

© Copyright SEK. Reproduction in any form without permission is prohibited.

## Elinstallationer i fartyg – Del 350: Kraftkablar och styrkablar för användning i fartyg och offshore-enheter

*Electrical installations in ships –*

*Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications*

Denna svenska standard innehåller den engelska texten i nedan angiven IEC-publikation, utarbetad inom International Electrotechnical Commission, IEC:

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

### Nationellt förord

Tidigare fastställd svensk standard SS-IEC 92, utgåva 4, 1995, gäller ej fr o m 2017-11-23.

---

ICS 29.060.20; 47.020.60

---

Denna standard är fastställd av SEK Svensk Elstandard, som också kan lämna upplysningar om **sakinnehållet** i standarden.  
Postadress: Box 1284, 164 29 KISTA  
Telefon: 08 - 444 14 00.  
E-post: sek@elstandard.se. Internet: www.elstandard.se

---

### *Standarder underlättar utvecklingen och höjer elsäkerheten*

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

### *SEK är Sveriges röst i standardiseringsarbetet inom elområdet*

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

### *Stora delar av arbetet sker internationellt*

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

### *Var med och påverka!*

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

### **SEK Svensk Elstandard**

Box 1284  
164 29 Kista  
Tel 08-444 14 00  
[www.elstandard.se](http://www.elstandard.se)

## CONTENTS

FOREWORD.....	7
1 Scope.....	9
2 Normative references .....	9
3 Terms and definitions .....	11
4 Construction requirements.....	16
4.1 General requirements .....	16
4.1.1 General .....	16
4.1.2 Voltage designation .....	16
4.1.3 Cable marking .....	16
4.1.4 Core identification.....	17
4.1.5 Halogen-free cables .....	17
4.2 Conductors .....	17
4.2.1 Material .....	17
4.2.2 Metal coating and separator .....	17
4.2.3 Class and form .....	18
4.2.4 Resistance .....	18
4.3 Insulation system .....	19
4.3.1 Material .....	19
4.3.2 Application.....	19
4.3.3 Insulation thickness .....	19
4.4 Screens .....	19
4.4.1 Conductor and insulation screens for high-voltage cables.....	19
4.4.2 Screens (shields) for low voltage cables .....	20
4.5 Cabling .....	20
4.5.1 Multi-core cables .....	20
4.5.2 Multi-unit cables .....	20
4.6 Inner coverings, fillers and binders .....	21
4.7 Inner sheath.....	21
4.7.1 Material .....	21
4.7.2 Application.....	21
4.7.3 Thickness of inner sheath.....	21
4.8 Metal braid armour.....	21
4.8.1 Material .....	21
4.8.2 Application.....	22
4.9 Outer sheath.....	22
4.9.1 Material .....	22
4.9.2 Application.....	22
4.9.3 Thickness of outer sheath.....	22
5 Test methods.....	23
5.1 Test conditions .....	23
5.1.1 Ambient temperature .....	23
5.1.2 Frequency, waveform and magnitude of power-frequency test voltages .....	23
5.2 Routine tests .....	23
5.2.1 General .....	23
5.2.2 Measurement of the electrical resistance of the conductors .....	23
5.2.3 Voltage test .....	24

5.2.4	Partial discharge test .....	25
6	Sample tests .....	26
6.1	General.....	26
6.2	Frequency of sample tests .....	26
6.3	Repetition of tests.....	26
6.4	Conductor examination .....	26
6.5	Measurement of thickness of insulation.....	27
6.5.1	General .....	27
6.5.2	Procedure.....	27
6.5.3	Requirements .....	27
6.6	Measurements of thickness of non-metallic sheaths.....	27
6.6.1	General .....	27
6.6.2	Procedure.....	27
6.6.3	Requirements .....	27
6.7	Measurement of external diameter .....	27
6.8	Hot-set test for insulations and sheaths .....	27
6.8.1	General procedure.....	27
6.8.2	Requirements .....	28
6.9	Insulation resistance test (volume resistivity determination).....	28
7	Type tests, electrical .....	29
7.1	General.....	29
7.2	Insulation resistance measurement.....	29
7.2.1	Measurement at ambient temperature.....	29
7.2.2	Measurement at maximum rated temperature .....	29
7.3	Increase in a.c. capacitance after immersion in water .....	30
7.3.1	General .....	30
7.3.2	Preparation of test specimens .....	30
7.3.3	Apparatus.....	30
7.3.4	Procedure.....	30
7.3.5	Requirements .....	30
7.4	High-voltage test for 4 h up to 1,8/3 kV .....	31
7.4.1	General .....	31
7.4.2	Requirement.....	31
7.5	Mutual capacitance (control and instrumentation cables only).....	31
7.6	Inductance to resistance ratio (control and instrumentation cables only) .....	31
7.7	High voltage sequence test (cables having a voltage rating higher than 3,6/6 (7,2) kV) .....	31
7.7.1	General .....	31
7.7.2	Special provisions .....	31
7.7.3	Partial discharge test.....	32
7.7.4	Bending test .....	32
7.7.5	Tan $\delta$ measurement as a function of the voltage .....	32
7.7.6	Tan $\delta$ measurement as a function of the temperature.....	32
7.7.7	Heating cycle test plus partial discharge test .....	33
7.7.8	Impulse withstand test, followed by a power-frequency voltage test .....	33
7.7.9	High-voltage test for 4h .....	33
8	Type tests, non-electrical.....	33
8.1	General.....	33
8.2	Measurement of thickness of insulation.....	33

8.3	Measurement of thickness of non-metallic sheaths (excluding inner coverings) .....	33
8.4	Tests for determining the mechanical properties of insulation before and after ageing .....	34
8.4.1	Sampling .....	34
8.4.2	Ageing treatments .....	34
8.4.3	Conditioning and mechanical tests.....	34
8.4.4	Requirements .....	34
8.5	Tests for determining the mechanical properties of sheaths before and after ageing .....	34
8.5.1	Sampling .....	34
8.5.2	Ageing treatments .....	34
8.5.3	Conditioning and mechanical tests.....	34
8.5.4	Requirements .....	34
8.6	Additional ageing test on pieces of completed cables (compatibility test) .....	34
8.6.1	General .....	34
8.6.2	Sampling .....	35
8.6.3	Ageing treatment .....	35
8.6.4	Mechanical tests.....	35
8.6.5	Requirements .....	35
8.7	Loss of mass test on PVC ST2 sheath .....	35
8.7.1	Procedure.....	35
8.7.2	Requirements .....	35
8.8	Test for the behaviour of PVC ST2 and halogen-free SHF 1 sheaths at high temperature (hot pressure test).....	35
8.8.1	Procedure.....	35
8.8.2	Requirements .....	35
8.9	Test for the behaviour of PVC sheath ST2 and halogen-free SHF 1 and SHF 2 sheaths at low temperature .....	35
8.9.1	Procedure.....	35
8.9.2	Requirements .....	36
8.10	Special test for low temperature behaviour (when required) .....	36
8.11	Test of the metal coating of copper wires .....	36
8.12	Galvanizing test .....	36
8.13	Test for resistance of PVC ST2 and halogen-free SHF1 sheaths to cracking (heat shock test).....	36
8.13.1	Procedure.....	36
8.13.2	Requirements .....	36
8.14	Ozone resistance test for insulation and for sheaths .....	36
8.14.1	Procedure.....	36
8.14.2	Requirements .....	36
8.15	Hot oil immersion test and enhanced hot oil immersion test for sheaths .....	36
8.15.1	Hot oil immersion test .....	36
8.15.2	Enhanced hot oil immersion test (when required).....	37
8.16	Mud drilling fluid test (when required) .....	37
8.17	Fire tests .....	37
8.17.1	Flame-spread test on single cables.....	37
8.17.2	Flame-spread test on bunched cables .....	37
8.17.3	Smoke emission test.....	37
8.17.4	Acid gas emission test.....	37

8.17.5	pH and conductivity test .....	37
8.17.6	Fluorine content test .....	37
8.17.7	Fire-resistance test (test for circuit integrity cables) .....	38
8.18	Determination of hardness for HEPR .....	38
8.19	Determination of elastic modulus for HEPR .....	38
8.20	Durability of print .....	38
Annex A (normative) Fictitious calculation method for determination of dimensions of protective coverings .....		39
A.1	Overview .....	39
A.2	General .....	39
A.3	Method .....	39
A.3.1	Conductors .....	39
A.3.2	Cores .....	40
A.3.3	Diameter over laid-up cores .....	41
A.3.4	Inner coverings .....	43
A.3.5	Sheath .....	43
A.3.6	Braid armour .....	43
Annex B (informative) Recommended minimum spark test voltage levels (according to IEC 62230) .....		45
B.1	General .....	45
B.2	Test voltages .....	45
B.2.1	General .....	45
B.2.2	Contact electrodes .....	45
B.2.3	Non-contact electrodes .....	46
Annex C (normative) Rounding of numbers .....		47
C.1	Rounding of numbers for the purpose of the fictitious calculation method .....	47
C.1.1	Rules .....	47
C.1.2	Illustrations .....	47
C.2	Rounding of numbers for other purposes .....	47
Annex D (normative) Calculation of the lower and upper limits for the outer dimensions of cables with circular copper conductors .....		49
D.1	General .....	49
D.2	Lower limit for the outer diameter .....	49
D.3	Upper limit for the outer diameter .....	49
D.4	Thickness of the mandatory or optional coverings other than the insulation and the sheath(s) .....	50
Annex E (normative) Cold bend test and impact test for low temperature behaviour .....		52
E.1	Cold bend test at any specified low temperature .....	52
E.1.1	Method No. 1 .....	52
E.1.2	Method No. 2 .....	52
E.1.3	Examination and Requirements .....	53
E.2	Impact test at any specified low temperature .....	53
E.2.1	Apparatus .....	53
E.2.2	Procedures .....	53
E.2.3	Requirements .....	53
Bibliography .....		54
Table 1 – Minimum size of conductors .....		18
Table 2 – Routine test voltage .....		25

Table 3 – Number of samples according to cable length .....	26
Table 4 – Tan $\delta$ versus voltage .....	32
Table 5 – Tan $\delta$ versus temperature.....	32
Table 6 – Impulse withstand voltages .....	33
Table 7 – Test methods and requirements for halogen-free components.....	38
Table A.1 – Fictitious diameter of conductor .....	40
Table A.2 – Increase of diameter for concentric conductors and metallic screens made of tape or wire.....	40
Table A.3 – Assembly coefficient $k$ for laid-up .....	42
Table A.4 – Coefficient $c_f$ .....	43
Table B.1 – Recommended minimum spark-test voltages for cables having rated voltage ( $U_0$ ) between 150 V and 1 800 V .....	45
Table D.1 – Lower and upper limits of circular copper conductors for cables for fixed installations .....	51
Table E.1 – Details of low temperature bending test .....	52

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL INSTALLATIONS IN SHIPS –****Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications**

## 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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60092-350 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 2008 and constitutes a technical revision.

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

- a) reference to IEC 60092-360 for both the insulating and sheathing compounds;
- b) partial discharge tests have been transferred from IEC 60092-354 to align it with IEC 60092-353;
- c) requirements for oil and drilling-fluid resistance (former Annexes F and G) have been transferred to IEC 60092-360;



- d) requirements for cold bending and shocks have been improved;
- e) the document reflects the changes of material types that have been introduced during the development of IEC 60092-353 and IEC 60092-360.

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

FDIS	Report on voting
18A/374/FDIS	18A/378/RVD

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

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

The 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 web site 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 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications**

#### **1 Scope**

This part of IEC 60092 provides the general constructional requirements and test methods for use in the manufacture of electric power, control and instrumentation cables with copper conductors intended for fixed electrical systems at voltages up to and including 18/30(36) kV on board ships and offshore (mobile and fixed) units.

The reference to fixed systems includes those that are subjected to vibration (due to the movement of the ship or installation) or movement (due to motion of the ship or installation) and not to those that are intended for frequent flexing. Cables suitable for frequent or continual flexing use are detailed in other IEC standards, for example IEC 60227 and IEC 60245, and their uses are restricted to those situations which do not directly involve exposure to a marine environment, for example, portable tools and domestic appliances.

The following types of cables are not included:

- optical fibre;
- sub-sea and umbilical cables;
- data and communication cables;
- coaxial cables.

#### **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 60050-461, *International Electrotechnical Vocabulary – Part 461: Electric cables*

IEC 60092-353, *Electrical installations in ships – Part 353: Power cables for rated voltages 1 kV and 3 kV*

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

IEC 60228, *Conductors of insulated cables*

IEC 60230, *Impulse tests on cables and their accessories*

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

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

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

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

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

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

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

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

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

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

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

IEC 60811-403, *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, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

IEC 60811-409, *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, *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 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Bending tests at low temperature for insulations and sheaths*

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

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-507, *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, *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 60811-509, *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 60885-2, *Electrical test methods for electric cables. Part 2: Partial discharge tests*

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

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

ISO 7989-2:2007, *Steel wire and wire products – Non-ferrous metallic coatings on steel wire – Part 2: Zinc or zinc-alloy coating*