



DPC: 24 / 30477371 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 10 May 2024

Origin: International

Latest date for receipt of comments: 3 July 2024

Project No. 2023/01605

Responsible committee: GEL/20/6 Electric Cables for Ships

Interested committees:

Title: BS EN IEC 60092-352 Electrical installations in ships

Part 352: Choice and installation of electrical cables

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

**WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 3 July 2024**

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Committee Secretary: **Mr Simon Bounds (BSI)**
Direct tel: **0208 996 7281**
E-mail: simon.bounds@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



PROJECT NUMBER:

IEC 60092-352 ED4

DATE OF CIRCULATION:

2024-05-10

CLOSING DATE FOR VOTING:

2024-08-02

SUPERSEDES DOCUMENTS:

18A/475/RR

IEC SC 18A : ELECTRIC CABLES FOR SHIPS AND MOBILE AND FIXED OFFSHORE UNITS

SECRETARIAT:

Italy

SECRETARY:

Mrs Alessandra Benelli

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

☐ SUBMITTED FOR CENELEC PARALLEL VOTING

☒ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any relevant "In Some Countries" clauses to be included should this proposal proceed. Recipients are reminded that the CDV stage is the final stage for submitting ISC clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

TITLE:

Electrical installations in ships - Part 352: Choice and installation of electrical cables

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

Copyright © 2024 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.



Documents

Document Sharing Hub

CONTENTS

1		
2	FOREWORD.....	5
3	INTRODUCTION.....	7
4	1 Scope.....	8
5	2 Normative references	8
6	3 Terms and definitions	10
7	4 Selection, installation and operating conditions of cables	11
8	4.1 Types of cables	11
9	4.2 Voltage rating	11
10	4.2.1 Power cables.....	11
11	4.2.2 Control and instrumentation cables.....	12
12	4.3 Current carrying capacities	12
13	4.3.1 Cross-sectional areas of conductors	12
14	4.3.2 Current carrying capacities	14
15	4.3.3 Current ratings for continuous service	14
16	4.3.4 Correction factors for different ambient air temperatures.	15
17	4.3.5 Correction factors for short time duty	16
18	4.3.6 Correction Factors for Cable Grouping.....	19
19	4.4 Voltage drop	19
20	4.5 Estimation of lighting loads	
21	4.6 Parallel connection of cables	20
22	4.7 Separation of circuits	20
23	4.8 Short circuit capacity (withstand capability).	20
24	4.9 Conductor	20
25	4.10 Insulation material	21
26	4.11 Screen, core screen or shield	21
27	4.12 Sheathing material.....	21
28	4.13 Metallic braid or armour.	21
29	4.14 Fire performance	21
30	4.15 Cable runs	22
31	4.16 Cable installation methods in relation to electromagnetic interference	23
32	4.17 Mechanical protection	24
33	4.17.1 General	24
34	4.17.2 Earthing of metal coverings and of mechanical protection of cables	25
35	4.18 Bending radius.....	25
36	4.19 Supports and fixing	26
37	4.20 Cables penetrating bulkheads and decks	27
38	4.21 Installation in metallic pipes or conduits or trunking	27
39	4.22 Installation in non-metallic pipes, conduits, trunking, ducts or capping and casing.....	28
40		
41	4.23 Installation in battery compartments.....	28
42	4.24 Installation in refrigeration spaces.....	28
43	4.25 Tensile stress	29
44	4.26 Special precautions for single core cables for AC wiring	29
45	4.27 Cable ends	30
46	4.28 Joints and tapplings (branch circuits)	31
47	4.29 Joint boxes	31
48		

49	Annex A (informative) Tabulated current carrying capacities – Defined installations.....	33
50	A.1 General.....	33
51	A.2 Reference methods of installation	33
52	A.3 Other methods of installation	34
53	A.4 Correction factors for cable grouping	34
54	A.4.1 General	34
55	A.4.2 Installation methods B and C	34
56	A.4.3 Installation methods E and F	35
57	Annex B (informative) Tabulated current carrying capacities – General installations	49
58	Annex C (normative) Fire stops.....	55
59	Annex D (informative) Method of preparation of a spliced connection	56
60	D.1 Procedure	56
61	Bibliography.....	57
62		
63	Figure 1 – Correction factors for half-hour and one hour service	17
64	Figure 2 – Time constant of cables	18
65	Figure 3 – Correction factor for intermittent service.....	19
66	Figure 4 – Acceptable method of installation AC cables	30
67	Figure 5 – Acceptable method of installation – DC cables.....	30
68	Figure 6 – Alternation of phases – unacceptable disposition	30
69		
70	Table 1 – Sizes of earth continuity conductor and equipment earthing connections.....	
71	Table 2 – Location of batteries.....	Error! Bookmark not defined.
72	Table 3 – Selection of cables for AC systems	12
73	Table 4 – Correction factor for various ambient air temperatures	15
74	Table 5 – Bending radius for cables rated up to 1,8/3 kV	26
75	Table 6 – Bending radius for cables rated at 3,6/6,0(7,2) kV and above	26
76	Table A.1 – Current carrying capacities in amperes – Copper conductor temperature:	
77	60 °C and reference ambient air temperature: 45 °C.....	36
78	Table A.2 – Current carrying capacities in amperes – Copper conductor temperature:	
79	70 °C and reference ambient air temperature: 45 °C	38
80	Table A.3 – Current carrying capacities in amperes – Copper conductors temperature:	
81	85 °C and reference ambient air temperature: 45 °C	40
82	Table A.4 – Current carrying capacities in amperes – Copper conductors temperature:	
83	90 °C and reference ambient air temperature: 45 °C	42
84	Table A.5 – Current carrying capacities in amperes – Copper conductors temperature:	
85	95 °C and Reference ambient air temperature: 45 °C.....	44
86	Table A.6 – Correction factors for groups of more than one circuit or of more than one	
87	multi-core cable to be used with current carrying capacities of Table A.1 to A.5	46
88	Table A.7 – Correction factors for group of more than one multi-core cable to be	
89	applied to reference ratings for multi-core cables in free air – Method of installation E	
90	in Table A.1 to Table A.5	47
91	Table A.8 – Correction factors for groups of more than one circuit of single-core cables	
92	to be applied to reference rating for one circuit of single-core cables in free air –	
93	Method of installation F in Table A.1 to Table A.5	48
94	Table B.1 – Maximum permissible service temperature of a conductor.....	49

95	Table B.2 – Current carrying capacities in continuous service at maximum rated	
96	conductor temperature of 60 °C	50
97	Table B.3 – Current carrying capacities in continuous service at maximum rated	
98	conductor temperature of 70 °C	51
99	Table B.4 – Current carrying capacities in continuous service at maximum rated	
100	conductor temperature of 85 °C	52
101	Table B.5 – Current carrying capacities in continuous service at maximum rated	
102	conductor temperature of 90 °C	53
103	Table B.6 – Current carrying capacities in continuous service at maximum rated	
104	conductor temperature of 95 °C	54
105		

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 352: Selection, installation and operating conditions of 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.
- 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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60092-352 has been prepared by IEC subcommittee 18A: Cables and cable installations, of IEC technical committee TC 18: Electrical installations of ships and of mobile and fixed offshore units.

This fourth edition cancels and replaces the third edition published in 2005. This edition constitutes a technical revision.

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

- a) Complete review of the document and establishment of the match with all other standards from the group IEC 60092-350 till IEC 60092-276
- b) Terms and definitions are completed
- c) Inclusion of the technical requirements for the installation of fibre optic cables

- d) b) Inclusion of the technical requirements for the installation of Symmetrical Category cables with transmission characteristics up to 1 000 MHz

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

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

181

INTRODUCTION

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

185 These standards form:

- 186 – a code of practical interpretation and amplification of the requirements of the International
187 Convention on Safety of Life at Sea;
- 188 – a guide for future regulations which may be prepared and
- 189 – a statement of practice for use by owners and builders of ships and fixed or mobile and
190 offshore units and other appropriate organisations.

191 This revision of IEC 60092-352 has been prepared by Maintenance Team 2 of IEC SC 18A, to
192 update and include developments identified in other parts of the 60092 series of standards
193 applicable to electric cables for electrical installations in ships.

194 NOTE Guidance for the use and installation of cables for offshore applications is being prepared jointly by SC18A, MT 2 and
195 TC 18, MT 18, and will be issued by TC 18, MT 18.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 352: Selection, installation and operating conditions of cables

1 Scope

This part of IEC 60092 provides the basic requirements for the selection and installation of electrical cables intended for fixed electrical systems on board ships at voltages (U) up to and including U_m 36 kV and also fibre optic cables..

The reference to fixed systems includes those that are subjected to vibration (due to the movement of the ship) or movement (due to motion of the ship) and not to those that are intended for frequent flexing.

Cables subject to frequent or continual flexing use shall be able to withstand the mechanical stress and the environment they are exposed to and are detailed in other IEC specifications e.g. IEC 60227 and IEC 60245. Flexible cables are frequently used for retractable thrusters, elevators, moving decks, cranes, shore connections and other moving applications on board ships.

The following types and applications of cables are not included:

- ~~optical fibre cables~~;
- sub-sea and umbilical cables;
- ~~data~~, telecommunication and radio frequency cables;
- the choice and installation of cables for use on offshore platforms;

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 60079 series Explosive atmospheres

IEC 60092-101: Electrical installations in ships - Part 101: Definitions and general requirements

IEC 60092-201: Electrical installations in ships – Part 201: System design – General

IEC 60092-203: Electrical installations in ships – Part 203: System design – Acoustic and optical signals IEC 61439-1 (2011-08), IEC 61439-2 (2011-08)

IEC 60092-350:2001, Electrical installations in ships – Part 350: Shipboard power cables – General construction and test requirements

IEC 60092-353:1995, Electrical installations in ships – Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1 kV and 3 kV

IEC 60092-354, Electrical installations in ships – 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)

- 235 IEC 60092-360: Requirements for electrical, mechanical and particular characteristics of
236 insulating and sheathing materials
- 237 IEC 60092-376, Electrical installations in ships – Part 376: Cables for control and
238 instrumentation circuits 150/250 V (300 V)
- 239 IEC 60092-378: Electrical installations in ships - Part 378: Optical fiber cables
- 240 IEC 60092-379: Electrical installations in ships - Part 379: Symmetrical Category cables with
241 transmission characteristics up to 1 000 MHz
- 242 IEC 60228: Conductors of insulated cables
- 243 IEC 60287 (all parts), Electric cables – Calculation of the current rating
- 244 IEC 60331-21:1999, Tests for electric cables under fire conditions – Circuit integrity – Part 21:
245 Procedures and requirements – Cables of rated voltage up to and including 0,6/1 kV
- 246 IEC 60331-31:2002, Tests for electric cables under fire conditions – Circuit integrity – Part 31:
247 Procedures and requirements for fire with shock – Cables of rated voltage up to and including
248 0,6/1 kV
- 249 IEC 60332-1-2:2004, Tests on electric and optical fibre cables under fire conditions – Part 1-2:
250 Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW
251 pre-mixed flame
- 252 IEC 60332-3-22:2000, Tests on electric cables under fire conditions – Part 3-22: Test for vertical
253 flame spread of vertically-mounted bunched wires or cables – Category A
- 254 IEC 60092-503: Electrical installations in ships – Part 503: Special features – AC supply
255 systems with voltages in the range of above 1 kV up to and including 36 kV
- 256 IEC 60533 Electrical and electronic installations in ships - Electromagnetic compatibility (EMC)
- 257 IEC 60364-1: Low-voltage electrical installations - Part 1: Fundamental principles, assessment
258 of general characteristics, definitions
- 259 IEC 60364-4-41: Low-voltage electrical installations - Protection for safety - Protection against
260 electric shock
- 261 IEC 60092-509 Electrical installations in ships - Part 509: Operation of electrical installations
- 262 IEC 60684-2:2003, Flexible insulating sleeving – Part 2: Methods of test Amendment 1 (2003)
- 263 IEC 60754-1: Test on gases evolved during combustion of materials from cables –
264 Determination of the amount of halogen acid gas.
- 265 IEC 60754-2: Test on gases evolved during combustion of electric cables – Determination of
266 degree of acidity of gases evolved during the combustion of materials taken from electric cables
267 by measuring pH and conductivity
- 268 IEC 61034-2:2005 Measurement of smoke density of cables burning under defined conditions
269 – Test procedure and requirements.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60092-101 and the following 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

Braid

covering formed from braided metallic or non-metallic material.

[SOURCE: IEC 60092-350, 3.2]

3.2

braid armour

Covering formed from braided metal wires used to protect a cable from external mechanical effects

[SOURCE: IEC 60092-350:2020, 3.3, modified – The notes to entry have been deleted]

3.3

armour

covering consisting of metal tape(s) or wires, generally used to protect the cable from external mechanical effects

[SOURCE: IEC 461-05-06]

3.4

screen

conducting layer or assembly of conducting layers having the function either of control of the electric field within the insulation or to reduce the coupling of an electric, magnetic or electromagnetic field with the internal wires and to conduct common mode currents. NOTE It may also provide smooth surfaces at the boundaries of the insulation and assist in the elimination of spaces at these boundaries

[SOURCE: IEC 461-03-01]

3.5

earthing conductor

grounding conductor, US)

Conductor forming a conductive path between a conductive part and an earth electrode.

EXAMPLE A: conductor connected between a main earthing terminal or busbar and an earth electrode.

[SOURCE: IEC 195-02-03]

3.6

extra low voltage

ELV

voltage not exceeding the maximum value of the prospective touch voltage that is acceptable to be maintained indefinitely under specified conditions of external influences

[SOURCE: IEC 195-05-24]

4 Selection, installation and operating conditions of cables

4.1 Types of cables

Cables constructed in accordance with IEC 60092-350, IEC 60092-353, IEC 60092-354, IEC 60092-376, IEC 60092-378 and IEC 60092-379 are to be used on board ships.

NOTE The use of other types of cables may be agreed.

4.2 Voltage rating

4.2.1 Power cables

In the voltage designation of cables $U_0 / U / (U_m)$:

U_0 is the rated voltage between conductor and earth or metallic screen for which the cable is designed;

U is the rated voltage between conductors for which the cable is designed;

U_m is the maximum value of the highest system voltage which may be sustained under normal operating conditions at any time and at any point in the system. It excludes transient voltage conditions and rapid disconnection of loads.

U_m is chosen to be equal to or greater than the highest voltage of the three-phase system. Where cables are permitted for use on circuits where the nominal system voltage exceeds the rated voltage of the cables, the nominal system voltage shall not exceed the maximum system voltage (U_m) of the cable.

Careful consideration shall be given to cables subjected to voltage surges associated with highly inductive circuits to ensure that they are of a suitable voltage rating.

The choice of standard cables of appropriate voltage designations for particular systems depends upon the system voltage and the system earthing arrangements

The rated voltage of any cable shall not be lower than the nominal voltage of the circuit for which it is used. To facilitate the choice of the cable, the values of U recommended for cables to be used in three-phase systems are listed in Table 1, in which systems are divided into the following three categories:

- **Category A**

This category comprises those systems in which any phase conductor that comes in contact with earth or an earth conductor is automatically disconnected from the system.

- **Category B**

This category comprises those systems that under fault conditions are operated for a short time, not exceeding 8 h on any single occasion, with one phase earthed. For example, for a 13,8 kV system of Category A or B, the cable should have a rated voltage not less than 8,7/15 kV.

NOTE In a system where an earth fault is not automatically and promptly eliminated, the increased stresses on the insulation of cables during the earth fault are likely to affect the life of the cables to a certain degree. If the system is expected to be operated fairly often with a sustained earth fault, it may be preferable to use cables suitable for Category C. In any case, for classification as Category B the expected total duration of earth faults in any year is not permitted to exceed 125 h.

- **Category C**

This category comprises all systems that do not fall into Categories A and B.

The nominal system voltages from 1,8/3 kV to 12/20 kV shown in Table 1 are generally in accordance with Series I in IEC 60038. For nominal system voltages intermediate between these standard voltages and also between 0,6/1 kV and 1,8/3 kV, the cables should be selected with a rated voltage not less than the next higher standard value.

For example: A first earth fault with one phase earthed causes a $\sqrt{3}$ higher voltage between the phases and earth during the fault. If the duration of this earth fault exceeds the times given for Category B, then according to Table 1, for a 6 kV system, the cable is to have a rated voltage not less than 6/10 kV.

A DC voltage to earth of up to a maximum of 1,5 times the AC U_0 RMS voltage may be used. However, consideration should be given to the peak value when determining the voltage of DC systems derived from rectifiers, bearing in mind that smoothing does not modify the peak value when the semiconductors are operating on an open circuit.

Table 1 – Selection of cables for AC systems

System voltage		System category	Minimum rated voltage of cable U_0/U	
Nominal voltage U kV	Maximum sustained voltage U_m kV		Unscreened kV	Single-core or screened kV
up to 0,25	0,30	A, B or C	0,15 / 0,25	–
1	1,2	A, B or C	0,6 / 1,0	0,6 / 1,0
3	3,6	A or B	1,8 / 3,0	1,8 / 3,0
3	3,6	C		3,6 / 6,0
6	7,2	A or B		3,6 / 6,0
6	7,2	C		6,0 / 10
10	12	A or B		6,0 / 10
10	12	C		8,7 / 15
15	17,5	A or B		8,7 / 15
15	17,5	C		12 / 20
20	24	A or B		12 / 20
20	24	C		18 / 30
30	36	A or B		18 / 30

4.2.2 Control and instrumentation cables

The maximum rated voltage (U) for control and instrumentation cables considered in this standard is 250 V.

In some instances, for conductor sizes 1,0 mm² and larger, or when circuits are to be supplied from a low impedance source, 0,6/1 kV rated cables are specified for use as control or instrumentation cables.

4.3 Current carrying capacities

4.3.1 Cross-sectional areas of conductors

The cross-sectional area of each conductor shall be selected to be large enough to comply with the following conditions.

- The highest load to be carried by the cable shall be calculated from the load demands and diversity factors.
- The “corrected current rating” calculated by applying the appropriate correction factors to the “current rating for continuous services” shall not be lower than the highest current likely

to be carried by the cable. The applicable correction factors are given in 4.3.4, 4.3.5 and 4.3.6.

- The voltage drop in the circuit shall not exceed the limits specified by the regulatory body for the circuits concerned – further guidance is given in 4.4.
- The cross-sectional area of the conductor shall be able to accommodate the mechanical and thermal effects of a short circuit current (see 4.8) and the effects upon voltage drop of motor starting currents (see NOTE 3 of 4.4).
- Class 5 conductors, where used, shall be subject to special consideration in respect of maximum current-carrying capacity. Class 5 conductors have, in most cases, a lower conductivity than the equivalent Class 2 conductors of the same nominal cross-section.
- The nominal cross-sections of the earth conductor shall comply with Table . One of the alternative methods of determining the cross sectional area of each earthing conductor is that based upon the rating of the fuse or circuit protection device installed to protect the circuit. If this method is used, the nominal cross sectional area finally selected shall be the higher of any cross sectional areas determined by each of the methods.

Table 2 – Sizes of earth conductor and equipment earthing connections

Arrangement of earth conductor		Cross-section Q of associated current carrying conductor (One phase or pole) mm^2	Minimum cross-section of earth conductor
1.	a) Insulated earth conductor in cable for fixed installation.	$Q \leq 16$	Q
	a) Copper braid of cable for fixed installation according to IEC 60092-350.	$Q > 16$	50 % of the current-carrying conductor, but not less than 16 mm^2
	b) Separate, insulated earth conductor for fixed installation in pipes in dry accommodation spaces, when carried in the same pipe as the supply cable.		
	c) Separate, insulated earth conductor when installed inside enclosures or behind covers or panels, including earth conductor for hinged doors as specified in IEC 60092-302-2.		
2.	Uninsulated earth conductor in cable for fixed installation, armour or copper braid and in metal-to-metal contact with this.	$Q \leq 2,5$	1 mm^2
		$2,5 < Q \leq 6$	$1,5 \text{ mm}^2$
		$Q > 6$	Not permitted
3.	Separately installed earth conductor for fixed installation other than specified in 1 iii) and 1 iv).	$Q < 2,5$	Same as current-carrying conductor subject to min. $1,5 \text{ mm}^2$ for stranded earthing connection or $2,5 \text{ mm}^2$ for unstranded earthing connection
		$2,5 < Q \leq 120$	50 % of current-carrying conductor, but not less than 4 mm^2
		$Q > 120$	70 mm^2
4.	Insulated earth conductor in flexible cable.	$Q \leq 16$	Same as current-carrying conductor
		$Q > 16$	50 % of current-carrying conductor, but minimum 16 mm^2
NOTE See 4.3.1 for a method based on the rating of fuses.			

4.3.2 Current carrying capacities

The procedure for cable selection employs rating factors to adjust the current carrying capacities for different ambient temperatures, for the mutual heating effects of grouping with other cables, methods of installation and short time duty. Guidance on the use of these factors is given below.

4.3.3 Current ratings for continuous service

Continuous service for a cable is to be considered, for the purpose of this standard, as a current-carrying service with constant load and having a duration longer than three times the thermal time constant of the cable, i.e. longer than the critical duration (see Figure 2).

The current to be carried by any conductor for sustained periods during normal operation shall be such that the appropriate conductor temperature limit is not exceeded.

The selection of the method applicable to any particular installation is the responsibility of the appropriate approval authority or governing regulation.

The current carrying capacity shall be calculated according to Annex A, Annex B or alternative methods as described below.

Annex A is more accurate than Annex B and should be used when there is enhanced risk of overheating. For example, when bunched cables are used under full continuous load simultaneously.

Annex B is the easiest method to use but is also less accurate than Annex A.

If distances between cable bunches are less than one cable Outer Diameter (OD), the bunches shall be considered as one bunch.

a) Annex A

A method for determination of current carrying capacities based upon those that have been accepted and established in other applications of cable use. This method has been derived from a technical basis established from experimental data on a number of cables and installation information. It allows for greater choice of use in different installation configurations. For further reference see IEC 60364-5-52.

The current carrying capacity is determined by the following formula:

$$I = A \times S^m - B \times S^n$$

where

I is the current carrying capacity (A);

S is the nominal cross-sectional area of conductor (mm²);

A and B are coefficients, m and n are exponents according to cable type and method of installation.

Values calculated using the above for various installations are given in Annex A together with guidance on selection.

or;

b) Annex B

A simplified method for the determination of current carrying capacities

NOTE The values were initially established in 1958 based on limited experimental data and have been both amended and their range extended in attempts to reflect the changes in construction of cables and their maximum conductor operating temperatures which have taken place.

The method was initially only intended for a limited number of installations under certain conditions used for refurbishment of ships.

The formula on which they are based is:

$$I = \alpha A^{0,625}$$

where

I is the current carrying capacity (A);

A is the nominal cross-sectional area of conductor (mm²);

α is a coefficient related to the maximum permissible service temperature of the conductor.

Values calculated using the above – given in Annex B – are only applicable when used in accordance with the basis as given.

or;

c) Alternative methods

- According to IEC 60287, or
- Calculation using a recognised method, which is documented, and where appropriate, account shall be taken of the characteristics of the load.

4.3.4 Correction factors for different ambient air temperatures.

The current-carrying capacity in Annex A and Annex B assume a reference ambient air temperature of 45 °C. This temperature is generally applicable to insulated conductors and cables in any kind of ship and for navigation in any climate, irrespective of the method of installation.

Where the ambient temperature in the intended location of the insulated conductors or cables differs from the reference ambient temperature, the appropriate correction factor specified in Table shall be applied to the values of current-carrying capacity in Annex A and Annex B.

NOTE The air temperature around the cables can be higher than 45 °C when, for instance, a cable is wholly or partly installed in spaces or compartments where heat is produced or due to heat transfer.

The correction factors in Table do not take account of the increase in temperature, if any, due to solar or other infrared radiation. Where the cables or insulated conductors are subject to such radiation, the current-carrying capacity shall be derived by the methods specified in IEC 60287.

Table 3 – Correction factor for various ambient air temperatures

Maximum rated conductor temperature °C	Correction factors for ambient air temperature of										
	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C	65 °C	70 °C	75 °C	80 °C	85 °C
60	1,29	1,15	1,00	0,82	-	-	-	-	-	-	-
65	1,22	1,12	1,00	0,87	0,71	-	-	-	-	-	-
70	1,18	1,10	1,00	0,89	0,77	0,63	-	-	-	-	-
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	-	-	-	-
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53	-	-	-
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	-	-
90	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	-
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

4.3.5 Correction factors for short time duty

If a cable is intended to supply a single motor or equipment operating for periods of 30 minutes or 60 minutes, its current rating, as given in the relevant table (see Annex A and Annex B), may be increased using the relevant correction factors obtained from Figure 11. These correction factors are only applicable if the intermediate periods of rests are longer than the critical duration (which is equal to three times the time constant of the cable), obtained from Figure 2, as a function of the cable diameter.

NOTE 1 The correction factors given in Figure 11 are approximate and depend mainly upon the diameter of the cable. In general, the 30 minutes service is applicable to mooring winches, windlasses, heavy cargo winches and bowthrusters. The 30minutes rating might not be adequate for automatic tensioning mooring winches and bowthrusters of specialised vessels.

NOTE 2 For cables supplying a single motor or other equipment intended to operate in an intermittent service, as is generally the case for cargo winches (except heavy cargo winches), engine room cranes and similar devices, the current ratings as given in Annex A and Annex B may be increased by applying the correction factor obtained from Figure 3.

NOTE 3 The correction factor given in Figure 3 has been calculated for periods of 10 min, of which 4 min are with a constant load and 6 min without load.