawn

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL INSTALLATIONS IN SHIPS –****Part 376: Cables for control and instrumentation  
circuits 150/250 V (300 V)**

## 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 co-operation 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.
- 2) The formal decisions or agreements of the 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 National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, 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.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60092-376 has been prepared by subcommittee 18A: Cables and cable installations, of IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units

This second edition of IEC 60092-376 cancels and replaces the first edition published in 1983, of which it constitutes a technical revision.

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

| FDIS         | Report on voting |
|--------------|------------------|
| 18A/242/FDIS | 18A/244/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.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

## ELECTRICAL INSTALLATIONS IN SHIPS –

### Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)

#### 1 Scope and object

This part of IEC 60092 is applicable to screened and unscreened cables for control and instrumentation circuits on ships and offshore units. The cables have extruded solid insulation with a voltage rating of 150/250V (300V) (see Clause 4) and are intended for fixed installations.

The various types of cables are given in Clause 8. The construction requirements and test methods are expected to comply with those indicated in IEC 60092-350, unless otherwise specified in this standard.

NOTE Provision is made for fire resistant (limited circuit integrity) cables to be specified if required.

The object of this part of IEC 60092 is

- to standardise cables whose safety and reliability are ensured when they are installed in accordance with the requirements of IEC 60092-352;
- to lay down standard manufacturing requirements and characteristics of such cables directly or indirectly bearing on safety;
- to specify test methods for checking conformity with those requirements.

#### 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 60228, *Conductors of insulated cables*

IEC 60092-350:2001, *Electrical installations in ships – Part 350: Shipboard power cables – General construction and test requirements*

IEC 60092-351, *Electrical installations in ships – Part 351: Insulating materials for shipboard and mobile and fixed offshore units power, telecommunication, and control data cables*

IEC 60092-352, *Electrical installation in ships – Part 352: Choice and installation of cables for low-voltage power systems*

IEC 60092-359, *Electrical installations in ships – Part 359: Sheathing materials for shipboard power and telecommunication cables*

IEC 60331-21, *Tests for electric cables under fire conditions – Circuit integrity – Part 21: Procedures and requirements – cables of rated voltage up to and including 0,6 / 1 kV*

IEC 60332-1, *Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable*

IEC 60332-3-22, *Tests on electric cables under fire conditions – Part 3-22: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category A*

IEC 60811 (all parts), *Common test methods for insulating and sheathing materials of electric cables*

IEC 61034-1, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus*

IEC 61034-2, *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements*

IEC 60092-353, *Electrical installations in ships – Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV*

### 3 Definitions

For the purposes of this standard, the definitions given in IEC 60092-350 and the following apply.

#### 3.1

##### **pair unit**

a unit which consists of two cores laid up with or without interstitial fillers or binder tape(s)

#### 3.2

##### **triple unit**

a unit which consists of three cores laid up with or without interstitial fillers or binder tape(s)

#### 3.3

##### **quad unit**

a unit which consists of four cores laid up with or without interstitial fillers or binder tape(s)

#### 3.4

##### **electrostatic screen**

surrounding earthed metallic layer to confine the electrical field within the cable cores, pair(s), triple(s) or quad(s) and/or to protect the cable core(s), pair(s), triple(s) or quad(s) from external electrical influence

#### 3.5

##### **drain wire**

an uninsulated conductor which has the specific function of earthing an electrostatic tape screen by ensuring a low resistive path throughout the length of the cable

#### 3.6

##### **single unit cable**

a cable consisting of either one pair, triple or quad unit, either unscreened or with an individual electrostatic screen

#### 3.7

##### **multi-unit cable**

a cable consisting of more than one pair, triple or quad units either unscreened or with an individual electrostatic screen around each unit or having an electrostatic screen applied around the assembly of units (a collective screen)

### 3.8 braid armour

a covering formed from braided metal wires used to protect the cable from external mechanical effects

NOTE Copper wire braid armour may also provide the function of an electrostatic collective screen, providing it is earthed.

### 3.9 inner covering

a non-metallic covering which surrounds the assembly of the cores (and filler if any) of a multi-conductor cable and over which the protective covering is applied

## 4 Rated voltage

The standard rated voltage  $U_o/U (U_m)$  is as follows:

$$U_o/U (U_m) = 150 \text{ V}/250 \text{ V} (300 \text{ V}) \text{ a.c.}$$

In the voltage designation of cables

$U_o$  is the rated power-frequency voltage between the conductor and the earth or metallic covering for which the cable is designed;

$U$  is the rated power-frequency voltage between conductors for which the cable is designed.

$U_m$  is the maximum value of the highest system voltage for which the equipment may be used.

A d.c. voltage up to a maximum of 1,5 times the a.c. voltage may be used, provided that the voltage to earth does not exceed 250 V.

NOTE When circuits are to be supplied from a low impedance source, attention is drawn to IEC 60092-353 for 600/1000 V cables having a minimum conductor size of 1,5 mm<sup>2</sup>.

## 5 Types of insulating compounds

The insulation compounds and their designations shall be selected from IEC 60092-351.

## 6 Types of sheathing compounds

The sheathing compounds and their designations shall be selected from IEC 60092-359.

## 7 Markings

### 7.1 Indication of origin and voltage rating

Identification of origin (manufacturer's name or trade mark), rated voltage ( $U_o/U$ ) and construction (number of cores, pairs, triples or quads and cross sectional area of the conductor) to be printed, embossed or indented on the oversheath. It is allowed, in addition, to include an identification printed tape.

|                     |                     |           |                                |
|---------------------|---------------------|-----------|--------------------------------|
| Multicore example : | "Name or Trade mark | 150/250 V | 19 x 1,5 mm <sup>2</sup> "     |
| Multi-unit example: | "Name or Trade mark | 150/250 V | 3 x 2 x 0,75 mm <sup>2</sup> " |

In the case of an outer metal braid armour applied above the oversheath, identification by threads or printed tapes inserted under the metal braid is permitted.

## 7.2 Continuity

The marking of the manufacturer's name or trademark is deemed to be continuous if the distance between the end of any marking and the beginning of the next does not exceed

- 550 mm if the indication is on the sheath, and
- 275 mm in all other cases.

## 7.3 Durability

The printed marking shall be indelible.

Compliance with this requirement is checked by the test described in 16.2.

## 7.4 Legibility

The marking of the manufacturer's name or trademark shall be legible.

The colours of identification threads, if any, shall be easy to recognise or easily made recognisable, if necessary, by cleaning.

## 7.5 Core identification

Identification of cores shall be made within multicore cables or cores within pair, triple or quad unit(s), according to one of the methods below.

### 7.5.1 Multicore cables

Identification shall be made by inscription of numbers on each core starting from the centre beginning with 1 in accordance with the following.

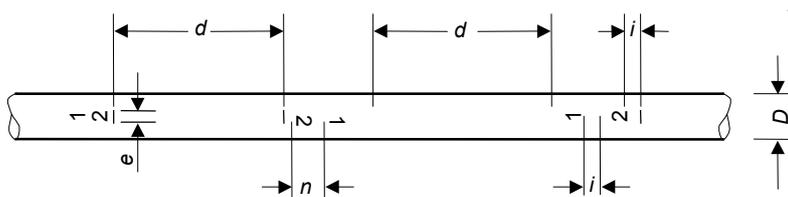
#### 7.5.1.1 Identification

The identification shall be composed of marks at regular intervals along the entire length of core and comprising of

- a) a reference number in Arabic numerals;
- b) a dash which underlines this reference number and indicates the direction in which the number must be read.

#### 7.5.1.2 Arrangement of the marks

Two consecutive marks shall always be placed upside down in relation to one another. The arrangement of the marks is shown in Figure 1.



IEC 1639/03

Figure 1 – Arrangement of the marks

When the reference consists of a single numeral, the dash is placed under it; if the reference number consists of two numerals, these are disposed one below the other and the dash is placed underneath the lower numeral.

### 7.5.1.3 Spacing and dimensions of the marks

The dimensions of the marks and the spacing are given in Table 1,

where

$D$  = nominal diameter of the core;

$e$  = minimum width of a mark;

$n$  = minimum height of a numeral;

$i$  = approximate interval, in a mark, between two consecutive numerals, as well as between numeral and dash;

$d$  = maximum interval between two consecutive marks.

**Table 1 – Dimension of the marks**

| Nominal diameter, $D$ ,<br>of the core<br>mm | $e^a$  | $n$    | $i$  | $d$   |
|----------------------------------------------|--------|--------|------|-------|
| $D \leq 2,4$                                 | 0,6 mm | 2,3 mm | 2 mm | 50 mm |
| $2,4 < D \leq 5$                             | 1,2 mm | 3,2 mm | 3 mm | 50 mm |

<sup>a</sup> When the numeral is 1, the minimum width is equal to half the dimension given in this table.

### 7.5.1.4 Appearance of identification

The identification shall be legible and of a colour which contrasts with that of the core. All the marks of the cores in multicore cable shall be of the same colour.

### 7.5.2 Single and multiunit cables

The cores of single and multiunit cables shall be provided with a suitable method of identification.

### 7.6 Unit identification

When requested by the purchaser, identification of the individual units of multiunit cables is permitted by the use of tape(s) marked with numbers.

NOTE Annex A gives details of a typical colour code.

## 8 General description

Screened and unshielded cables for control and instrumentation circuits in fixed installations on ships and offshore units, 150/250 V (300 V) shall consist of copper conductors insulated with one of the materials listed in IEC 60092-351 and assembled as follows:

- cores laid up in concentric layers, unshielded, provided with an optional tape wrapping, finished to one of the constructions detailed below in (1) to (5);
- cores laid up in concentric layers, with an overall collective screen with drain wire, with an optional tape wrapping, finished to one of the constructions detailed below in (1) to (5).
- Cores twisted together to form a pair, triple or quad unit each unit being individually shielded with drain wire, then cabled together, provided with an optional tape wrapping or optional tape screen, finished to one of the constructions detailed below in (1) to (5).

- d) Cores twisted to form a pair, triple or quad unit, these unscreened units cabled together with an overall collective screen with drain wire, provided with an optional tape wrapping, finished to one of the constructions detailed below in (1) to (5).

Unarmoured types:

- 1) a single sheath;
- 2) i) an inner sheath and an outer sheath – double sheathed;  
ii) an inner covering and an outer sheath.

Armoured types:

- 3) an inner covering, metal armour and an outer sheath;
- 4) a single sheath with an outer metal armour;
- 5) an inner sheath, a metal armour and an outer sheath.

Non-cross-linked insulation shall not be used when the cross-linking process of the sheath leads to a detrimental change in the properties and/or shape of the insulation.

Where a cable is claimed to be “halogen-free” <sup>1)</sup> all non-metallic components shall be “halogen-free”.

Cables for installation in spaces where corrosion may occur, for example weather decks, wet locations, battery compartments, refrigeration rooms, etc., shall have an outer sheath over the metal armour.

## 9 Conductors

The material, metal coating, separator, class and form of the conductors shall be in accordance with IEC 60092-350 and shall be circular Class 2 or Class 5 constructions of cross-sectional area 0,50 mm<sup>2</sup>, 0,75 mm<sup>2</sup>, 1,0 mm<sup>2</sup>, 1,5 mm<sup>2</sup> or 2,5 mm<sup>2</sup>.

Conductor resistance shall be in accordance with Table 6.

NOTE The preferred conductor sizes are 0,75 mm<sup>2</sup> and 1,5 mm<sup>2</sup>.

## 10 Insulation system

### 10.1 Material

The insulation system shall consist of either

- one of the insulating compounds indicated in Table 2,
- a combination of one or more layers of inorganic tape(s) and a layer of one of the insulating compounds indicated in Table 2 or
- a combination of S95 compound together with a varnished glass braid.

### 10.2 Electrical and non-electrical characteristics of the insulation system

These shall be as specified in IEC 60092-351 for the relevant type of insulating compound used.

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1) A definition of “halogen-free” is under discussion.

### 10.3 Application to the conductor

The insulation shall be applied closely to the conductor, to the separator or to inorganic tape(s), if any. It shall be possible to remove the insulation without damaging the conductor or its metal coating, if any. Compliance shall be checked by visual inspection.

### 10.4 Thickness of insulation

- The average thickness shall be not less than the value specified in Table 2 for each type of insulation and cross-section of conductor.
- For multicore cables the thickness at any point may be less than the specified value, provided the difference does not exceed 0,1 mm + 10 % of the specified value.
- For multiunit cables the thickness at any point may be less than the specified value, provided the difference does not exceed 0,1 mm + 20 % of the specified value.
- The thickness of any separator or inorganic tape(s) applied over the conductor or over the insulation shall not be included in the thickness of insulation.
- The thickness of the inorganic tape(s) shall be adequate to meet the performance requirements of this standard (see in particular 17.3 (i)).

**Table 2 – Specified thickness of insulation**

| Nominal cross-sectional area of conductor<br>mm <sup>2</sup> | PVC/A<br>mm | EPR<br>HF EPR<br>mm | XLPE<br>HF XLPE<br>mm | HEPR<br>HF HEPR<br>mm | HF 85<br>mm | S 95<br>HF S 95<br>mm |
|--------------------------------------------------------------|-------------|---------------------|-----------------------|-----------------------|-------------|-----------------------|
| 0,50                                                         | 0,6         | 0,6                 | 0,4                   | 0,4                   | 0,6         | 0,6                   |
| 0,75                                                         | 0,6         | 0,6                 | 0,5                   | 0,5                   | 0,6         | 0,6                   |
| 1,0                                                          | 0,6         | 0,6                 | 0,5                   | 0,5                   | 0,6         | 0,6                   |
| 1,5                                                          | 0,7         | 0,7                 | 0,6                   | 0,6                   | 0,7         | 0,7                   |
| 2,5                                                          | 0,7         | 0,7                 | 0,6                   | 0,6                   | 0,7         | 0,7                   |

NOTE 1 IEC 60092-351 is currently under revision: under consideration is the renaming of HF85 as HF90.

NOTE 2 For cables which include inorganic tape(s) or varnished glass braid to confer fire resistance (limited circuit integrity), all the values of insulation given in Table 2 shall be increased by 0,20 mm for subsequent consideration in the calculation of fictitious diameters.

NOTE 3 For the calculation of fictitious diameters, see method outlined in Annexes A and B of IEC 60092-350.

## 11 Cabling

### 11.1 Core assembly (multicore cables)

The individual cores identified in accordance with 7.5.1 shall be twisted together in concentric layers. When necessary, filler(s) as detailed in 11.4 may be used to obtain a circular cable.

NOTE A non-hygroscopic binder tape or tapes may be applied over each layer.

### 11.2 Forming pair, triple or quad units

Cores identified in accordance with 7.5 shall be twisted together with either a left hand or right hand lay to form a pair, triple or quad unit.

If the pair, triple or quad units are not individually screened the lay length of the cores, in adjacent units, shall be selected so as to reduce inductive effects and cross-talk to a minimum and ensure that the cores of the pair, triple or quad units do not become disassociated by normal handling.

The lay length of the cores individually or collectively screened shall not exceed 120 mm for sizes below 1,5 mm<sup>2</sup> and 150 mm for sizes 1,5 mm<sup>2</sup> and above.

NOTE A non-hygroscopic binder tape or tapes may be applied over each unit.

### 11.3 Unit assembly (multiunit cables)

The individual units, screened or unscreened, and identified in accordance with 7.5.2 shall be assembled in concentric layers using either a unidirectional or reverse lay. When necessary, a filler(s) as detailed in 11.4 may be used to obtain a circular cable. Different lay lengths shall be selected for neighbouring unscreened units.

NOTE A non-hygroscopic binder tape or tapes may be applied over each layer.

### 11.4 Fillers

Use of fillers is permitted, as necessary, to give the completed cable a substantially circular cross section. When used, they shall be composed of a vulcanised or unvulcanised elastomeric compound, thermoplastic compound or natural or synthetic textiles. The fillers shall be non-hygroscopic and there shall be no harmful interactions between the constituents of the filler and the insulation and/or the sheath and they shall be capable of being removed without damaging any other component in the cable. Alternatively, interstitial fillers may be applied integrally with the sheath of unarmoured cables or the inner sheath or inner covering of metal armoured cables.

### 11.5 Number of cores, pairs, triples or quads.

Within practical physical limits any number of cores, pairs, triples or quads can be laid up to form a cable assembly, however Annex B gives recommended cable assemblies the adoption of which will enable cable makers and stockists to provide an ex-stock service to the customer.

## 12 Electrostatic screen

### 12.1 Individually taped screened pair, triple or quad constructions

When an individual taped screened pair, triple or quad construction is required, each pair, triple or quad shall have a laminated electrostatic screening tape applied with the metallic side in electrical contact with a drain wire. The nominal overlap shall not be less than 25 %.

The laminated electrostatic screening tape shall be either aluminium bonded to polyester having a minimum thickness of aluminium of 0,008 mm and a minimum thickness of polyester of 0,010 mm, or copper bonded to polyester having a minimum thickness of copper of 0,018 mm and a minimum thickness of polyester of 0,023 mm.

The drain wire shall be composed of a number of strands of tinned annealed copper wires in the case of aluminium laminate tape and either plain or tinned annealed copper wires in the case of copper laminate tape. The drain wire shall have a maximum resistance in accordance with Table 3.

### 12.2 Individually braided screened pair, triple or quad constructions

When an individual braided screened pair, triple or quad construction is required, each pair, triple or quad shall have a non-hygroscopic separator tape applied over the cores and under the braid. The nominal overlap shall not be less than 25 %.

The braid shall be either plain or metal coated copper wires; the minimum diameter of the braid wire shall be:

- 0,15 mm for fictitious cable diameters under the braid less than or equal to 9 mm;
- 0,2 mm for fictitious cable diameters under the braid greater than 9 mm.

Joints in the braiding wires shall be soldered, twisted or woven in and the complete braid shall not be welded. The braid shall be evenly applied.

The "filling factor" F of the braid shall be not less than 0,6 when calculated in accordance with the alternative method given in IEC 60092-350.

NOTE The percent coverage  $F = (2F - F^2) * 100$

The fictitious diameter under the braid is calculated by the method described in Appendix A of IEC 60092-350.

When required, to aid termination, a drain wire may be applied under and in direct contact with the braid screen. The drain wire shall be composed of a number of strands of tinned or plain annealed copper wires. The drain wire shall have a maximum resistance in accordance with Table 3.

**Table 3 – Requirements of drain wire**

| Nominal area of core conductor<br>mm <sup>2</sup> | Maximum drain wire resistance<br>Ω/km |
|---------------------------------------------------|---------------------------------------|
| 0,50                                              | 61,2                                  |
| 0,75                                              | 42,5                                  |
| 1,0                                               | 28,3                                  |
| 1,5                                               | 28,3                                  |
| 2,5                                               | 21,2                                  |

Polyester tape of either 0,023 mm or 0,050 mm nominal thickness shall be applied over the screen with a minimum overlap of 20 % of its total width.

## 12.3 Collectively screened constructions

### 12.3.1 Laminated electrostatic screening

When collectively screened constructions are required, a laminated electrostatic screening tape shall be applied with the metallic side in electrical contact with the drain wire. The minimum overlap of the laminated tape shall be 25 % of its total width.

The laminated tape shall be either aluminium bonded to polyester having a minimum thickness of aluminium of 0,008 mm and a minimum thickness of polyester of 0,010 mm, or copper bonded to polyester having a minimum thickness of copper of 0,018 mm and a minimum thickness of polyester of 0,023 mm.

The drain wire shall be composed of a number of strands of tinned annealed copper wires in the case of aluminium laminate tape and either plain or tinned annealed copper wires in the case of copper laminate tape. The drain wire shall have a maximum resistance in accordance with Table 3.

Alternatively a braid screen may be applied.

### 12.3.2 Braided electrostatic screen

The braid shall be either plain or metal coated copper wires; the nominal diameter of the braid wire shall be:

- 0,15 mm for fictitious cable diameters under the braid less than or equal to 9 mm;
- 0,2 mm for fictitious cable diameters under the braid greater than 9 mm.

Joints in the braiding wires shall be soldered, twisted or woven in and the complete braid shall not be welded. The braid shall be evenly applied.

The "filling factor" F of the braid shall be not less than 0,6 when calculated in accordance with the alternative method given in IEC 60092-350.

NOTE The percent coverage  $K = (2F - F^2) * 100$

The fictitious diameter under the braid is calculated by the method described in Appendix A of IEC 60092-350.

When required to aid termination, a drain wire may be applied under and in direct contact with the braid screen. The drain wire shall be composed of a number of strands of tinned or plain annealed copper wires. The drain wire shall have a maximum resistance in accordance with Table 3.

In the case of metal armour consisting of copper braid metal armour, this may also provide the function of a collective screen.

NOTE A suitable tape or tapes may be applied over the collectively screened cores or units.

## 13 Inner Coverings and binders

### 13.1 General

The covering over the core assembly (inner covering), if any, shall be extruded with a protective layer in accordance with IEC 60092-350 or lapped with one or more suitable non-hygroscopic tapes.

This protective layer is mandatory for the cable constructions listed in 2(ii) and 3 of Clause 8.

### 13.2 Thickness of inner covering

The approximate values of the thickness of the inner covering either, extruded or lapped, are given in Table 4

**Table 4 – Thickness of inner covering**

| Fictitious diameter over laid-up cores |                     | Thickness of inner covering (approximate value) |        |
|----------------------------------------|---------------------|-------------------------------------------------|--------|
| Above                                  | Up to and including | Extruded                                        | Lapped |
| mm                                     | Mm                  | mm                                              | mm     |
| -                                      | 25                  | 1,0                                             | 0,1    |
| 25                                     | 35                  | 1,2                                             | 0,1    |
| 35                                     | 45                  | 1,4                                             | 0,1    |
| 45                                     | 60                  | 1,6                                             | 0,1    |
| 60                                     | -                   | 1,8                                             | 0,1    |

NOTE For the calculation of fictitious diameters, see method outlined in Annexes A and B of IEC 60092-350 and the following Clause 14.

## 14 Sheath(s)

### 14.1 Thickness of sheath(s)

The thicknesses of outer sheaths and of the inner sheath, if any, are given as a function of the fictitious internal diameter of the sheath under consideration, this fictitious diameter being calculated by the method outlined in Annexes A and B of IEC 60092-350.

The formulae are as follows.

- a) Diameter over laid up cores:

use the method given in Annex A of IEC 60092-350.

- b) Diameter over a pair ( $dp$ ), a triple ( $dt$ ) or a quad ( $dq$ ):

$$dp = D_c \times 2, \text{ in millimetres}$$

or

$$dt = D_c \times 2, 16, \text{ in millimetres}$$

or

$$dq = D_c \times 2,42, \text{ in millimetres}$$

where  $D_c$  is the diameter of a single core.

- c) Diameter over laid up pairs ( $Dp$ ), triples ( $Dt$ ) or quads ( $Dq$ ):

$$Dp = dp \times k \times cf, \text{ in millimetres}$$

or

$$Dt = d_t \times k \times cf, \text{ in millimetres}$$

or

$$Dq = dq \times k \times cf, \text{ in millimetres}$$

where the coefficient  $k$  is as given in Annex A of IEC 60092-350.

The coefficient  $cf$  is as given in Table 5.

**Table 5 –Coefficient  $cf$**

| Cable type                    | Coefficient $cf$ |
|-------------------------------|------------------|
| Individual screened pairs     | 0,89             |
| Collectively screened pairs   | 0,82             |
| Individually screened triples | 0,94             |
| Collectively screened triples | 0,87             |
| Individually screened quads   | 1,0              |
| Collectively screened quads   | 1,0              |

- d) for armoured or unarmoured single sheathed cables see Clause 8, numbers 1), 3) and 4):

$$t_1 = 0,04 D + 0,8 \text{ mm with a minimum thickness of } 1,0 \text{ mm;}$$

( $D$  = fictitious diameter under the sheath).

- e) for unarmoured double (inner sheath or inner covering with outsheath) sheathed cables see Clause 8, numbers 2(i) and 2(ii):

– inner sheath  $t_1 = 0,025 D + 0,6$  mm with a minimum thickness of 0,8;

– inner covering = see Table 4;

– outer sheath  $t_2 = 0,025 D + 0,9$  mm with a minimum thickness of 1,0 mm.

- f) for armoured cables with inner and outer sheaths see Clause 8, number 5):
- inner sheath  $t_1 = 0,04 D + 0,8$  mm with a minimum thickness of 1,0 mm;
  - outer sheath  $t_2 = 0,025 D + 0,6$  mm with a minimum thickness of 0,8 mm.

#### 14.2 Colour of sheath

The sheath shall be coloured black or grey unless otherwise specified.

NOTE The sheath may be of other colours, thereby providing a visual difference to that of LV and MV Power cables.

### 15 Metal braid armour

In this standard the braid wires are either:

- copper (plain or tinned),
- copper alloy (plain or tinned),
- aluminium alloy, or
- zinc coated (galvanised) steel.

Joints in the braiding wires shall be soldered, twisted or woven in and the complete braid shall not be welded. The braid shall be evenly applied.

NOTE 1 In the case of plain or tinned copper wire braids, these may also provide the function of an electrostatic collective screen providing they are terminated to earth.

NOTE 2 The risk of corrosion shall be considered when aluminium alloys are used.

#### 15.1 Braid wire diameter

Irrespective of the metal used, the nominal diameter of the braid wire shall be

- 0,2 mm for fictitious cable diameters under the braid less than or equal to 10 mm,
- 0,3 mm for fictitious cable diameters under the braid greater than 10 mm and less than or equal to 30 mm, or
- 0,4 mm, as a minimum, for fictitious cable diameters under the braid greater than 30 mm.

#### 15.2 Coverage density

The "coverage density" of the braid shall be in accordance with IEC 60092-350.

The fictitious diameter under the braid is calculated by the method described in Annex A of IEC 60092-350.

#### 15.3 Application of the braid armour

The braid armour shall be applied in such a way that it shall not adhere to the inner covering or inner sheath nor to the outer sheath.

NOTE A suitable non-hygroscopic tape or tapes may be applied under and over the braid.

## 16 Particular tests

### 16.1 Additional compatibility test

This is an additional test to be performed on cables with elastomeric insulation and/or sheath where plain copper conductors and/or armour (with or without separators) are used. A compatibility test in accordance with IEC 60811-1-2 shall be carried out on a completed core/cable.

The conditions and requirements for this test are detailed in IEC 60092-350.

### 16.2 Durability

Compliance with the requirements of 7.3 is checked by trying to remove the marking of the manufacturer's name or trade mark and the colour of the cores by rubbing them lightly ten times with a piece of cotton wool or cloth soaked in water.

## 17 Tests on completed cables

For these tests, reference is made to the relevant clauses of IEC 60092-350.

For test methods of insulations and sheaths, reference should be made to IEC 60811.

### 17.1 Routine tests

- a) Measurement of electrical resistance of conductors, including drain wires.

**Table 6 – Electrical resistance of conductors**

| Nominal cross-section<br>mm <sup>2</sup> | Class 2 Stranding                                        |                                                           | Class 5 Stranding                                        |                                                           |
|------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|
|                                          | DC resistance of plain copper conductors<br>Ω/km at 20°C | DC resistance of tinned copper conductors<br>Ω/km at 20°C | DC resistance of plain copper conductors<br>Ω/km at 20°C | DC resistance of tinned copper conductors<br>Ω/km at 20°C |
| 0,50                                     | 40,4                                                     | 41,6                                                      | 41,4                                                     | 42,5                                                      |
| 0,75                                     | 26,0                                                     | 26,3                                                      | 27,6                                                     | 28,3                                                      |
| 1,00                                     | 19,2                                                     | 19,3                                                      | 20,7                                                     | 21,2                                                      |
| 1,50                                     | 12,8                                                     | 12,9                                                      | 14,1                                                     | 14,5                                                      |
| 2,50                                     | 7,86                                                     | 8,02                                                      | 8,47                                                     | 8,71                                                      |

- b) High voltage test (see IEC 60092-350).
- c) Insulation resistance test on cores (see IEC 60092-350).
- d) Screen insulation resistance, the insulation resistance between individually screened pair, triple or quad units and any collective screening, shall be not less than 1 MΩ·km at 20 °C ± 5 °C when tested in accordance with IEC 60092-350.
- e) The insulation resistance between any screen and the armour for armoured cables shall be not less than 0,25 MΩ·km at 20 °C ± 5 °C when tested in accordance with IEC 60092-350.