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Third edition
2004-04

Electrical installations in ships –

**Part 351:
Insulating materials for shipboard
and offshore units, power, control,
instrumentation, telecommunication
and data cables**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables

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 60092-351 has been prepared by subcommittee 18A: Cables and cable installations, of IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This third edition cancels and replaces the second edition published in 2000, and constitutes a technical revision. The title has been updated and changes introduced to the tables.

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

FDIS	Report on voting
18A/252/FDIS	18A/254/RVD

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

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

IEC 60092 consists of the following parts under the general title *Electrical installations in ships*:

- Part 101: Definitions and general requirements
- Part 201: System design – General
- Part 202: System design – Protection
- Part 203: System design – Acoustic and optical signals
- Part 204: System design – Electric and electrohydraulic steering gear
- Part 301: Equipment – Generators and motors
- Part 302: Low-voltage switchgear and controlgear assemblies
- Part 303: Equipment – Transformers for power and lighting
- Part 304: Equipment – Semiconductor convertors
- Part 305: Equipment – Accumulator (storage) batteries
- Part 306: Equipment – Luminaires and accessories
- Part 307: Equipment – Heating and cooking appliances
- Part 350: Shipboard power cables – General construction and test requirements
- Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables
- Part 352: Choice and installation of cables for low-voltage power systems
- Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV
- Part 354: Single- and three-core power cables with extruded solid insulation for rated voltages 6 kV ($U_m = 7,2$ kV) up to 30 kV ($U_m = 36$ kV)
- Part 359: Sheathing materials for shipboard power and telecommunication cables
- Part 373: Shipboard telecommunication cables and radio-frequency cables – Shipboard flexible coaxial cables
- Part 374: Shipboard telecommunication cables and radio-frequency cables – Telephone cables for non-essential communication services
- Part 375: Shipboard telecommunication cables and radio-frequency cables – General instrumentation, control and communication cables
- Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)
- Part 390: Cable penetrations – Fire type test procedures
- Part 401: Installation and test of completed installation
- Part 501: Special features – Electric propulsion plant
- Part 502: Tankers – Special features
- Part 503: Special features – A.C. supply systems with voltages in the range above 1 kV up to and including 11 kV
- Part 504: Special features – Control and instrumentation
- Part 506: Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk
- Part 507: Pleasure craft
- Part 508: Switchgear and controlgear assemblies for rated voltages above 1kV and up to and including 15kV (in preparation)

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

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

A bilingual version may be issued at a later date.

INTRODUCTION

IEC 60092 forms a series of International Standards concerning electrical installations in sea-going ships and fixed and mobile offshore units, incorporating good practice and co-ordinating as far as possible existing rules.

These standards form a code of practical interpretation and amplification of the requirements of the International Convention on Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by shipowners, shipbuilders, mobile and fixed offshore unit owners and builders and appropriate organisations.

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ELECTRICAL INSTALLATIONS IN SHIPS –

Part 351: Insulating materials for shipboard and offshore units, power, control, instrumentation, telecommunication and data cables

1 Scope

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

2 Normative references

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

IEC 60502-1:1997, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) – Part 1: Cables for rated voltages of 1 kV ($U_m = 1,2$ kV) and 3 kV ($U_m = 3,6$ kV)*

IEC 60754-2, *Test on gases evolved during combustion of electric cables – Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity*

IEC 60811-1-1:1993, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*¹⁾
Amendment 1 (2001)

IEC 60811-1-2:1995, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Two: Thermal ageing methods*
Amendment 1 (1989)
Amendment 2 (2000)

IEC 60811-1-4:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section four: Test at low temperature*
Amendment 1 (1993)
Amendment 2 (2001)

IEC 60811-2-1:1998, *Insulating and sheathing materials of electric and optical cables – Common test methods – Part 2-1: Methods specific to elastomeric compounds – Ozone resistance, hot set and mineral oil immersion tests*²⁾
Amendment 1 (2001)

IEC 60811-3-1:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section One: Pressure test at high temperature – Tests for resistance to cracking*
Amendment 1 (1994)
Amendment 2 (2001)

¹⁾ A consolidated edition 2.1 (2001) exists, including edition 2.0 and its Amendment 1.

²⁾ A consolidated edition 2.1 (2001) exists, including edition 2.0 and its Amendment 1.

IEC 60811-3-2:1985 *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section Two: Loss of mass test – Thermal stability test*
Amendment 1 (1993)

ISO 48, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

3 Insulating materials

3.1 General

The types of insulating compound covered by this standard are listed in the following Table 1 together with their abbreviated designations and maximum rated conductor temperatures during normal operation and short-circuit.

Table 1 – Type of insulating compounds, abbreviated designation and maximum rated conductor temperature during normal operation and short circuit

Type of insulating compound	Abbreviated designation	Maximum rated conductor temperature °C	
		Normal operation	Short-circuit
a) Thermoplastic:			
– based upon polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC	70	150
b) Elastomeric or thermoset:			
– based upon ethylene-propylene rubber or similar (EPM or EPDM)	EPR	90	250
– based upon high modulus or hard grade ethylene propylene rubber	HEPR	90	250
– based upon cross-linked polyethylene	XLPE	90	250
– based upon silicone rubber	S 95	95	350 ^a
– based upon ethylene-propylene rubber or similar (EPM or EPDM) halogen-free	HF EPR	90	250
– based upon high modulus or hard grade halogen-free ethylene propylene rubber	HF HEPR	90	250
– based upon halogen-free cross-linked polyethylene	HF XLPE	90	250
– based upon halogen-free silicone rubber	HF S 95	95	350 ^a
– based upon cross-linked polyolefin material for halogen-free cables	HF 90	90	250
^a This temperature is applicable only to power cables and not appropriate for tinned copper conductors.			

3.2 Electrical characteristics

The test requirements for electrical characteristics of insulating compounds are listed in the following Table 2.

Table 2 – Test requirements for electrical characteristics of insulating compounds

Designation of the insulating compound	EPR and HF EPR	HEPR and HF HEPR	XLPE and HF XLPE	S 95 and HF S 95	HF 90	PVC
1 Insulation resistance constant K_i ($M\Omega \cdot km$) (see Clause 17 of IEC 60502-1)						
1a – at 20 °C, minimum;	3 670	3 670	3 670	1 500	500	36,7
1b – at maximum operating temperature, minimum	3,67	3,67	3,67	2	0,5	0,037
2 Increase in a.c. capacity after immersion in water at 50 °C						
2a – between the end of the 1st and the end of the 14th day, maximum (%)	15	15	–	15	15	15
2b – between the end of the 7th and the end of the 14th day, maximum (%)	5	5	–	5	5	5

3.3 Mechanical characteristics

The test requirements for mechanical characteristics of insulating compounds are listed in the following Table 3.

Table 3 – Test requirements for mechanical characteristics of insulating compounds

Designation of the insulating compound	EPR and HF EPR	HEPR and HF HEPR	XLPE and HF XLPE	S 95 and HF S 95	HF 90	PVC
Mechanical characteristics without ageing (see 9.1 of IEC 60811-1-1)						
Tensile strength, minimum (N/mm ²)	4,2	8,5	12,5	5,0	9,0	12,5
Elongation at break, minimum (%)	200	200	200	150	120	150
Mechanical characteristics after ageing in air oven (see 8.1 of IEC 60811-1-2)						
After ageing without conductor						
Treatment – temperature (°C)	135	135	135	200	135	100
– tolerance (°C)	±2	±2	±2	±3	±2	±2
– duration (h)	168	168	168	240	168	168
Tensile strength:						
a) minimum value (N/mm ²)	–	–	–	4,0	–	12,5
b) variation, maximum (%)	±30	±30	±25	–	±30	±25
Elongation at break:						
a) minimum value (%)	–	–	–	120	100	150
b) variation, maximum (%)	±30	±30	±25	–	±30	±25
After ageing with copper conductor						
Treatment – temperature (°C)	–	150	–	–	–	–
– tolerance (°C)	–	±3	–	–	–	–
– duration (h)	–	168	–	–	–	–
Tensile strength:						
variation, maximum (%)	–	±30	–	–	–	–
Elongation at break:						
variation, maximum (%)	–	±30	–	–	–	–
Mechanical characteristics after ageing in air bomb at (0,55 ± 0,02) MPa (see 8.2 of IEC 60811-1-2)						
Treatment – temperature (°C)						
– tolerance (°C)	127	127	–	–	–	–
– duration (h)	±1	±1	–	–	–	–
Tensile strength:						
variation, maximum (%)	40	40	–	–	–	–
Elongation at break:						
variation, maximum (%)	±30	±30	–	–	–	–
a Test is only applicable to cables having bare copper conductors without any separator on the conductor.						

Table 4 (continued)

Designation of the insulating compound	EPR	HEPR	XLPE	S 95	HF EPR	HF HEPR	HF XLPE	HF S 95	HF 90	PVC
Ozone resistance test (see Clause 8 of IEC 60811-2-1) Ozone concentration (by volume) (%)	0,025 to 0,030	0,025 to 0,030	-	-	0,025 to 0,030	0,025 to 0,030	-	-	0,025 to 0,030	-
Test duration without cracks ^a (h)	30	30	-	-	30	30	-	-	30	-
Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity (see IEC 60754-2) pH conductivity ($\mu\text{S}\cdot\text{mm}^{-1}$)	- -	- -	- -	- -	$\geq 4,3$ ≤ 10	- -				
Determination of hardness (see Annex A) IRHD ^b minimum	-	80	-	-	-	80	-	-	-	-
Determination of elastic modulus (see Annex B) Modulus at 150 % elongation minimum (N/mm^2)	-	4,5	-	-	-	4,5	-	-	-	-
<p>^a An alternative test method may be used in some countries for legal reasons. In this case, the ozone concentration and test duration listed here are replaced by the conditions in Annex C.</p> <p>^b IRHD = International Rubber Hardness Degree</p>										

Annex A (normative)

Determination of hardness of HEPR and HF HEPR insulation

A.1 Test piece

The test piece shall be a sample of completed cable with all the coverings external to the rubber surface to be measured carefully removed. Alternatively, a sample of insulated core may be used.

A.2 Test procedure

Tests shall be made in accordance with ISO 48 with exceptions as indicated below.

A.2.1 Surfaces of large radius of curvature

The test instrument, in accordance with ISO 48, shall be constructed so as to rest firmly on the rubber surface and permit the presser foot and indenter to make vertical contact with this surface. This is done in one of the following ways:

- a) the instrument is fitted with feet movable in universal joints so that they adjust themselves to the curved surface;
- b) the base of the instrument is fitted with two parallel rods A and A' at a distance apart depending on the curvature of the surface (see figure A.1).

These methods may be used on surfaces with a radius of curvature down to 20 mm.

When the thickness of rubber tested is less than 4 mm, an instrument as described in the method in ISO 48 for thin and small test pieces shall be used.

A.2.2 Surfaces of small radius of curvature

On surfaces with too small a radius of curvature for the procedures described in A.2.1, the test piece shall be supported on the same rigid base as the test instrument, in such a way as to minimise bodily movement of the rubber surface when the indenting force increment is applied to the indenter and so that the indenter is vertically above the axis of the test piece. Suitable procedures are as follows:

- a) by resting the test piece in a groove or trough in a metal jig (see Figure A.2a);
- b) by resting the ends of the conductor of the test piece in V-blocks (see Figure A.2b).

The smallest radius of curvature of the surface to be measured by these methods shall be at least 4 mm.

For smaller radii, an instrument as described in the method in ISO 48 for thin and small test pieces shall be used.

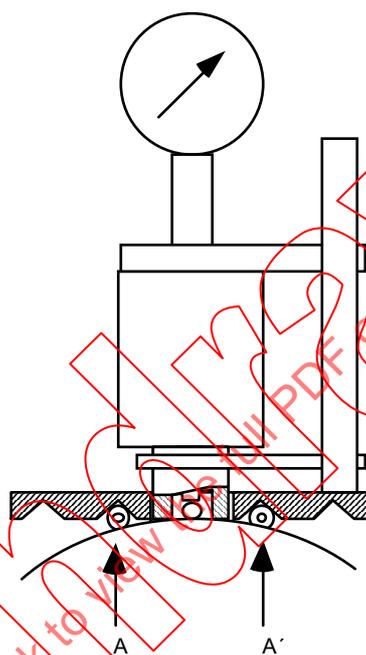
A.2.3 Conditioning and test temperature

The minimum time between manufacture, i.e. vulcanisation, and testing shall be 16 h.

The test shall be carried out at a temperature of (20 ± 2) °C and the test pieces shall be maintained at this temperature for at least 3 h immediately before testing.

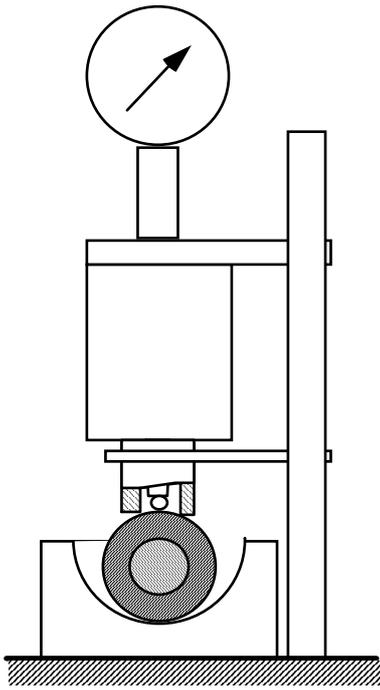
A.2.4 Number of measurements

One measurement shall be made at each of three or five different points distributed around the test piece. The median of the results shall be taken as the hardness of the test piece, reported to the nearest whole number in International Rubber Hardness Degrees (IRHD).

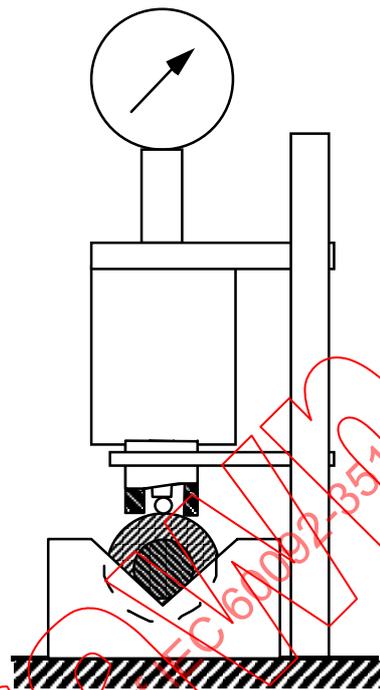


IEC 2493/2000

Figure A.1 – Testing surfaces of large radius of curvature



IEC 2494/2000



IEC 2495/2000

Figure A.2a – Metal jig

Figure A.2b – V blocks

Figure A.2 – Testing surfaces of small radius of curvature

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