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INTERNATIONAL STANDARD

colour inside

Electrical installations in ships –
Part 353: Power cables for rated voltages 1 kV and 3 kV

IEC 60092-353:2016-09 RLV(en)

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ELECTRICAL INSTALLATIONS IN SHIPS –

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FOREWORD

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International Standard IEC 60092-353 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 fourth edition cancels and replaces the third edition published in 2011. This edition constitutes a technical revision.

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

a) updated references to IEC 60092-350 for general construction and test methods and IEC 60092-360 for insulating and sheathing materials.

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

FDIS	Report on voting
18A/399/FDIS	18A/400/RVD

Full information on the voting for the approval of this document 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.

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

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

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- withdrawn,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

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ELECTRICAL INSTALLATIONS IN SHIPS –

Part 353: Power cables for rated voltages 1 kV and 3 kV

1 Scope and object

This part of IEC 60092 is applicable to shipboard and offshore non radial field power cables with extruded solid insulation, having a voltage rating of 0,6/1 (1,2) kV ~~and~~ or 1,8/3 (3,6) kV intended for fixed installations.

Cables ~~for use in circuits requiring resistance to~~ designed to maintain circuit integrity during fire are included.

The various types of power cables are given in 5.1. The constructional requirements and test methods ~~shall comply~~ are aligned with those indicated in IEC 60092-350, unless otherwise specified in this document.

The object of this document is

– to standardize cables whose safety and reliability is ensured when they are installed in accordance with the requirements of IEC 60092-352 or IEC 61892-4,

– 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 60038:2009, *IEC standard voltages*~~

IEC 60050-461~~:2008~~, *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 60092-351, *Electrical installations in ships – Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables*~~

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

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

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

IEC 60228~~:2004~~, *Conductors of insulated cables*

IEC 60331-1~~:2009~~, *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~~:2009~~, *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 60331-11:1999, *Tests for electric cables under fire conditions – Circuit integrity – Part 11: Apparatus – Fire alone at a flame temperature of at least 750 °C*~~
~~Amendment 1 (2009)[1]~~

IEC 60331-21~~:1999~~, *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~~:2004~~, *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~~:2000~~, *Tests on electric cables and optical fibre cables under fire conditions – Part 3-22: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category A*
~~Amendment 1 (2008)[2]~~

IEC 60445~~:2010~~, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60684-2~~:1997~~, *Flexible insulating sleeving – Part 2: Methods of test*
~~Amendment 1 (2003)[3]~~

IEC 60754-1~~:1994~~, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the ~~amount of~~ halogen acid gas content*

IEC 60754-2~~:1991~~, *Test on gases evolved during combustion of ~~electric~~ materials from cables – Part 2: Determination of ~~degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH~~ acidity (by pH measurement) and conductivity*
~~Amendment 1 (1997)~~

~~IEC 61034-1:2005, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus*~~

IEC 61034-2~~:2005~~, *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements*

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

~~[1] There exists a consolidated edition (1.1) which includes IEC 60331-11:1999 and its amendment 1.~~

~~[2] There exists a consolidated edition (1.1) which includes IEC 60332-3-22:2000 and its amendment 1.~~

~~[3] There exists a consolidated edition (2.1) which includes IEC 60684-2:1997 and its amendment 1 and its corrigendum.~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60092-350 and in 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 following 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 ~~r.m.s.~~ RMS values.

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

$$U_o/U\ (U_m) = 0{,}6/1\ (1{,}2)\ \text{kV and}\ 1{,}8/3\ (3{,}6)\ \text{kV}$$

For 0,6/1 (1,2) kV cables, ~~d.c.~~ DC voltage up to a maximum of 1,5 times the ~~a.c.~~ AC voltage may be used provided that the voltage to earth does not exceed 0,9 kV.

4.2 Markings

4.2.1 Indication of origin and voltage identification

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

a) indication of origin,

b) rated voltage and cable construction (number of cores and cross sectional area of the construction),

c) continuity of marking, and

d) 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

a) 550 mm if the marking is on the outer surface of the cable, and

b) 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.

4.2.3.3 Numbered cores – Multicore cables

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

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 cables (excluding 1,8/3 kV)

a) Single-core unarmoured unsheathed cable

- copper conductor, see 5.2;
- insulation applied as a single layer of insulating compound of one of the types described in 5.3 with an enhanced thickness equivalent to that of a combined insulation and outer sheath for use in unarmoured cables installed in an adequately protected environment (see 5.3.3 for the thickness).

b) 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 or a metal tape 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 cables

a) 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 or a metal tape 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.

NOTE 1 Variable frequency drives induce specific electrical constraints on the connected power cables (for example voltage peaks, harmonics, reflection or earthing method among other electrical stresses).

b) Armoured double-sheathed cable with inner and outer sheath

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided or a metal tape 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.

NOTE 2 The use of a thermoplastic inner sheath (ST2 or SHF1) is ~~not recommended if the outer sheath consists of an elastomeric crosslinked material~~ compatible with cross-linking technology of elastomeric outer sheath.

c) 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 or a metal tape 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.

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

5.2 Conductors

The material, metal coating, class and form of the conductors shall be in accordance with IEC 60092-350. For cables having rated voltage 1,8/3 kV, only circular stranded compacted or non-compacted conductors with a minimum cross-section of 10 mm² are permitted. A separator between conductors and insulation is permitted.

5.3 Insulation

5.3.1 Material

The insulating compounds and their designations shall be as given in ~~IEC 60092-351~~ IEC 60092-360, as follows:

– for 0,6/1 (1,2) kV cables, types EPR, HEPR, XLPE, HF 90 or S 95 shall be used;
– for 1,8/3 (3,6) kV cables, types only EPR, HEPR, XLPE 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 1 hereinafter and meet the requirements of IEC 60092-350:2014, 4.3.3.

For single-core unarmoured unsheathed cables (see 5.1.2 a)), the total insulation thickness shall be the sum of

a) the thickness t_j as specified in Table 1, and

b) the thickness as calculated in accordance with 5.9.3 a), with fictitious diameter $D = d_L + 2\ t_i$ (see also IEC 60092-350:2014, A.3.1 and A.3.2). The total thickness shall meet the requirements of IEC 60092-350:2014, 4.3.3.

Table 1 – Insulation thickness

Nominal cross sectional area of conductor	0,6/1 kV		1,8/3 kV	
	EPR S 95	HEPR HF90 XLPE	EPR	HEPR XLPE
mm^2	mm	mm	mm	mm
1	1,0	0,7	–	–
1,5	1,0	0,7	–	–
2,5	1,0	0,7	–	–
4	1,0	0,7	–	–
6	1,0	0,7	–	–
10	1,0	0,7	2,2	2,0
16	1,0	0,7	2,2	2,0
25	1,2	0,9	2,2	2,0
35	1,2	0,9	2,2	2,0
50	1,4	1,0	2,2	2,0
70	1,4	1,1	2,2	2,0
95	1,6	1,1	2,4	2,0
120	1,6	1,2	2,4	2,0
150	1,8	1,4	2,4	2,0
185	2,0	1,6	2,4	2,0
240	2,2	1,7	2,4	2,0
300	2,4	1,8	2,4	2,0
400	2,6	2,0	2,6	2,0
500	2,8	2,2	2,8	2,2
630	2,8	2,4	2,8	2,4

NOTE Alternative enhanced insulation thickness ~~may~~ can be given in some countries for legal reasons. These alternative values are based on those given in Annex A.

5.4 Cabling (including fillers and binders)

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.

5.5 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 IEC 60092-350:2014, 4.6.

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 2.

Table 2 – Thickness of extruded inner covering and fictitious diameters

Fictitious diameter over laid up cores		Thickness of extruded inner covering
Above mm	Up to and including mm	(approximate value) mm
–	25	1,0
25	35	1,2
35	45	1,4
45	60	1,6
60	80	1,8
80	–	2,0

The values of the (approximate) thickness of lapped covering for the calculation of the fictitious diameters are 0,4 mm for fictitious diameter over laid-up cores up to and including 40 mm and 0,6 mm for larger diameters.

NOTE For the calculation of fictitious diameter, see IEC 60092-350:2014, Annexes A and C.

5.6 Screen

5.6.1 Construction

5.6.1.1 General

The screen, if any, shall be a collective metallic screen and 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(s).

5.6.1.2 Metal/polyester 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 15 % of its total width, to ensure coverage in case of bending of the cable. 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.

Table 3 – Requirements of drain wire

Nominal area of conductor of the cores mm^2	Maximum drain wire resistance ohm/km
~~1~~	~~28,3~~
1,0 to 1,5	28,3
2,5 and above	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 15 % of its total width.

~~NOTE~~ A screen consisting of a laminated electrostatic screening tape and a drain wire is not suitable for carrying large short-circuit currents and should not be grounded with the protective earth conductor of the applicable power circuit.

5.6.1.3 Metal tape

The specified nominal thickness for a plain metal tape shall be at least 0,1 mm.

5.6.1.4 Braid

The specified nominal ~~thickness~~ diameter for the braiding wires shall be at least 0,2 mm.

5.6.2 Application

The screen, if any, shall be applied over the inner covering in case of a braided or a metal tape screen (see 5.1.2 and 5.1.3).

5.7 Inner sheath

5.7.1 Material

The inner sheathing compound and its designation shall be one of those given in ~~IEC 60092-359 except that PVC type ST1 is not permitted~~ 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 given in IEC 60092-350:2014, Annexes A and C.

The formula is the following:

a) for double-sheathed unarmoured cable as in 5.1.2 b):

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

b) for armoured cable as 5.1.3 b) and c):

t_1 = 0,04 D + 0,8 mm, with a minimum thickness of 1,0 mm for construction 5.1.3 b) and 1,4 mm for construction 5.1.3 c)

where

D is the fictitious diameter under the inner sheath.

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

5.8 Braid armour

5.8.1 General

In this document, only metal braid armours are specified, the braid wires being of copper, copper alloy or galvanized steel.

Joints in the braiding wires shall be soldered, twisted or woven-in, and the complete braid shall not be 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.

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 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 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.

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 armour shall be applied in such a way that it shall neither adhere to the inner covering or inner sheath nor to the outer sheath.

5.9 Outer sheath

5.9.1 Material

The outer sheathing compound and its designation shall be one of those given in ~~IEC 60092-359 except that PVC type ST1 is not permitted~~ 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 given in IEC 60092-350:2014, Annexes A and C.

The formula is the following:

a) for unarmoured or armoured single-sheathed cables as in 5.1.2 a) and b) and 5.1.3 a):

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 as in 5.1.2 b):

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

c) for armoured double-sheathed cables as in 5.1.3 b):

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~~ requirements given in IEC 60092-350:2014, 4.9.3.

5.9.4 Colour of outer sheath

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

6 Tests – Methods and requirements

The tests shall be carried out according to Tables 4 to 8 where applicable.

Table 4 – Tests applicable to all cables *(1 of 2)*

Test	Applicability – all types of cable unless otherwise stated	Status	Method – subclause number given in IEC 60092-350:2014	Requirement – as in IEC 60092-350 unless otherwise stated
Measurement of electrical resistance of conductors		Routine	5.2.2	IEC 60228
Voltage test		Routine	5.2.3	–
Voltage test on sheath	Armoured cables	Routine	5.2.3.4	–
Insulation resistance test		~~Routine; sample~~ ~~Type~~ Sample	~~5.2.4~~ 7.2.~~1~~	–
Conductor examination		Sample and type	6.4	
Check of cable dimensions – thickness of insulation – thickness of non metallic sheaths (excluding inner coverings) – external diameter		Sample and type	 6.5 and 8.2 6.6 and 8.3 6.7	 – – –
Hot set test	HEPR, EPR, XLPE, HF 90, S 95 insulations and ~~SE1~~ SH, SE, SHF2 sheaths	Sample	6.8	~~IEC 60092-351 and IEC 60092- 359~~ IEC 60092-360
Coverage density of braid	Braid armoured cables	Type	4.8.2	
Insulation resistance measurement at maximum rated temperature		Type	7.2.2	~~IEC 60092-351~~ IEC 60092-360
Increase in ~~a.c.~~ AC capacitance after immersion in water		Type	7.3	~~IEC 60092-351~~ IEC 60092-360
High-voltage test for 4 h		Type	7.7.9	
Mechanical properties of insulation before and after ageing		Type	8.4	~~IEC 60092-351~~ IEC 60092-360
Mechanical properties of sheath before and after ageing		Type	8.5	~~IEC 60092-359~~ IEC 60092-360
Additional ageing compatibility test		Type	8.6	~~IEC 60092-351 and IEC 60092- 359~~ IEC 60092-360
Loss of mass test	PVC ST2 sheath	Type	8.7	~~IEC 60092-359~~ IEC 60092-360

Table 4 *(2 of 2)*

Test	Applicability – all types of cable unless otherwise stated	Status	Method – subclause number given in IEC 60092-350:2014	Requirement – as in IEC 60092-350 unless otherwise stated
Behaviour at high temperature	PVC ST2 and SHF1 sheaths	Type	8.8	~~IEC 60092-359~~ IEC 60092-360
Behaviour at low temperatures	PVC ST2, SHF1 and SHF2 sheaths	Type	8.9	~~IEC 60092-359~~ 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 60092-359~~ IEC 60092-360
Ozone resistance	HEPR, EPR, HF90 insulations and SH, SE, SHF2 sheaths	Type	8.14	IEC 60092-360
Hot oil immersion	SE1, SH and SHF2 sheaths	Type	8.15.1	~~IEC 60092-359~~ IEC 60092-360
~~Flame-spread~~ Fire-retardant tests: IEC 60332-1-2 and IEC 60332-3-22		Type	8.17.1 8.17.2	IEC 60332-1-2 and IEC 60332-3-22 in which case cables shall be installed in the touching configuration on the front of the ladder.
Determination of hardness	HEPR insulation	Type	8.18	~~IEC 60092-351~~ IEC 60092-360
Determination of modulus of elasticity	HEPR insulation	Type	8.19	~~IEC 60092-351~~ IEC 60092-360
Durability of marking		Type	8.20	The marking shall remain legible following the test as given in IEC 60092-350:2014, 8.20

Table 5 – Additional tests required for halogen-free cables

Test	Status	Method – subclause 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 6 – Additional test required for low smoke cables

Test	Status	Method – subclause 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 61034-1 and~~ IEC 61034-2	Type	8.17.3	The test is satisfactory for the finished cables if the levels of light transmittance exceed~~s~~ 60 % throughout the test
NOTE The smoke emission test is in general applicable to halogen-free cables. See also Table 5.			

Table 7 – Additional test~~s~~ required for fire resistant cables

Test	Status	Method – subclause 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 8 – Additional tests required for specific performances

Test	Status	Method – subclause 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
~~Mud fluid~~ Drilling fluid test	Type	8.16	IEC 60092-360

Annex A
(informative)

Alternative enhanced insulation thickness for 0,6/1 kV

NOTE ~~1~~ For legal reasons, in some countries, Annex A may become normative.

Table A.1 gives an overview of alternative enhanced insulation thickness for 0,6/1 kV.

Table A.1 – Alternative enhanced insulation thickness for 0,6/1 kV

Rated voltage 0,6/1 kV			
Silicone rubber/EPR		XLPE	
Nominal cross-sectional area (S) mm^2	Insulation thickness (t) [a] and [b] mm	Nominal cross-sectional area (S) mm^2	Insulation thickness (t) [c] mm
1	1,0	1,0	0,9
1,5	1,0	1,5	0,9
2,5	1,0	2,5	0,9
4	1,1	4	1,0
6	1,1	6	1,0
10	1,2	10	1,1
16	1,3	16	1,2
25	1,4	25	1,3
35	1,5	35	1,3
50	1,6	50	1,4
70	1,7	70	1,6
95	1,9	95	1,7
120	2,0	120	1,8
150	2,1	150	1,9
185	2,3	185	2,0
240	2,4	240	2,2
300	2,6	300	2,4
400	2,9	400	2,6
500	3,1	500	2,8
630	3,4	630	3,1

NOTE ~~2~~ For cross sections of 185 mm² and above, the insulation thickness is suitable for 3 kV. If in this case a voltage rating of 3 kV is designated to the cable, this cable should be tested as a 3 kV cable.

[a] These values of the insulation thickness correspond approximately to the formula:
$t = 0,1\sqrt{S} + 0,9$ mm

[b] All these values may be reduced by 0,1 mm if the rubber wall is covered by an extruded skin of polyamide or equivalent material.

[c] These values of the insulation thickness correspond approximately to the formula:
$t = 0,09\sqrt{S} + 0,8$ mm

Annex B
(informative)

Identification of cores of multicore cables

B.1 Inscription

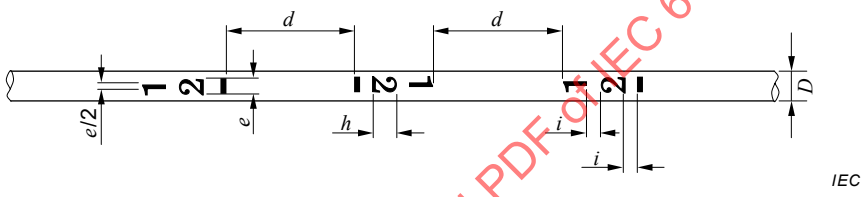
The inscription shall be composed of marks at regular intervals along the entire length of core and comprising:

a) a reference number in Arabic numerals;

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

B.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 B.1.



Key

Refer to Clause B.3 below.

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, where:

D is the nominal diameter of the core;

e is the minimum width of a mark;

h is the minimum height of a numeral;

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

d is the maximum interval between two consecutive marks.

Table B.1 – Dimensions of the marks

Nominal diameter, D, of the core mm	e [a]	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
$D > 5$	1,6 mm	4,6 mm	4 mm	50 mm
[a] 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 be legible and of a colour which contrasts with that of the core. All the marks of the cores in a multicore cable shall be of the same colour.

Bibliography

IEC 60038, *IEC standard voltages*

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 60092-353

Edition 4.0 2016-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electrical installations in ships – Part 353: Power cables for rated voltages 1 kV and 3 kV

Installations électriques à bord des navires – Partie 353: Câbles d'énergie pour les tensions assignées 1 kV et 3 kV

IEC 60092-353:2016-09(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 353: Power cables for rated voltages 1 kV and 3 kV

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60092-353 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 fourth edition cancels and replaces the third edition published in 2011. This edition constitutes a technical revision.

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

a) updated references to IEC 60092-350 for general construction and test methods and IEC 60092-360 for insulating and sheathing materials.

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

FDIS	Report on voting
18A/399/FDIS	18A/400/RVD

Full information on the voting for the approval of this document 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.

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

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

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

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 353: Power cables for rated voltages 1 kV and 3 kV

1 Scope and object

This part of IEC 60092 is applicable to shipboard and offshore non radial field power cables with extruded solid insulation, having a voltage rating of 0,6/1 (1,2) kV or 1,8/3 (3,6) kV intended for fixed installations.

Cables designed to maintain circuit integrity during fire are included.

The various types of power cables are given in 5.1. 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 standardize cables whose safety and reliability is ensured when they are installed in accordance with the requirements of IEC 60092-352 or IEC 61892-4,

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

IEC 60228, *Conductors of insulated 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 and optical fibre 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 in 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 following 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 the following:

$$U_o/U\ (U_m) = 0{,}6/1\ (1{,}2)\ \text{kV and}\ 1{,}8/3\ (3{,}6)\ \text{kV}$$

For 0,6/1 (1,2) kV 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 0,9 kV.

4.2 Markings

4.2.1 Indication of origin and voltage identification

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

a) indication of origin,
b) rated voltage and cable construction (number of cores and cross sectional area of the construction),
c) continuity of marking, and
d) 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

a) 550 mm if the marking is on the outer surface of the cable, and
b) 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.

4.2.3.3 Numbered cores – Multicore cables

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

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 cables (excluding 1,8/3 kV)

a) Single-core unarmoured unsheathed cable
- copper conductor, see 5.2;

- insulation applied as a single layer of insulating compound of one of the types described in 5.3 with an enhanced thickness equivalent to that of a combined insulation and outer sheath for use in unarmoured cables installed in an adequately protected environment (see 5.3.3 for the thickness).

b) 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 or a metal tape 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 cables

a) 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 or a metal tape 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.

NOTE 1 Variable frequency drives induce specific electrical constraints on the connected power cables (for example voltage peaks, harmonics, reflection or earthing method among other electrical stresses).

b) Armoured double-sheathed cable with inner and outer sheath

- copper conductor, see 5.2;
- insulation, see 5.3;
- cabling (for multicore cables), see 5.4;
- inner covering (optional, but mandatory when a braided or a metal tape 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.

NOTE 2 The use of a thermoplastic inner sheath (ST2 or SHF1) is not compatible with cross-linking technology of elastomeric outer sheath.

c) 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 or a metal tape 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 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, class and form of the conductors shall be in accordance with IEC 60092-350. For cables having rated voltage 1,8/3 kV, only circular stranded compacted or non-compacted conductors with a minimum cross-section of 10 mm² are permitted. A separator between conductors and insulation is permitted.

5.3 Insulation

5.3.1 Material

The insulating compounds and their designations shall be as given in IEC 60092-360, as follows:

– for 0,6/1 (1,2) kV cables, types EPR, HEPR, XLPE, HF 90 or S 95 shall be used;
– for 1,8/3 (3,6) kV cables, types only EPR, HEPR, XLPE 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 1 hereinafter and meet the requirements of IEC 60092-350:2014, 4.3.3.

For single-core unarmoured unsheathed cables (see 5.1.2 a)), the total insulation thickness shall be the sum of

a) the thickness t_j as specified in Table 1, and
b) the thickness as calculated in accordance with 5.9.3 a), with fictitious diameter $D = d_L + 2\ t_i$ (see also IEC 60092-350:2014, A.3.1 and A.3.2). The total thickness shall meet the requirements of IEC 60092-350:2014, 4.3.3.

Table 1 – Insulation thickness

Nominal cross sectional area of conductor	0,6/1 kV		1,8/3 kV	
	EPR S 95	HEPR HF90 XLPE	EPR	HEPR XLPE
mm^2	mm	mm	mm	mm
1	1,0	0,7	–	–
1,5	1,0	0,7	–	–
2,5	1,0	0,7	–	–
4	1,0	0,7	–	–
6	1,0	0,7	–	–
10	1,0	0,7	2,2	2,0
16	1,0	0,7	2,2	2,0
25	1,2	0,9	2,2	2,0
35	1,2	0,9	2,2	2,0
50	1,4	1,0	2,2	2,0
70	1,4	1,1	2,2	2,0
95	1,6	1,1	2,4	2,0
120	1,6	1,2	2,4	2,0
150	1,8	1,4	2,4	2,0
185	2,0	1,6	2,4	2,0
240	2,2	1,7	2,4	2,0
300	2,4	1,8	2,4	2,0
400	2,6	2,0	2,6	2,0
500	2,8	2,2	2,8	2,2
630	2,8	2,4	2,8	2,4

NOTE Alternative enhanced insulation thickness can be given in some countries for legal reasons. These alternative values are based on those given in Annex A.

5.4 Cabling (including fillers and binders)

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.

5.5 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 IEC 60092-350:2014, 4.6.

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 2.

Table 2 – Thickness of extruded inner covering and fictitious diameters

Fictitious diameter over laid up cores		Thickness of extruded inner covering
Above mm	Up to and including mm	(approximate value) mm
–	25	1,0
25	35	1,2
35	45	1,4
45	60	1,6
60	80	1,8
80	–	2,0

The values of the (approximate) thickness of lapped covering for the calculation of the fictitious diameters are 0,4 mm for fictitious diameter over laid-up cores up to and including 40 mm and 0,6 mm for larger diameters.

NOTE For the calculation of fictitious diameter, see IEC 60092-350:2014, Annexes A and C.

5.6 Screen

5.6.1 Construction

5.6.1.1 General

The screen, if any, shall be a collective metallic screen and 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(s).

5.6.1.2 Metal/polyester 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 15 % of its total width, to ensure coverage in case of bending of the cable. 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.

Table 3 – Requirements of drain wire

Nominal area of conductor of the cores mm^2	Maximum drain wire resistance ohm/km
1,0 to 1,5	28,3
2,5 and above	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 15 % of its total width.

A screen consisting of a laminated electrostatic screening tape and a drain wire is not suitable for carrying large short-circuit currents and should not be grounded with the protective earth conductor of the applicable power circuit.

5.6.1.3 Metal tape

The specified nominal thickness for a plain metal tape shall be at least 0,1 mm.

5.6.1.4 Braid

The specified nominal diameter for the braiding wires shall be at least 0,2 mm.

5.6.2 Application

The screen, if any, shall be applied over the inner covering in case of a braided or a metal tape screen (see 5.1.2 and 5.1.3).

5.7 Inner sheath

5.7.1 Material

The inner sheathing compound and its designation shall be one of those given in 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 given in IEC 60092-350:2014, Annexes A and C.

The formula is the following:

a) for double-sheathed unarmoured cable as in 5.1.2 b):

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

b) for armoured cable as 5.1.3 b) and c):

t_1 = 0,04 D + 0,8 mm, with a minimum thickness of 1,0 mm for construction 5.1.3 b) and 1,4 mm for construction 5.1.3 c)

where

D is the fictitious diameter under the inner sheath.

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

5.8 Braid armour

5.8.1 General

In this document, only metal braid armours are specified, the braid wires being of copper, copper alloy or galvanized steel.

Joints in the braiding wires shall be soldered, twisted or woven-in, and the complete braid shall not be 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.

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 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 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.

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 armour shall be applied in such a way that it shall neither adhere to the inner covering or inner sheath nor to the outer sheath.

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 given in IEC 60092-350:2014, Annexes A and C.

The formula is the following:

a) for unarmoured or armoured single-sheathed cables as in 5.1.2 a) and b) and 5.1.3 a):

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 as in 5.1.2 b):

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

c) for armoured double-sheathed cables as in 5.1.3 b):

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

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

5.9.4 Colour of outer sheath

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

6 Tests – Methods and requirements

The tests shall be carried out according to Tables 4 to 8 where applicable.

Table 4 – Tests applicable to all cables *(1 of 2)*

Test	Applicability – all types of cable unless otherwise stated	Status	Method – subclause number given in IEC 60092-350:2014	Requirement – as in IEC 60092-350 unless otherwise stated
Measurement of electrical resistance of conductors		Routine	5.2.2	IEC 60228
Voltage test		Routine	5.2.3	–
Voltage test on sheath	Armoured cables	Routine	5.2.3.4	–
Insulation resistance test		Sample	7.2	–
Conductor examination		Sample and type	6.4	–
Check of cable dimensions – thickness of insulation – thickness of non metallic sheaths (excluding inner coverings) – external diameter		Sample and type	 6.5 and 8.2 6.6 and 8.3 6.7	 – – –
Hot set test	HEPR, EPR, XLPE, HF 90, S 95 insulations and SH, SE, SHF2 sheaths	Sample	6.8	IEC 60092-360
Coverage density of braid	Braid armoured cables	Type	4.8.2	
Insulation resistance measurement at maximum rated temperature		Type	7.2.2	IEC 60092-360
Increase in AC capacitance after immersion in water		Type	7.3	IEC 60092-360
High-voltage test for 4 h		Type	7.7.9	
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

Table 4 *(2 of 2)*

Test	Applicability – all types of cable unless otherwise stated	Status	Method – subclause number given in IEC 60092-350:2014	Requirement – as in IEC 60092-350 unless otherwise stated
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	SE1, 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 8.17.2	IEC 60332-1-2 and IEC 60332-3-22 in which case cables shall be installed in the 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 IEC 60092-350:2014, 8.20

Table 5 – Additional tests required for halogen-free cables

Test	Status	Method – subclause 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 6 – Additional test required for low smoke cables

Test	Status	Method – subclause 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 exceed 60 % throughout the test
NOTE The smoke emission test is in general applicable to halogen-free cables. See also Table 5.			

Table 7 – Additional test required for fire resistant cables

Test	Status	Method – subclause 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 8 – Additional tests required for specific performances

Test	Status	Method – subclause 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)

Alternative enhanced insulation thickness for 0,6/1 kV

NOTE For legal reasons, in some countries, Annex A may become normative.

Table A.1 gives an overview of alternative enhanced insulation thickness for 0,6/1 kV.

Table A.1 – Alternative enhanced insulation thickness for 0,6/1 kV

Rated voltage 0,6/1 kV			
Silicone rubber/EPR		XLPE	
Nominal cross-sectional area (S) mm^2	Insulation thickness (t) [a] and [b] mm	Nominal cross-sectional area (S) mm^2	Insulation thickness (t) [c] mm
1	1,0	1,0	0,9
1,5	1,0	1,5	0,9
2,5	1,0	2,5	0,9
4	1,1	4	1,0
6	1,1	6	1,0
10	1,2	10	1,1
16	1,3	16	1,2
25	1,4	25	1,3
35	1,5	35	1,3
50	1,6	50	1,4
70	1,7	70	1,6
95	1,9	95	1,7
120	2,0	120	1,8
150	2,1	150	1,9
185	2,3	185	2,0
240	2,4	240	2,2
300	2,6	300	2,4
400	2,9	400	2,6
500	3,1	500	2,8
630	3,4	630	3,1

For cross sections of 185 mm² and above, the insulation thickness is suitable for 3 kV. If in this case a voltage rating of 3 kV is designated to the cable, this cable should be tested as a 3 kV cable.

[a] These values of the insulation thickness correspond approximately to the formula:
$t = 0{,}1\sqrt{S} + 0{,}9$ mm

[b] All these values may be reduced by 0,1 mm if the rubber wall is covered by an extruded skin of polyamide or equivalent material.

[c] These values of the insulation thickness correspond approximately to the formula:
$t = 0{,}09\sqrt{S} + 0{,}8$ mm

Annex B
(informative)

Identification of cores of multicore cables

B.1 Inscription

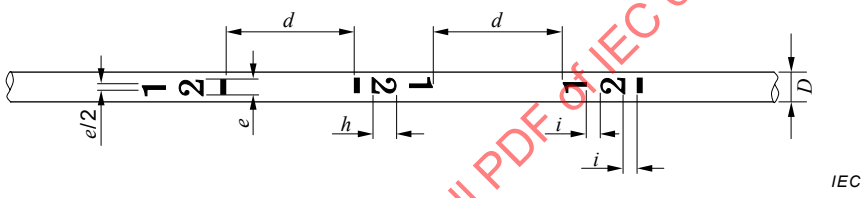
The inscription shall be composed of marks at regular intervals along the entire length of core and comprising:

a) a reference number in Arabic numerals;

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

B.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 B.1.



Key

Refer to Clause B.3 below.

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, where:

D is the nominal diameter of the core;

e is the minimum width of a mark;

h is the minimum height of a numeral;

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

d is the maximum interval between two consecutive marks.

Table B.1 – Dimensions of the marks

Nominal diameter, *D*, of the core mm	***e*** [a]	***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
$D > 5$	1,6 mm	4,6 mm	4 mm	50 mm
[a] 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 be legible and of a colour which contrasts with that of the core. All the marks of the cores in a multicore cable shall be of the same colour.

Bibliography

IEC 60038, *IEC standard voltages*

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*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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INSTALLATIONS ÉLECTRIQUES À BORD DES NAVIRES –

Partie 353: Câbles d'énergie pour les tensions assignées 1 kV et 3 kV

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La Norme internationale IEC 60092-353 a été établie par le sous-comité 18A: Câbles électriques pour navires et unités mobiles et fixes en mer, du comité d'études 18 de l'IEC: Installations électriques des navires et des unités mobiles et fixes en mer.

Cette quatrième édition annule et remplace la troisième édition parue en 2011. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mise à jour des références à l'IEC 60092-350 pour la construction générale et les méthodes d'essai et à l'IEC 60092-360 pour les matériaux d'isolation et de gainage.

Le texte de ce document est issu des documents suivants:

FDIS	Rapport de vote
18A/399/FDIS	18A/400/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60092, publiées sous le titre général *Installations électriques à bord des navires*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

INSTALLATIONS ÉLECTRIQUES À BORD DES NAVIRES –

Partie 353: Câbles d'énergie pour les tensions assignées 1 kV et 3 kV

1 Domaine d'application et objet

La présente partie de l'IEC 60092 est applicable aux câbles pour installations à bord des navires et en mer, à champ non radial, à isolement massif extrudé et avec une tension assignée de 0,6/1 (1,2) kV ou de 1,8/3 (3,6) kV destinés aux installations fixes.

Les câbles conçus pour assurer l'intégrité des circuits au cours d'un incendie sont inclus.

Les différents types de câbles d'énergie sont indiqués en 5.1. Leurs exigences de fabrication et leurs méthodes d'essai sont conformes à celles qui sont indiquées dans l'IEC 60092-350 sauf spécification contraire dans le présent document.

L'objet du présent document est

– de normaliser des câbles qui soient sûrs et fiables lorsqu'ils sont installés conformément aux exigences de l'IEC 60092-352 ou de l'IEC 61892-4,
– d'établir les caractéristiques pour de tels câbles et les exigences normalisées relatives à leur fabrication se référant directement ou indirectement à la sécurité, et
– de préciser les méthodes d'essai pour vérifier la conformité à ces exigences.

2 Références normatives

Les documents ci-après, dans leur intégralité ou non, sont des références normatives indispensables à l'application du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-461, *Vocabulaire Électrotechnique International – Partie 461: Câbles électriques*

IEC 60092-350:2014, *Installations électriques à bord des navires – Partie 350: Construction générale et méthodes d'essai des câbles d'énergie, de commande et d'instrumentation des navires et des unités mobiles et fixes en mer*

IEC 60092-360, *Installations électriques à bord des navires – Partie 360: Matériaux d'isolation et de gainage des câbles d'alimentation, de commande, d'instrumentation et de télécommunication installés à bord des navires et des unités en mer*

IEC 60228, *Âmes des câbles isolés*

IEC 60331-1, *Essais pour câbles électriques soumis au feu – Intégrité des circuits – Partie 1: Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe supérieur à 20 mm, à une température d'au moins 830 °C*

IEC 60331-2, *Essais pour câbles électriques soumis au feu – Intégrité des circuits – Partie 2: Méthode d'essai au feu avec chocs pour les câbles de tension assignée au plus égale à 0,6/1,0 kV et de diamètre externe inférieur ou égal à 20 mm, à une température d'au moins 830 °C*

IEC 60331-21, *Essais de câbles électriques soumis au feu – Intégrité des circuits – Partie 21: Procédures et prescriptions – Câbles de tension assignée jusque et y compris 0,6/1,0 kV*

IEC 60332-1-2, *Essais des câbles électriques et à fibres optiques soumis au feu – Partie 1-2: Essai de propagation verticale de la flamme sur conducteur ou câble isolé – Procédure pour flamme à prémélange de 1 kW*

IEC 60332-3-22, *Essais des câbles électriques et des câbles à fibres optiques soumis au feu – Partie 3-22: Essai de propagation verticale de la flamme des fils ou câbles montés en nappes en position verticale – Catégorie A*

IEC 60445, *Principes fondamentaux et de sécurité pour les interfaces homme-machines, le marquage et l'identification – Identification des bornes de matériels, des extrémités de conducteurs et des conducteurs*

IEC 60684-2, *Gaines isolantes souples – Partie 2: Méthodes d'essai*

IEC 60754-1, *Essai sur les gaz émis lors de la combustion des matériaux prélevés sur câbles – Partie 1: Détermination de la quantité de gaz acide halogéné*

IEC 60754-2, *Essai sur les gaz émis lors de la combustion des matériaux prélevés sur câbles – Partie 2: Détermination de la conductivité et de l'acidité (par mesure du pH)*

IEC 61034-2, *Mesure de la densité de fumées dégagées par des câbles brûlant dans des conditions définies – Partie 2: Procédure d'essai et exigences*

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 60092-350 et de l'IEC 60050-461 s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

4 Exigences générales

4.1 Tension assignée

La méthode normalisée utilisée pour la désignation des tensions assignées des câbles couverts par le présent document doit prendre la forme suivante:

$$U_o/U\ (U_m)$$

où

U_o est la tension assignée à fréquence industrielle entre le conducteur de phase et la terre ou un écran métallique, pour laquelle le câble est conçu;

U est la tension assignée à fréquence industrielle entre les conducteurs de phase, pour laquelle le câble est conçu;

U_m est la valeur maximale de la tension la plus élevée du réseau pour laquelle le matériel (y compris le câble) peut être utilisé (voir l'IEC 60038).

Toutes les tensions sont exprimées en valeurs efficaces.

Les tensions assignées normales U_o/U (U_m) des câbles prévues par le présent document sont les suivantes:

U_o/U (U_m) = 0,6/1 (1,2) kV et 1,8/3 (3,6) kV

Pour les câbles 0,6/1 (1,2) kV, la tension en courant continu peut être utilisée jusqu'à 1,5 fois au maximum la tension en courant alternatif, à condition que la tension par rapport à la terre ne dépasse pas 0,9 kV.

4.2 Marquages

4.2.1 Indication de l'origine et indication de tension

Les câbles doivent être conformes au 4.1.3 de l'IEC 60092-350:2014, quant à

a) l'indication de l'origine,
b) la tension assignée et la construction du câble (nombre de conducteurs et section de la construction),
c) la continuité du marquage, et
d) la durabilité/lisibilité.

4.2.2 Continuité du marquage

Le marquage est considéré comme continu si l'intervalle compris entre la fin de chaque marquage et le commencement du suivant ne dépasse pas

a) 550 mm si le marquage se trouve sur la surface extérieure du câble, et
b) 275 mm dans tous les autres cas.

4.2.3 Identification des conducteurs

4.2.3.1 Généralités

Les conducteurs de câble doivent être clairement identifiés par des couleurs ou des numéros.

4.2.3.2 Conducteurs de couleur

Les couleurs du conducteur doivent être conformes à l'IEC 60445.

4.2.3.3 Conducteurs numérotés – Câbles multipolaires

L'identification doit apparaître sous la forme de numéros placés sur chaque conducteur, commençant par 1 à partir du centre, conformément à l'Annexe B.

5 Exigences de construction

5.1 Description générale

5.1.1 Vue d'ensemble

Les câbles installés à bord des navires et dans les installations fixes en mer doivent être des câbles uniques ou multipolaires, en général construits comme suit.

5.1.2 Câbles non armés (à l'exclusion de 1,8/3 kV)

a) Câble sans gaine non armé unipolaire

- âme en cuivre, voir 5.2;
- isolation appliquée en une seule couche de mélange d'isolation de l'un des types décrits en 5.3, avec une épaisseur renforcée équivalente à celle d'une isolation combinée et une gaine externe utilisée pour les câbles non armés installés dans un environnement convenablement protégé (voir 5.3.3 pour l'épaisseur).

b) Câble non armé à une ou deux gaines

- âme en cuivre, voir 5.2;
- isolation, voir 5.3;
- assemblage (pour les câbles multipolaires), voir 5.4;
- revêtement d'assemblage (facultatif, mais obligatoire si tressé ou si un écran électrostatique à ruban métallique est appliqué sur l'assemblage des conducteurs), voir 5.5;
- écran électrostatique (facultatif), voir 5.6;
- gaine interne (facultative), voir 5.7;
- gaine externe appliquée comme des systèmes à une ou deux couches, voir 5.9.

5.1.3 Câbles armés

a) Câble armé à une seule gaine, externe uniquement

- âme en cuivre, voir 5.2;
- isolation, voir 5.3;
- assemblage (pour les câbles multipolaires), voir 5.4;
- revêtement d'assemblage sous un écran électrostatique (facultatif, mais obligatoire si tressé ou si un écran électrostatique à ruban métallique est appliqué sur l'assemblage des conducteurs), voir 5.5;
- écran électrostatique (facultatif), voir 5.6;
- revêtement d'assemblage (facultatif, mais obligatoire dans le cas d'une armure tressée en feuillard d'acier galvanisé, auquel cas le revêtement d'assemblage doit être extrudé), voir 5.5;
- armure tressée, voir 5.8;
- gaine externe appliquée comme des systèmes à une ou deux couches, voir 5.9.

NOTE 1 Les dispositifs d'entrainement à fréquence variable induisent des contraintes électriques spécifiques sur les câbles de puissance connectés (par exemple, les pics de tension, les harmoniques, la méthode de réflexion ou de mise à la terre entre autres contraintes électriques)

b) Câble armé à deux gaines, interne et externe

- âme en cuivre, voir 5.2;
- isolation, voir 5.3;
- assemblage (pour les câbles multipolaires), voir 5.4;
- revêtement d'assemblage (facultatif, mais obligatoire si tressé ou si un écran électrostatique à ruban métallique est appliqué sur l'assemblage des conducteurs), voir 5.5;
- écran électrostatique (facultatif), voir 5.6;
- gaine interne, voir 5.7;
- armure tressée, voir 5.8;
- gaine externe appliquée comme des systèmes à une ou deux couches, voir 5.9.

NOTE 2 L'utilisation d'une gaine interne thermoplastique (ST2 ou SHF1) n'est pas compatible avec la technologie de réticulation d'une gaine externe élastomère.

c) Câble armé à une seule gaine, interne uniquement

- âme en cuivre, voir 5.2;
- isolation, voir 5.3;
- assemblage (pour les câbles multipolaires), voir 5.4;
- revêtement d'assemblage (facultatif, mais obligatoire si tressé ou si un écran électrostatique à ruban métallique est appliqué sur l'assemblage des conducteurs), voir 5.5;
- écran électrostatique (facultatif), voir 5.6;
- gaine interne, voir 5.7;
- armure tressée, voir 5.8.

Il convient d'équiper les câbles prévus pour être installés dans des locaux présentant des risques de corrosion (ponts exposés aux intempéries, endroits humides, salles réservées aux accumulateurs, chambres frigorifiques, par exemple) d'une gaine externe sur la tresse, sauf si la tresse elle-même est résistante à la corrosion.

5.2 Âmes conductrices

Le matériau, le revêtement métallique, la classe et la forme des âmes conductrices doivent être conformes à l'IEC 60092-350. Pour les câbles présentant une tension assignée de 1,8/3 kV, seules des âmes conductrices câblées circulaires compactées ou non compactées de section minimale de 10 mm² sont admises. La présence d'un séparateur placé entre les âmes conductrices et l'isolation est admise.

5.3 Isolation

5.3.1 Matériau

Les mélanges d'isolation et leurs désignations doivent être ceux donnés dans l'IEC 60092-360, comme suit:

– pour les câbles 0,6/1 (1,2) kV, les types EPR, HEPR, XLPE, HF 90 ou S 95 doivent être utilisés;

– pour les câbles 1,8/3 (3,6) kV, les types EPR, HEPR, XLPE uniquement doivent être utilisés.

Le système d'isolation doit être composé de l'une des options (a) à (c) telles qu'énumérées en 4.3.1 de l'IEC 60092-350:2014.

5.3.2 Application

L'application doit être celle présentée en 4.3.2 de l'IEC 60092-350:2014.

5.3.3 Épaisseur de l'enveloppe isolante

L'épaisseur de l'enveloppe isolante doit être celle indiquée dans le Tableau 1 ci-après et satisfaire aux exigences de 4.3.3 de l'IEC 60092-350:2014.

Pour les câbles sans gaine non armés unipolaires (voir 5.1.2 a)), l'épaisseur totale de l'enveloppe isolante doit être égale à la somme de

a) l'épaisseur t_j telle que spécifiée au Tableau 1, et