# IEC 60092-376

Edition 3.0 2017-05
REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside



## Electrical installations in ships –
## Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)

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# ELECTRICAL INSTALLATIONS IN SHIPS –

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

## FOREWORD

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

This third edition of IEC 60092-376 cancels and replaces the second edition published in 2003, of which it constitutes a technical revision.

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

a) new structure in line with IEC 60092-353 and IEC 60092-354;

b) requirements and test methods have been divided in several tables for clarification (enhanced cold properties, oil resistance or resistance to drilling fluids) and have been aligned to IEC 60092-350;

c) the new testing methods for fire resistant cables are referenced in this document.

The text of this International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 18A/404/FDIS | 18A/409/RVD |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60092 series, published under the general title *Electrical installations in ships*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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

**IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.**

# 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 5. The constructional requirements and test methods are ~~expected to comply~~ aligned with those indicated in IEC 60092-350, unless otherwise specified in this document.

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

The object of this document 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, and

– to specify test methods for checking conformity with those requirements.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-461, *International Electrotechnical Vocabulary – Part 461: Electric cables*

~~IEC 60228, *Conductors of insulated cables*~~

IEC 60092-350:~~2001~~ 2014, *Electrical installations in ships – Part 350: ~~Shipboard power cables –~~ General construction and test ~~requirements~~ methods of power, control and instrumentation cables for shipboard and offshore applications*

~~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 installations in ships – Part 352: Choice and installation of electrical cables ~~for low-voltage power systems~~*

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

IEC 60092-360:2014, *Electrical installations in ships – Part 360: Insulating and sheathing materials for shipboard and offshore units, power, control, instrumentation and telecommunication cables*

IEC 60331-1, *Tests for electric cables under fire conditions – Circuit integrity – Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm*

IEC 60331-2, *Tests for electric cables under fire conditions – Circuit integrity – Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

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 0,6/1,0 kV*

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

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

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 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60684-2, *Flexible insulating sleeving – Part 2: Methods of test*

IEC 60754-1, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content*

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

~~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 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60092-350 and IEC 60050-461 apply.

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

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

~~**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 General requirements

### 4.1 Rated voltage

The standard method of designating the rated voltages of cables covered by this document shall take the form $U_o/U$ ($U_m$) ~~is as follows~~.

where

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

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

$U_m$ is the maximum value of the "highest system voltage" for which the equipment (including cable) may be used (see IEC 60038).

All voltages are given as RMS values.

The standard rated voltages $U_o/U$ ($U_m$) of the cables considered in this document are:

$U_o/U$ ($U_m$) = 150 V/250 V (300 V) AC

For 150/250 (300) V cables, DC voltage up to a maximum of 1,5 times the AC 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$^2$.

~~**5 Types of insulating compounds**~~

~~The insulation compounds and their designations shall be selected fromIEC 60092-351.~~

~~**6 Types of sheathing compounds**~~

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

### 4.2 Markings

#### 4.2.1 Indication of origin and voltage identification

~~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$^2$ "~~

~~Multi-unit example: "Name or Trade mark 150/250 V 3 x 2 x 0,75 mm$^2$"~~

~~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.~~

Cables shall comply with 4.1.3 of IEC 60092-350:2014 with respect to:

- indication of origin;
- rated voltage and cable construction (number of cores and cross sectional area of the construction);
- continuity of marking;
- durability/legibility.

#### 4.2.2 Continuity of marking

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~~ marking is on the outer surface of the cable, 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.~~

### 4.2.3 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.~~

#### 4.2.3.1 General

Cable cores shall be clearly identified by either colours or numbers.

#### 4.2.3.2 Coloured cores

The core colours shall be in accordance with IEC 60445.

NOTE Annex A gives details of preferred colour code.

#### 4.2.3.3 Numbered cores – multicore cables

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

~~**7.5.2 Single and multiunit cables**~~

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

#### 4.2.3.4 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.~~

## 5 Constructional requirements

### 5.1 General description

#### 5.1.1 Overview

~~Screened and unscreened 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:~~

~~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" [1)] all non-metallic components shall be "halogen-free".~~

Shipboard and offshore cables for fixed installations shall be single or multicore cables generally constructed as follows.

### 5.1.2 Unarmoured single- or double-sheathed cable

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner sheath (optional), see 5.7;
- outer sheath applied as either one or two layer systems, see 5.9.

### 5.1.3 Armoured single-sheathed cable with outer sheath only

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering below electrostatic screening (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner covering (optional, but mandatory in case of a braid armour of galvanised steel wires in which case the inner covering shall be extruded), see 5.5;
- braid armour, see 5.8;
- outer sheath applied as either one or two layer systems, see 5.9.

### 5.1.4 Armoured double-sheathed cable with inner and outer sheath only

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner sheath, see 5.7;
- braid armour, see 5.8;

~~1) A definition of "halogen-free" is under discussion.~~

- outer sheath applied as either one or two layer systems, see 5.9.

### 5.1.5 Armoured single-sheathed cable with inner sheath only

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner sheath, see 5.7;
- braid armour, see 5.8.

Cables for installation in spaces where corrosion ~~may~~ can occur, for example weather decks, wet locations, battery compartments, refrigeration rooms, ~~etc., shall~~ should have an outer sheath over the ~~metal armour~~ braid, unless the braid itself is corrosion-resistant.

## 5.2 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 $mm^2$, 0,75 $mm^2$, 1,0 $mm^2$, 1,5 $mm^2$ or 2,5 $mm^2$.

NOTE The preferred conductor sizes are 0,75 $mm^2$ and 1,5 $mm^2$.

Conductor resistance shall be in accordance with Table 1.

**Table 1 – Electrical resistance of conductors**

| Nominal cross-section | Maximum DC resistance for class 2 stranding | | Maximum DC resistance for class 5 stranding | |
|---|---|---|---|---|
| | of plain copper conductors | of tinned copper conductors | of plain copper conductors | of tinned copper conductors |
| $mm^2$ | Ω/km at 20°C | Ω/km at 20°C | Ω/km at 20°C | 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 |

## 5.3 Insulation ~~system~~

### 5.3.1 Material

The insulating compounds and their designations shall be as given in IEC 60092-360, thus types EPR, HEPR, XLPE, HF 90 or S 95 shall be used.

The insulation system shall consist of ~~either~~ one of the options (a) to (c) as listed in IEC 60092-350:2014, 4.3.1.

~~– 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.~~

### 5.3.2 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.~~

The application shall be as detailed in IEC 60092-350:2014, 4.3.2.

### 5.3.3 Thickness of insulation

~~a) The average thickness shall be not less than the value specified in Table 2 for each type of insulation and cross-section of conductor.~~

~~b) 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.~~

~~c) 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.~~

~~d) 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.~~

~~e) The thickness of the inorganic tape(s) shall be adequate to meet the performance requirements of this standard (see in particular 17.3 (i)).~~

The thickness of the insulation shall be as specified in Table 2 hereinafter and meet the requirements of IEC 60092-350:2014, 4.3.3.

**Table 2 – ~~Specified thickness of Insulation~~ Insulation thickness**

| ~~Nominal cross-sectional area of conductor~~ ~~mm²~~ | ~~PVC/A~~ ~~mm~~ | ~~EPR~~ ~~HF EPR~~ ~~mm~~ | ~~XLPE~~ ~~HF XLPE~~ ~~mm~~ | ~~HEPR~~ ~~HF HEPR~~ ~~mm~~ | ~~HF 85~~ ~~mm~~ | ~~S 95~~ ~~HF S 95~~ ~~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~~ |

| Nominal cross-sectional area of conductor | EPR<br>HF 90<br>S 95 | XLPE<br>HEPR |
|---|---|---|
| mm² | mm | mm |
| 0,50 | 0,6 | 0,4 |
| 0,75 | 0,6 | 0,5 |
| 1,0 | 0,6 | 0,5 |
| 1,5 | 0,7 | 0,6 |
| 2,5 | 0,7 | 0,6 |

~~NOTE~~ 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 this table shall be increased by 0,20 mm for subsequent consideration in the calculation of fictitious diameters.

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

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

## 5.4 Cabling

### 5.4.1 General

Cores of a multicore cable shall be laid up, and the interstices filled if necessary with fillers, inner covering or inner sheath (outer sheath in the case of unarmoured cables) according to IEC 60092-350:2014, 4.5.

### 5.4.2 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.~~

– Cores laid up in concentric layers, unscreened, provided with an optional tape wrapping, finished to one of the constructions detailed in 5.1.2.

– 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 in 5.1.3, 5.1.4 and 5.1.5.

– Cores twisted together to form a pair, triple or quad unit each unit being individually screened with drain wire ,then cabled together, provided with an optional tape wrapping or optional tape screen, finished to one of the constructions detailed in 5.1.3, 5.1.4 and 5.1.5.

– 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 in 5.1.3, 5.1.4 and 5.1.5.

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

### 5.4.3 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 then 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 $mm^2$ and 150 mm for sizes 1,5 $mm^2$ and above.

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

~~**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.~~

### 5.4.4 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~~ crosslinked or non crosslinked elastomeric compound, a 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.

### 5.4.5 Number of cores, pair, triple or quad units

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

## 5.5 Inner covering ~~and binders~~

### 5.5.1 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.~~

The inner covering, if any, may be extruded (mandatory below galvanized steel wire braid) or lapped. The relevant material and characteristics shall be in accordance with 4.6 of IEC 60092-350:2014.

### 5.5.2 Thickness of inner covering

The values of the (approximate) thickness of extruded inner covering for the calculation of fictitious diameters are given in Table 3.

**Table 3 – 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 diameter, see Annex A and Annex C of IEC 60092-350. | | | |

## 5.6 ~~Electrostatic~~ Screen

### 5.6.1 Individual screen

#### 5.6.1.1 General

The screen, if any, shall be individually metallic screen of pair, triple or quad. It shall be in accordance with IEC 60092-350:2014, 4.4.2, and shall consist of one or more tapes, a braid or a combination of a braid with tape.

#### 5.6.1.2 Metal/polymer tape

~~**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~~ The laminated electrostatic screening tape shall be applied with the metallic side in electrical contact with a drain wire. The ~~nominal~~ minimum overlap of the laminated tape shall ~~not~~ be ~~less than~~ 25 % of its total width, to ensure coverage in case of bending the cable. The laminated tape shall be either aluminium bonded to ~~polyester~~ polymeric material having a minimum thickness of aluminium of 0,008 mm and a minimum thickness of ~~polyester~~ polymer of 0,010 mm, or copper bonded to ~~polyester~~ polymer having a minimum thickness of copper of 0,018 mm and a minimum thickness of ~~polyester~~ polymer 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 4.

#### 5.6.1.3 Braided screen

~~**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, and
- 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 ~~$F = (2F - F^2) * 100$~~ $K = (2F - F^2) \times 100$

The fictitious diameter under the braid is calculated by the method described in Annex A of IEC 60092-350:2014.

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 4.

**Table 4 – Requirements of drain wire**

| Nominal area of core conductor<br>mm$^2$ | 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~~ Polymer 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**~~

**5.6.2 Collective electrostatic screen**

**5.6.2.1 Metal/polymer tape**

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~~ polymer having a minimum thickness of aluminium of 0,008 mm and a minimum thickness of ~~polyester~~ polymer of 0,010 mm, or copper bonded to ~~polyester~~ polymer having a minimum thickness of copper of 0,018 mm and a minimum thickness of ~~polyester~~ polymer 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 4.

Alternatively a braid screen may be applied.

#### 5.6.2.2 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, and
- 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 $K = (2F - F^2) \times 100$

The fictitious diameter under the braid is calculated by the method described in Annex 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 4.

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.~~

#### 5.6.2.3 Application

The screen, if any, shall be applied over the inner covering in case of a braided or a metal/polymer tape screen (see 5.1.3, 5.1.4 and 5.1.5).

### 5.7 Inner sheath

#### 5.7.1 Material

The inner sheathing compound and its designation shall be one of those given in Tables 5 or 7 of IEC 60092-360.

#### 5.7.2 Application

The application shall be as detailed in IEC 60092-350:2014, 4.7.2.

#### 5.7.3 Thickness of inner sheath

The thickness~~es~~ of ~~outer sheaths and of~~ the inner sheath~~, if any, are~~ is given as a function of the ~~fictitious~~ internal diameter of the sheath under consideration, the fictitious diameter being calculated by the method ~~outlined~~ in IEC 60092-350:2014, Annex A and Annex C.

~~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):~~

~~$dp = D_c \times 2$, in millimetres~~

~~or~~

~~$dt = D_c \times 2,16$, in millimetres~~

~~or~~

~~$dq = D_c \times 2,42$, in millimetres~~

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

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

~~$Dp = dp \times k \times cf$, in millimetres~~

~~or~~

~~$Dt = d_t \times k \times cf$, in millimetres~~

~~or~~

~~$Dq = dq \times k \times cf$, 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):~~

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

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

~~e) for unarmoured double (inner sheath or inner covering with outersheath) 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.~~

The formula is the following:

a) for unarmoured double sheathed cables (see 5.1.2):

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

– where $D$ is the fictitious diameter under the inner sheath

b) for armoured cables (see 5.1.4 and 5.1.5):

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

– where $D$ is the fictitious diameter under the inner sheath.

The thickness at any point shall satisfy the prescriptions given in 4.7.3 of IEC 60092-350:2014.

### 5.8 ~~Metal~~ Braid armour

#### 5.8.1 General

In this document, only metal braid armours are specified, the braid wires being of copper (plain or tinned), copper alloy (plain or tinned)~~, aluminium alloy~~ or zinc coated (galvanized) steel.

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

The armour may serve as a collective metallic screen (see 5.6).

NOTE In some countries, the use of an armour as an earthing collective metallic screen is prohibited for legal reasons.

~~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.~~

#### 5.8.2 Braid wire diameter

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

– 0,2 mm, as a minimum, for cables having fictitious diameter under the braid less than or equal to 10 mm,

– 0,3 mm, as a minimum, for cables having fictitious diameter under the braid ~~greater~~ larger than 10 mm and less than or equal to 30 mm, and

– 0,4 mm, as a minimum, for cables having fictitious diameter under the braid ~~greater~~ larger than 30 mm.

#### 5.8.3 Coverage density

The coverage density of the braid shall be in accordance with IEC 60092-350:2014, 4.8.2.

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

NOTE In case the alternative method in accordance with IEC 60092-350:2014, 4.8.2 is used to evaluate the coverage density, the mean diameter of the braid to be used is the fictitious diameter under the braid plus two times the nominal diameter of the braiding wires.

#### 5.8.4 Application of the armour

The ~~braid~~ armour shall be applied in such a way that it shall ~~not~~ neither 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.~~

### 5.9 Outer sheath

#### 5.9.1 Material

The outer sheathing compound and its designation shall be one of those given in IEC 60092-360.

### 5.9.2 Application

The application shall be as detailed in IEC 60092-350:2014, 4.9.2.

### 5.9.3 Thickness of outer sheath

The thickness of outer sheath is given as a function of the internal diameter of the sheath under consideration, the fictitious diameter being calculated by the method in IEC 60092-350:2014, Annex A and Annex C.

The formula is the following:

a) for unarmoured or armoured single-sheathed cables (see 5.1.2 and 5.1.3):

$t_1$ = 0,04 $D$ + 0,8 mm with a minimum thickness of 1,0 mm

where $D$ is the fictitious diameter under the sheath

b) for unarmoured double-sheathed cables (see 5.1.2):

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

c) for armoured double-sheathed cables (see 5.1.4):

$t_2$ = 0,025 D + 0,6 mm, with a minimum thickness of 0,8 mm

The thickness at any point shall satisfy the prescriptions given in 4.9.3 of IEC 60092-350:2014.

### 5.9.4 Colour of outer sheath

The outer sheath shall be coloured black or grey, or, for fire resistant cables orange, unless otherwise specified by the purchaser at the time of ordering.

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

## ~~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**

| | Class 2 Stranding | | Class 5 Stranding | |
|---|---|---|---|---|
| Nominal cross-section | DC resistance of plain copper conductors | DC resistance of tinned copper conductors | DC resistance of plain copper conductors | DC resistance of tinned copper conductors |
| $mm^2$ | Ω/km at 20°C | Ω/km at 20°C | Ω/km at 20°C | 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.

### 17.2 Special tests

a) Conductor examination (see IEC 60092-350).

b) Check of cable dimensions (see IEC 60092-350).

c) Hot set test for crosslinked/ thermoset compounds(see IEC 60092-350).

d) Test at low temperature for thermoplastic compounds (see IEC 60092-350).

e) Coverage density of the braid (see IEC 60092-350).

### 17.3 Type tests, non-electrical

a) Measurement of thickness of insulation (see IEC 60092-350).

b) Measurement of thickness of sheath (see IEC 60092-350).

c) Non-electrical characteristics of insulation (Test to IEC 60092-351).

d) Non-electrical characteristics of sheaths (Test to IEC 60092-359).

e) Additional ageing test on pieces of completed cable (see IEC 60092-350).

f) Single cable flame spread test (see IEC 60092-350 and IEC 60332-1)

g) Bunched cable flame spread test (see IEC 60092-352 and IEC 60332-3-22)

h) Smoke (light) transmittance of completed cable (IEC 61034-1 and IEC 61034-2 with a minimum light transmittance of 60 %).

NOTE this test is only applicable to those cables claimed by the manufacturer to possess "low smoke" properties in order to validate this claim.

i) Test for fire resistance (limited circuit integrity), (see IEC 60092-350 and using the test methodology specified in IEC 60331-21 but with a withstand period of 90 min).

~~**17.4 Type tests, electrical**~~

~~a) The mutual capacitance shall be determined from measurements made at 1 kHz on a total of at least two pairs, triples or quads which have been selected from the inner and outer layers. The values obtained shall be recorded in the cable type test report.~~

~~b) The inductance to resistance ratio (L/R ratio) shall be determined from measurements of inductance (L) made at 1 kHz on at least two in total pairs, triples or quads which have been selected from inner and outer layers and the d.c. resistance measured at 20 °C. The values obtained shall be recorded in the cable type test report.~~

## 6 Tests – methods and requirements

The tests shall be carried out according to Table 5 to Table 9 where applicable.

**Table 5 – Tests applicable to all cables**

| Test | Applicability – all types of cable unless otherwise stated | Status | Method – clause number given in IEC 60092-350:2014 | Requirement – as in IEC 60092-350 unless otherwise stated |
|---|---|---|---|---|
| Measurement of electrical resistance of conductors and drain wires | | Routine | 5.2.2 | Table 1 |
| Voltage test | | Routine | 5.2.3 | - |
| Voltage test on sheath | Armoured cables | Routine | 5.2.3.4 | - |
| Insulation resistance test | | Sample | 6.9 | - |
| Insulation resistance constant test | | Type | 7.2.1 | IEC 60092-360:2014, Table 3 |
| Screen insulation resistance, the insulation resistance between individually screened pair triple or quad units and any collective screening | | Sample | 6.9 | ≥ 1 MΩ·km |
| The insulation resistance between any screen and the armour for armoured cables | | Sample | 6.9 | ≥ 0,25 MΩ·km |
| Conductor examination | | Sample and Type | 6.4 | - |
| Check of cable dimensions | | Sample and Type | | |
| – Thickness of insulation | | | 6.5 and 8.2 | - |
| – Thickness of non-metallic sheaths (excluding inner coverings) | | | 6.6 and 8.3 | - |
| – External diameter | | | 6.7 | - |
| Hot set test | HEPR, EPR, XLPE, HF 90, S 95 insulations and SH, SE, SHF2 sheaths | Sample | 6.8 | IEC 60092-360 |

| Test | Applicability – all types of cable unless otherwise stated | Status | Method – clause number given in IEC 60092-350:2014 | Requirement – as in IEC 60092-350 unless otherwise stated |
|---|---|---|---|---|
| Coverage density of braid | Braid armoured cables and/or braid screened cable | Type | 4.8.2 | |
| Insulation resistance measurement at maximum rated temperature | | Type | 7.2.2 | IEC 60092-360 |
| Mutual capacitance | | Type | 7.5 | - |
| Inductance to resistance ratio | | Type | 7.6 | - |
| Mechanical properties of insulation before and after ageing | | Type | 8.4 | IEC 60092-360 |
| Mechanical properties of sheath before and after ageing | | Type | 8.5 | IEC 60092-360 |
| Additional ageing compatibility test | | Type | 8.6 | IEC 60092-360 |
| Loss of mass test | PVC ST2 sheath | Type | 8.7 | IEC 60092-360 |
| Behaviour at high temperature | PVC ST2 and SHF1 sheaths | Type | 8.8 | IEC 60092-360 |
| Behaviour at low temperatures | PVC ST2, SHF1 and SHF2 sheaths | Type | 8.9 | IEC 60092-360 |
| Test for coating of copper wires | | Type | 8.11 | |
| Galvanizing test | | Type | 8.12 | |
| Resistance to cracking heat shock | PVC ST2 and SHF1 sheaths | Type | 8.13 | IEC 60092-360 |
| Ozone resistance | HEPR, EPR, HF90 insulations and SH, SE, SHF2 sheaths | Type | 8.14 | IEC 60092-360 |
| Hot oil immersion | SE, SH and SHF2 sheaths | Type | 8.15.1 | IEC 60092-360 |
| Fire-retardant tests: IEC 60332-1-2 and IEC 60332-3-22 | | Type | 8.17.1<br>8.17.2 | IEC 60332-1-2 and IEC 60332-3-22 in which case cables shall be installed in touching configuration on the front of the ladder. |
| Determination of hardness | HEPR insulation | Type | 8.18 | IEC 60092-360 |
| Determination of modulus of elasticity | HEPR insulation | Type | 8.19 | IEC 60092-360 |
| Durability of marking | | Type | 8.20 | The marking shall remain legible following the test as given in 8.20 of IEC 60092-350:2014. |

**Table 6 – Additional tests required for halogen-free cables**

| Test | Status | Method – clause number given in IEC 60092-350:2014 | Requirement – as in IEC 60092-350 unless otherwise stated |
|---|---|---|---|
| Acid gas emission | Type | 8.17.4 | IEC 60754-1 |
| pH and conductivity | Type | 8.17.5 | IEC 60754-2 |
| Fluorine content test | Type | 8.17.6 | IEC 60684-2 |

**Table 7 – Additional test required for low smoke cables**

| Test | Status | Method – clause number given in IEC 60092-350:2014 | Requirement – as in IEC 60092-350 unless otherwise stated |
|---|---|---|---|
| Smoke emission test for cables insulated and sheathed with halogen-free materials. When tested according to IEC 61034-2 | Type | 8.17.3 | The test is satisfactory for the finished cables if the levels of light transmittance exceeds 60 % throughout the test |
| NOTE The smoke emission test is in general applicable to halogen-free cables. See also Table 6. | | | |

**Table 8 – Additional tests required for fire resistant cables**

| Test | Status | Method – clause number given in IEC 60092-350:2014 | Requirement – as in IEC 60092-350 unless otherwise stated |
|---|---|---|---|
| Test for fire resistance (limited circuit integrity) | Type | 8.17.7 | The test shall be carried out in accordance with IEC 60331-21 or IEC 60331-1 or IEC 60331-2 and the minimum time to failure shall be 90 min |
| NOTE The test apparatus for the test procedure defined in IEC 60331-21 is detailed in IEC 60331-11. | | | |

**Table 9 – Additional tests required for specific performances**

| Test | Status | Method – clause number given in IEC 60092-350:2014 | Requirement – as in IEC 60092-350 unless otherwise stated |
|---|---|---|---|
| Special test for low temperature behaviour | Type | 8.10 | |
| Enhanced hot oil immersion | Type | 8.15.2 | IEC 60092-360 |
| Drilling fluid test | Type | 8.16 | IEC 60092-360 |

# Annex A
(informative)

## Core identification

An example of ~~a typical~~ the preferred colour code for single unit cables is given in Table A.1. In the case of multiunit cables, the additional identification of the same number printed on the insulation of each core within the same unit is also required.

For arrangement, appearance, spacing and dimensions of the marks, see Annex B.

**Table A.1 – ~~Typical~~ Preferred colour code for single unit cables**

| Unit element | Wire a | Wire b | Wire c | Wire d |
|---|---|---|---|---|
| Pair unit | Black or blue | White | - | - |
| Triple unit | Black or blue | White | Red | - |
| Quad unit | Black or blue | White | Red | Blue or black |
| ~~NOTE~~ Other suitable colour codes may be supplied by agreement between the purchaser and supplier. | | | | |

# Annex B
(informative)

# Identification of cores of multicore cables

## B.1 ~~Identification~~ Inscription

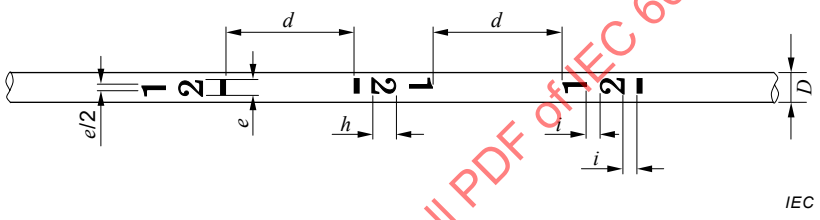
The ~~identification shall~~ inscription should be composed of marks at regular intervals along the entire length of core and comprised of

a) a reference number in Arabic numerals, and

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

## B.2 Arrangement of the marks

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




**Key**

Refer to Table B.1.

**Figure B.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.

## B.3 Spacing and dimensions of the marks

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

**Table B.1 – Dimensions of the marks**

| **Nominal diameter, *D*, of the core** mm | ***e*[1]** | ***h*** | ***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 |

**Key**

$D$ = nominal diameter of the core;

$e$ = minimum width of a mark;

$h$ = 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.

[1] When the numeral is 1, the minimum width is equal to half the dimension given in this table.

## B.4 Appearance of inscription

The inscription ~~shall~~ should 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.

# Annex C
(informative)

# Number of cores, pair, triple or quad units

## C.1 Number of cores

It is recommended that the number of cores ~~shall~~ should be selected from one of the following:

2, 4, 7, 12, 19, 27, 37.

## C.2 Number of pair, triple or quad units

It is recommended that the number of pair units ~~shall~~ should be selected from one of the following:

~~1, 3, 7, 12, 19, 27, 37.~~

1, 2, 4, 7, 10, 14, 19, 27, 37.

~~NOTE 1~~ Due to difficulties in manufacture, 2-pair screened or non-screened cables are not recommended. The use of either a quad or a 3-pair cable is ~~to be~~ preferred.

~~NOTE 2~~ When a quad is used to substitute a 2-pair, core diametrically opposed should be taken.

It is recommended that the number of triple units ~~shall~~ should be selected from one of the following:

~~1, 3, 7, 12.~~

1, 2, 4, 7, 10.

~~NOTE 3~~ Due to difficulties in manufacture, 2-triple screened or non-screened cables are not recommended. The use of a 3-triple cable is ~~to be~~ preferred.

It is recommended that the number of quad units ~~shall~~ should be selected from one of the following:

1, 3, 7.

~~NOTE 4~~ Due to difficulties in manufacture 2-quad screened or non-screened cables are not recommended. The use of a 3-quad cable is ~~to be~~ preferred.

## Bibliography

IEC 60038, *IEC standard voltages*

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

IEC 60092-354, *Electrical installations in ships – Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)*

IEC 60331-11, *Tests for electric cables under fire conditions – Circuit integrity – Part 11: Apparatus – Fire alone at a flame temperature of at least 750°C*

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

IEC 61892-4, *Mobile and fixed offshore units – Electrical installations – Part 4: Cables*

# IEC 60092-376

Edition 3.0 2017-05

# INTERNATIONAL STANDARD

## Electrical installations in ships –
## Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)



IEC 60092-376:2017-05(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# ELECTRICAL INSTALLATIONS IN SHIPS –

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

This third edition of IEC 60092-376 cancels and replaces the second edition published in 2003, of which it constitutes a technical revision.

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

a) new structure in line with IEC 60092-353 and IEC 60092-354;
b) requirements and test methods have been divided in several tables for clarification (enhanced cold properties, oil resistance or resistance to drilling fluids) and have been aligned to IEC 60092-350;

c) the new testing methods for fire resistant cables are referenced in this document.

The text of this International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 18A/404/FDIS | 18A/409/RVD |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60092 series, published under the general title *Electrical installations in ships*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

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

# 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 5. The constructional requirements and test methods are aligned with those indicated in IEC 60092-350, unless otherwise specified in this document.

The object of this document 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, and

– to specify test methods for checking conformity with those requirements.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-461, *International Electrotechnical Vocabulary – Part 461: Electric cables*

IEC 60092-350:2014, *Electrical installations in ships – Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications*

IEC 60092-352, *Electrical installations in ships – Part 352: Choice and installation of electrical cables*

IEC 60092-360:2014, *Electrical installations in ships – Part 360: Insulating and sheathing materials for shipboard and offshore units, power, control, instrumentation and telecommunication cables*

IEC 60331-1, *Tests for electric cables under fire conditions – Circuit integrity – Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm*

IEC 60331-2, *Tests for electric cables under fire conditions – Circuit integrity – Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm*

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 0,6/1,0 kV*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

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 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60684-2, *Flexible insulating sleeving – Part 2: Methods of test*

IEC 60754-1, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content*

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

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

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60092-350 and IEC 60050-461 apply.

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

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

## 4 General requirements

### 4.1 Rated voltage

The standard method of designating the rated voltages of cables covered by this document shall take the form $U_o/U$ ($U_m$),

where

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

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

$U_m$ is the maximum value of the "highest system voltage" for which the equipment (including cable) may be used (see IEC 60038).

All voltages are given as RMS values.

The standard rated voltages $U_o/U$ ($U_m$) of the cables considered in this document are:

$U_o/U$ ($U_m$) = 150 V/250 V (300 V) AC

For 150/250 (300) V cables, DC voltage up to a maximum of 1,5 times the AC 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 $mm^2$.

### 4.2 Markings

#### 4.2.1 Indication of origin and voltage identification

Cables shall comply with 4.1.3 of IEC 60092-350:2014 with respect to:

- indication of origin;
- rated voltage and cable construction (number of cores and cross sectional area of the construction);
- continuity of marking;
- durability/legibility.

#### 4.2.2 Continuity of marking

The marking 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 marking is on the outer surface of the cable, and
- 275 mm in all other cases.

#### 4.2.3 Core identification

##### 4.2.3.1 General

Cable cores shall be clearly identified by either colours or numbers.

##### 4.2.3.2 Coloured cores

The core colours shall be in accordance with IEC 60445.

NOTE Annex A gives details of preferred colour code.

##### 4.2.3.3 Numbered cores – multicore cables

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

##### 4.2.3.4 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.

## 5 Constructional requirements

### 5.1 General description

#### 5.1.1 Overview

Shipboard and offshore cables for fixed installations shall be single or multicore cables generally constructed as follows.

### 5.1.2 Unarmoured single- or double-sheathed cable

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner sheath (optional), see 5.7;
- outer sheath applied as either one or two layer systems, see 5.9.

### 5.1.3 Armoured single-sheathed cable with outer sheath only

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering below electrostatic screening (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner covering (optional, but mandatory in case of a braid armour of galvanised steel wires in which case the inner covering shall be extruded), see 5.5;
- braid armour, see 5.8;
- outer sheath applied as either one or two layer systems, see 5.9.

### 5.1.4 Armoured double-sheathed cable with inner and outer sheath only

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner sheath, see 5.7;
- braid armour, see 5.8;
- outer sheath applied as either one or two layer systems, see 5.9.

### 5.1.5 Armoured single-sheathed cable with inner sheath only

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided electrostatic screening is applied over the core lay-up), see 5.5;
- electrostatic screening (optional), see 5.6;
- inner sheath, see 5.7;
- braid armour, see 5.8.

Cables for installation in spaces where corrosion can occur, for example weather decks, wet locations, battery compartments, refrigeration rooms, should have an outer sheath over the braid, unless the braid itself is corrosion-resistant.

## 5.2 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 $mm^2$, 0,75 $mm^2$, 1,0 $mm^2$, 1,5 $mm^2$ or 2,5 $mm^2$.

NOTE The preferred conductor sizes are 0,75 $mm^2$ and 1,5 $mm^2$.

Conductor resistance shall be in accordance with Table 1.

**Table 1 – Electrical resistance of conductors**

| | Maximum DC resistance for class 2 stranding | | Maximum DC resistance for class 5 stranding | |
|---|---|---|---|---|
| **Nominal cross-section** $mm^2$ | **of plain copper conductors** Ω/km at 20°C | **of tinned copper conductors** Ω/km at 20°C | **of plain copper conductors** Ω/km at 20°C | **of tinned copper conductors** 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 |

## 5.3 Insulation

### 5.3.1 Material

The insulating compounds and their designations shall be as given in IEC 60092-360, thus types EPR, HEPR, XLPE, HF 90 or S 95 shall be used.

The insulation system shall consist of one of the options (a) to (c) as listed in IEC 60092-350:2014, 4.3.1.

### 5.3.2 Application

The application shall be as detailed in IEC 60092-350:2014, 4.3.2.

### 5.3.3 Thickness of insulation

The thickness of the insulation shall be as specified in Table 2 hereinafter and meet the requirements of IEC 60092-350:2014, 4.3.3.

**Table 2 – Insulation thickness**

| Nominal cross-sectional area of conductor<br><br>mm$^2$ | EPR<br>HF 90<br>S 95<br><br>mm | XLPE<br>HEPR<br><br>mm |
|---|---|---|
| 0,50 | 0,6 | 0,4 |
| 0,75 | 0,6 | 0,5 |
| 1,0 | 0,6 | 0,5 |
| 1,5 | 0,7 | 0,6 |
| 2,5 | 0,7 | 0,6 |
| 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 this table shall be increased by 0,20 mm for subsequent consideration in the calculation of fictitious diameters.<br><br>NOTE For the calculation of fictitious diameters, see method outlined in Annex A and Annex B of IEC 60092-350. | | |

## 5.4 Cabling

### 5.4.1 General

Cores of a multicore cable shall be laid up, and the interstices filled if necessary with fillers, inner covering or inner sheath (outer sheath in the case of unarmoured cables) according to IEC 60092-350:2014, 4.5.

### 5.4.2 Core assembly

– Cores laid up in concentric layers, unscreened, provided with an optional tape wrapping, finished to one of the constructions detailed in 5.1.2.

– 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 in 5.1.3, 5.1.4 and 5.1.5.

– Cores twisted together to form a pair, triple or quad unit each unit being individually screened with drain wire ,then cabled together, provided with an optional tape wrapping or optional tape screen, finished to one of the constructions detailed in 5.1.3, 5.1.4 and 5.1.5.

– 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 in 5.1.3, 5.1.4 and 5.1.5.

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

### 5.4.3 Forming pair, triple or quad units

If the pair, triple or quad units are not individually screened then 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$^2$ and 150 mm for sizes 1,5 mm$^2$ and above.

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

### 5.4.4 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 crosslinked or non crosslinked elastomeric compound, a 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.

#### 5.4.5 Number of cores, pair, triple or quad units

Within practical physical limits any number of cores, pairs, triples or quads can be laid up to form a cable assembly, however Annex C gives recommended cable assemblies.

### 5.5 Inner covering

#### 5.5.1 General

The inner covering, if any, may be extruded (mandatory below galvanized steel wire braid) or lapped. The relevant material and characteristics shall be in accordance with 4.6 of IEC 60092-350:2014.

#### 5.5.2 Thickness of inner covering

The values of the (approximate) thickness of extruded inner covering for the calculation of fictitious diameters are given in Table 3.

**Table 3 – 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 diameter, see Annex A and Annex C of IEC 60092-350. | | | |

### 5.6 Screen

#### 5.6.1 Individual screen

##### 5.6.1.1 General

The screen, if any, shall be individually metallic screen of pair, triple or quad. It shall be in accordance with IEC 60092-350:2014, 4.4.2, and shall consist of one or more tapes, a braid or a combination of a braid with tape.

##### 5.6.1.2 Metal/polymer tape

The laminated electrostatic screening tape shall be applied with the metallic side in electrical contact with a drain wire. The minimum overlap of the laminated tape shall be 25 % of its total width, to ensure coverage in case of bending the cable. The laminated tape shall be either aluminium bonded to polymeric material having a minimum thickness of aluminium of 0,008 mm and a minimum thickness of polymer of 0,010 mm, or copper bonded to polymer having a minimum thickness of copper of 0,018 mm and a minimum thickness of polymer 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 4.

#### 5.6.1.3 Braided screen

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, and
- 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 $K = (2F - F^2) \times 100$

The fictitious diameter under the braid is calculated by the method described in Annex A of IEC 60092-350:2014.

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 4.

**Table 4 – Requirements of drain wire**

| Nominal area of core conductor<br>$mm^2$ | 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 |



Polymer 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.

### 5.6.2 Collective electrostatic screen

#### 5.6.2.1 Metal/polymer tape

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 polymer having a minimum thickness of aluminium of 0,008 mm and a minimum thickness of polymer of 0,010 mm, or copper

bonded to polymer having a minimum thickness of copper of 0,018 mm and a minimum thickness of polymer 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 4.

Alternatively a braid screen may be applied.

#### 5.6.2.2 Braided 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, and
- 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 $K = (2F - F^2) \times 100$

The fictitious diameter under the braid is calculated by the method described in Annex 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 4.

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

#### 5.6.2.3 Application

The screen, if any, shall be applied over the inner covering in case of a braided or a metal/polymer tape screen (see 5.1.3, 5.1.4 and 5.1.5).

### 5.7 Inner sheath

#### 5.7.1 Material

The inner sheathing compound and its designation shall be one of those given in Tables 5 or 7 of IEC 60092-360.

#### 5.7.2 Application

The application shall be as detailed in IEC 60092-350:2014, 4.7.2.

#### 5.7.3 Thickness of inner sheath

The thickness of the inner sheath is given as a function of the internal diameter of the sheath under consideration, the fictitious diameter being calculated by the method in IEC 60092-350:2014, Annex A and Annex C.