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INTERNATIONAL STANDARD

colour inside

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

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Part 360: Insulating and sheathing materials for shipboard and offshore units, power, control, instrumentation and telecommunication cables

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60092-360:2014. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60092-360 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 second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

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

a) updates of normatives references;
b) replacement of linear swelling with volume swelling;
c) correction of a calculation mistake in Table 3;
d) change in Table 4 and Table 6 (treatment conditions) of time under load (from 15 min to 10 min);
e) addition of mechanical properties after aging in oil based test fluid in Table 10 (CAS number 64742-46-7; EC number: 934-956-3).

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

FDIS	Report on voting
18A/437/FDIS	18A/440/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 of 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- withdrawn,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.

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ELECTRICAL INSTALLATIONS IN SHIPS –

Part 360: Insulating and sheathing materials for shipboard and offshore units, power, control, instrumentation and telecommunication cables

1 Scope

This part of IEC 60092 specifies the requirements for electrical, mechanical and particular characteristics of insulating and sheathing materials intended for use in shipboard and fixed and mobile offshore unit power, control, instrumentation and telecommunication cables.

The different insulating and sheathing materials have been divided into three categories as listed in Table 1.

Table 1 – Categories and types of materials

Title	Compounds included
Cross-linked insulating compounds	EPR; HEPR; XLPE; S 95; HF 90
Cross-linked sheathing compounds	SE; SH; SHF 2
Thermoplastic sheathing compounds	SHF 1; ST 2

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60092-350:~~—[1]~~2020, *Electrical installations in ships – Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications*

IEC 60684-2:2011, *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 60811-201:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*
IEC 60811-201:2012/AMD1:2017

IEC 60811-202:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*
IEC 60811-202:2012/AMD1:2017

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~~[1] To be published.~~

IEC 60811-401:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*
IEC 60811-401:2012/AMD1:2017

IEC 60811-403:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds*

IEC 60811-404:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

IEC 60811-409:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 409: Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

IEC 60811-501:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*
IEC 60811-501:2012/AMD1:2018

IEC 60811-505:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Elongation at low temperature for insulations and sheaths*

IEC 60811-507:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 507: Mechanical tests – Hot set test for cross-linked materials*

IEC 60811-508:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-508:2012/AMD1:2017

IEC 60811-509:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*
IEC 60811-509:2012/AMD1:2017

~~ISO 48:2007, *Rubber, vulcanised or thermoplastic – Determination of hardness (Hardness between 10 IRHD and 100 IRHD)*~~

ISO 48-2:2018, *Rubber, vulcanised or thermoplastic – Determination of hardness – Part 2: Hardness between 10 IRHD and 100 IRHD*

ISO 1817, *Rubber, vulcanised or thermoplastic – Determination of the effect of liquids*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
variation
difference between the median value after ageing and the median value without ageing

Note 1 to entry: Variation is expressed as a percentage between the median value before and after ageing.

3.2
median value
middle value if the number of available values is odd andmean of the two middle values if the number is even, when several test results have been obtained and ordered in an increasing or decreasing succession

3.3
types of insulating compounds

3.3.1
EPR
ethylene-propylene rubber
cross-linked compound in which the elastomer is an ethylene-propylene, EPDM or an equivalent synthetic elastomer providing a compound compliant with type EPR

~~Note 1 to entry: This note applies to the French language only.~~

3.3.2
HEPR
hard ethylene-propylene rubber
cross-linked high modulus or hard grade compound in which the elastomer is an ethylene-propylene, EPDM or an equivalent synthetic elastomer providing a compound compliant with type HEPR

~~Note 1 to entry: This note applies to the French language only.~~

3.3.3
XLPE
cross-linked polyethylene
cross-linked compound in which the polymer is a low density polyethylene or equivalent synthetic polymer providing a compound compliant with type XLPE

~~Note 1 to entry: This note applies to the French language only.~~

3.3.4
HF 90
cross-linked polyolefin halogen-free
cross-linked compound in which the polymer is a polyolefin or equivalent synthetic polymer not containing halogens providing a compound which is compliant with type HF 90

3.3.5
S 95
cross-linked silicone rubber
compound based on a polysiloxane elastomer which, when cross-linked, is compliant with type S 95

3.4
types of sheathing compounds

3.4.1
SE
polychloroprene rubber
cross-linked compound in which the elastomer is a polychloroprene (PCP) or equivalent synthetic elastomer providing a compound which is compliant with type SE

3.4.2
SH
chlorosulphonated polyethylene rubber
chlorinated polyethylene rubber
cross-linked compound in which the characteristic constituent is a synthetic chlorinated rubber

EXAMPLE Chlorosulphonated polyethylene (CSP) or chlorinated polyethylene (CPE), which is compliant with type SH.

~~Note 1 to entry: This note applies to the French language only.~~

3.4.3
SHF 2
halogen-free rubber
cross-linked compound in which the polymer is a polyolefin or equivalent synthetic polymer, not containing halogens, providing a compound which is compliant with type SHF 2

3.4.4
SHF 1
halogen-free thermoplastic
thermoplastic compound in which the polymer is a polyolefin or equivalent synthetic polymer not containing halogens providing a compound which is compliant with type SHF 1

3.4.5
ST 2
polyvinyl chloride thermoplastic
thermoplastic compound based on plasticised polyvinyl chloride which is compliant with type ST 2

3.5
halogen-free
compound that complies with the assessment of halogen requirements in Table 4, Table 6 or Table 8

4 Cross-linked insulating compounds

4.1 General

The types of cross-linked insulating compound covered by this document are listed in Table 2 together with their abbreviated designations and maximum rated conductor temperatures during normal operation and short-circuit.

Table 2 – Types of cross-linked insulating compounds

Abbreviated designation	Maximum rated conductor temperature °C		Type of insulating material
	Normal operation	Short-circuit	
EPR	90	250	Ethylene propylene rubber
HEPR	90	250	Hard grade ethylene propylene rubber
XLPE	90	250	Cross-linked polyethylene
HF 90	90	250	Cross-linked polyolefin halogen-free
S 95	95[a]	350[b]	Cross-linked silicone rubber

[a] The normal maximum rated conductor temperature for silicone is 180 °C but it is limited in view of the type of sheathing material used.

[b] This temperature is applicable only to power cables and is not appropriate for tinned conductors.

4.2 Electrical characteristics

The test requirements for electrical characteristics of insulating compounds are listed in Table 3.

Table 3 – Electrical requirements of insulation compounds

Designation of the insulating compound	EPR	HEPR	XLPE	HF 90	S 95
Insulation resistance constant K_i (MΩ·km) (see 7.2 of IEC 60092-350:2020)					
– at 20 °C, minimum,	3 670	3 670	3 670	550	1 850
– at maximum operating temperature, minimum.	3,67	3,67	3,67	0,55	1,85
Volume resistivity ρ(Ω·cm) (see 7.2 of IEC 60092-350:2020)					
– at 20 °C, minimum,	$1,0 \times 10^{15}$	$1,0 \times 10^{15}$	$1,0 \times 10^{15}$	$1,5 \times 10^{14}$	~~$5,0 \times 10^{13}$~~ $5,0 \times 10^{14}$
– at maximum operating temperature, minimum.	$1,0 \times 10^{12}$	$1,0 \times 10^{12}$	$1,0 \times 10^{12}$	$1,5 \times 10^{11}$	~~$5,0 \times 10^{10}$~~ $5,0 \times 10^{11}$
Increase in AC capacity after immersion in water at 50 °C, (see 7.3 of IEC 60092-350:2020)					
– between the end of the 1st and the end of the 14th day, maximum (%),	15	15	–	15	15
– between the end of the 7th and the end of the 14th day, maximum (%).	5	5	–	5	5

4.3 Mechanical characteristics

The test requirements for mechanical characteristics of cross-linked insulating compounds are listed in Table 4.

Table 4 – Test requirements for cross-linked elastomeric insulating compounds

Test description	Unit	Test method described in		Type of insulating compound				
		Std	Reference	EPR	HEPR	XLPE	HF 90	S 95
Mechanical properties in the state as delivered		IEC 60811-501						
Values to be obtained for the:								
– tensile strength, min.	N/mm^2			4,2	8,5	12,5	9,0	7,0
– elongation at break, min.	%			200	200	200	120	150
Mechanical properties after ageing in air oven without conductor		IEC 60811-401						
Ageing conditions:								
– temperature/ tolerance	°C			135 ± 3	135 ± 3	135 ± 3	135 ± 3	200 ± 3
– duration of treatment	h			168	168	168	168	240
Value to be obtained for the tensile strength								
– minimum value	N/mm^2			-	-	-	-	5,5
– variation max.	%			±30	±30	±25	±30	-
Value to be obtained for the elongation at break								
– minimum value	%			-	-	-	100	120
– variation max.	%			±30	±30	±25	±30	-
Mechanical properties after ageing in air oven with copper conductor		IEC 60811-401						
Ageing conditions:								
– temperature/ tolerance	°C			135 ± 3	150 ± 3			
– duration of treatment	h			168	168			
Value to be obtained for the tensile strength								
– variation max.	%			±30	±30	-		-
Value to be obtained for the elongation at break								
– variation max.	%			±30	±30	–		–
Hot set test		IEC 60811-507						
Treatment conditions:								
– temperature/ tolerance	°C			250 ± 3	250 ± 3	200 ± 3	200 ± 3	250 ± 3
– time under load min.	min			~~15~~ 10	~~15~~ 10	~~15~~ 10	~~15~~ 10	~~15~~ 10
– mechanical stress	N/cm^2			20	20	20	20	20

Test description	Unit	Test method described in		Type of insulating compound				
		Std	Reference	EPR	HEPR	XLPE	HF 90	S 95
Test requirements:								
– elongation max. under load	%			175	175	175	175	175
– elongation max. after unloading	%			15	15	15	15	25
Determination of hardness IRHD minimum		IEC 60092-360	Annex A		80			
Determination of elastic modulus		IEC 60092-360	Annex B					
Modulus at 150 % elongation (minimum)	N/mm^2				4,5			
Ozone resistance test (method A or B)		IEC 60811-403						
Test conditions of method A				–	–	–	–	–
– temperature	°C			25 ± 2	25 ± 2	–	25 ± 2	–
– duration	h			30	30	–	30	–
– ozone concentration	ppm			~~250-300~~ 275 ± 25	~~250-300~~ 275 ± 25	–	~~250-300~~ 275 ± 25	–
Result to be obtained				No cracks	No cracks	–	No cracks	–
Test conditions of method B						–		–
– temperature	°C			40 ± 2	40 ± 2	–	40 ± 2	–
– duration	h			72	72	–	72	–
– ozone concentration, (by volume)	%			(200 ± 50) x 10^{-6}	(200 ± 50) x 10^{-6}	–	(200 ± 50) x 10^{-6}	–
– relative humidity	%			55 ± 10	55 ± 10	–	55 ± 10	–
– minimum air speed at the level of the test piece	mm/s			500	500	–	500	–
Result to be obtained				No cracks	No cracks		No cracks	
Assessment of halogens [a]								
pH		IEC 60754-2		≥4,3	≥4,3	≥4,3	≥4,3	≥4,3
Conductivity	$\mu S \cdot mm^{-1}$			≤10	≤10	≤10	≤10	≤10
Amount of halogen acid gas:								
– HCl and HBr (max.)	%	IEC 60754-1		0,5	0,5	0,5	0,5	0,5
– HF (max.)	%	IEC 60684-2: 2011	45	0,1	0,1	0,1	0,1	0,1

[a] Test required when materials are used in halogen-free cables or identified as a halogen-free compound.