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colour inside

Electrical installations in ships –
Part 202: System design – Protection

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Part 202: System design – Protection

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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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. 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 60092-202 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This fifth edition cancels and replaces the fourth edition published in 1994 and Amendment 1:1996. This edition constitutes a technical revision.

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

This document: **Clause/subclause No. and heading**	**Previous document:** **Corresponding clause/subclause No., remark**
1 Scope	1, No change
2 Normative references	2, Updated
3 Definitions	3, Several definitions changed and added
4 General requirements	4, Text changed
4.1 General	New clause/subclause
4.2 Basic protection	New clause/subclause
4.3 Studies and calculations	New clause/subclause
5 Electrical load study	New clause/subclause
6 Short-circuit current calculations	5, Heading change
-	5.1, Text changed and moved to new Clause 6
-	5.2, Text deleted, for DC-Systems reference to IEC 61660-1 added
7 Protection discrimination study	New clause/subclause
7.1 General	New clause/subclause
7.2 Current selectivity	New clause/subclause
7.3 Time-current selectivity	New clause/subclause
8 Characteristics and choice of protective devices with reference to short-circuit rating	6, Text completely revised and extended
8.1 General	6.1
8.2 Protective devices	New clause/subclause
8.3 Rated short-circuit breaking capacity	6.2
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The text of this standard is based on the following documents:

FDIS	Report on voting
18/1538/FDIS	18/1542/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.

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

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- withdrawn,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

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

The IEC 60092 series~~: Electrical installations in ships~~ includes international standards for electrical installations in sea-going ships, 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~~ for the safety of life at sea, a guide for future regulations which may be prepared and a statement of practice for use by ship owners, ship builders and appropriate organizations.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 202: System design – Protection

1 Scope

This part of IEC 60092 is applicable to the main features of the electrical protective system to be applied to electrical installations for use in ships.

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 92-301:1980, *Electrical installations in ships - Part 301: Equipment - Generators and motors*~~

~~IEC 363:1972, *Short-circuit current evaluation with special regard to rated short-circuit capacity of circuit-breakers in installations in ships*~~

IEC 60909 (all parts), *Short-circuit currents in three-phase a.c. systems*

IEC 60909-0, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

IEC TR 60909-1, *Short-circuit currents in three-phase a.c. systems – Part 1: Factors for the calculation of short-circuit currents according to IEC 60909-0*

IEC 60947-2:~~1989~~ 2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2006/AMD1:2009
IEC 60947-2:2006/AMD2:2013

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61363-1, *Electrical installations of ships and mobile and fixed offshore units – Part 1: Procedures for calculating short-circuit currents in three-phase a.c.*

IEC 61660-1, *Short-circuit currents in d.c. auxiliary installations in power plants and substations – Part 1: Calculation of short-circuit currents*

IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply~~1)~~.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/

~~1) The International Electrotechnical Vocabulary (IEV) definitions for these four terms are not applicable to this standard.~~

- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
rated load
the highest value of load specified for rated conditions

3.2
overload
~~Excess of the actual load over the nominal load.~~
operating conditions in an electrically undamaged circuit, which cause an overload above the rated load

[SOURCE: IEC 60050-441:1984, 441-11-08, modified — The words "which cause an over-current" has been replaced with "which cause an overload above the rated load".]

~~**3.3**~~
~~**nominal load, full load**~~
~~Power for which a machine has been designed.~~

3.3
over-current
~~Abnormal current greater than the full load~~
current exceeding the rated current

[SOURCE IEC 60050-441:1984, 441-11-06]

3.4
short-circuit
~~Intentional or accidental connection of two points of a circuit through a negligible impedance. The term is often applied to the group of phenomena which accompany a short circuit between points at different potentials.~~
accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal to or close to zero

[SOURCE IEC 60050-195:1998, 195-04-11]

3.5
backup protection
protection equipment or system which is intended to operate when a system fault is not cleared in due time because of:

– failure or inability of a protective device closest to the fault to operate or

– failure of a protective device other than the protective device closest to the fault to operate

Note 1 to entry: This definition differs from the one given in IEC 60050-448:1995, 448-11-14.

3.6
over-current discrimination
selectivity
co-ordination of the operating characteristics of two or more over-current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the other(s) does (do) not

Note 1 to entry: Distinction is made between series discrimination, involving different over-current protective devices passing substantially the same over-current, and network discrimination involving identical protective devices passing different proportions of the over-current.

[SOURCE 60050-441:1984, 441-17-15, modified — The term "selectivity" has been added as an equivalent term.]

3.7
total discrimination
total selectivity
selectivity (over-current discrimination) where, in the presence of two over-current protective devices in series, the protective device on the load side effects the protection without causing the other protective device to operate

[SOURCE IEC 60947-2:2006/AMD2:2013, 2.17.2, modified — The term "total discrimination" has been added as an equivalent term and the term "over-current discrimination" has been replaced by "selectivity (over-current discrimination)" in the definition.]

3.8
partial discrimination
partial selectivity
selectivity (over-current discrimination) where, in the presence of two or more over-current protective devices in series, the protective device closest to the fault at the load side effects the protection up to a given level of short-circuit current without causing the other protective devices to operate

[SOURCE IEC 60947-2:2006/AMD2:2013, 2.17.3, modified —The term "partial discrimination" has been added as an equivalent term and the definition has been rephrased..]

3.9
continuity of service
condition where, after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established

3.10
continuity of supply

condition where during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured

Note 1 to entry: This definition is different from that given in IEC 60050-614:2016, 614-01-22.

3.11
basic protection
minimum required protection for equipment

3.12
electrical load study
study reflecting the different operational modes and their respective load requirements

Note 1 to entry: Typical examples of operational modes are harbour, manoeuvre, seagoing mode.

4 General requirements

4.1 General

Electrical installations shall be protected against accidental over-currents, up to and including short-circuit, by appropriate devices. Choice, arrangement and performance of the various protective devices shall provide complete and co-ordinated automatic protection in order to ~~ensure as far as possible~~ obtain

– elimination of the effects of faults to reduce damage to the system and the hazard of fire ~~as much as possible~~, and
– continuity of ~~service through discrimination or another system of co-ordinated action of the protective devices to maintain supply to healthy circuits in the event of a fault elsewhere~~ supply.

Under these conditions, the elements of the healthy system shall be designed and constructed to withstand the thermal and electrodynamic stresses caused by the possible over-current, including short-circuit, for the admissible durations.

4.2 Basic protection

Devices provided for ~~overcurrent~~ basic protection shall be ~~chosen according to the requirements~~ suitable for the equipment they are protecting, especially with regard to

~~– overload;~~
– over-current,
– short-circuit, and

– earth fault, as appropriate.

The complexity of the protections is driven by a number of factors such as improved system performance, reliability, and reduction of the damage to the equipment for economical reason. Additional protection features shall not interfere with the basic protection requirements of this standard.

Electrical installation shall be provided with protections against electric shock in accordance with IEC 61140.

4.3 Studies and calculations

Studies and calculations shall demonstrate the proper coordination of power ratings, load requirements, system dynamics and protection.

In order to confirm the design of the electrical system and to confirm the ratings of the equipment selected, system studies shall be carried out. The system studies and calculation shall include

– an electrical load study (see Clause 5),
– short-circuit current calculations (see Clause 6), and
– a protection discrimination study (see Clause 7).

5 Electrical load study

An electrical load list shall be prepared to establish the electrical power requirements throughout the installation.

Based on analysis, load shedding shall be applied when required in order to avoid a blackout. Load shedding can be implemented by shedding of individual/groups of consumers or by appropriate separation of switchboard busbars.

Care should be taken to ensure that the response time is sufficient to enable the load shedding system to perform its function and maintain a stable electrical system.

Load estimates should be carried out for all operational conditions, for example

– navigation at sea,
– estuary trading and navigation close to port, and
– emergency power supply.

6 Short-circuit current calculations

~~An example of the short-circuit calculation in both a.c. and d.c. systems is given in IEC 363.~~

~~5.1 *Short-circuit current in a.c. systems*~~

~~5.1.1 For the evaluation of the prospective short-circuit current, the equivalent system impedance shall be considered seen from the point of fault.~~

~~5.1.2 The source of current shall include the maximum number of generators which can be simultaneously connected, and the maximum number of motors which are normally simultaneously connected in the system. The contribution of generators and motors shall be calculated on the basis of their characteristics.~~

The fault currents that flow as a result of short-circuits shall be calculated at each system voltage under three-phase fault conditions. These calculated currents shall be used to select suitably rated equipment and to allow the selection and setting of protective devices to ensure that successful discriminatory fault clearance is achieved.

The fault current shall be calculated for maximum and minimum system supply. The contribution of induction motors should be included in the study.

For general information regarding short-circuit calculations, reference shall be made to IEC 61363-1, IEC 60909-0 and IEC TR 60909-1 for AC systems, and IEC 61660-1 for DC systems.

IEC 60909 (all parts) is written for installations in which the short-circuit behaviour is predominantly ruled by passive elements (e.g. transformers, cables). It shall therefore only be applied for small transformer-fed low voltage installations. In all other cases, IEC 61363-1, which takes generator short-circuit behaviour into account, shall be applied.

~~NOTE~~ Where precise information of their characteristics is lacking, the contribution of induction motors for determining the maximum peak value attainable by the short-circuit current (i.e. the value of the current to be added to the maximum peak value of the short-circuit due to the generators) can be taken as equal to 8 I_n where I_n is the sum of the rated currents of the motors estimated normally when simultaneously in service (I_n is an ~~r.m.s.~~ RMS value).

For more precise calculation, the following ~~r.m.s.~~ RMS values may be used:

– at the instant of short-circuit occurrence (sub-transient value): 6,25 I_n

– at the instant T, i.e. after one cycle from short-circuit inception: 2,5 I_n

– at the instant $2T$, i.e. after two cycles from short-circuit inception: 1,0 I_n

~~5.2 Short-circuit current in d.c. systems~~

~~5.2.1 The prospective short-circuit current at a definite point of the system shall be evaluated by considering the equivalent system resistance seen from the point of fault.~~

~~5.2.2 The source of a short-circuit current shall include the maximum number of generators which can be simultaneously connected, and the maximum number of motors which are normally simultaneously connected in the system. The contribution of each rotating machine shall be evaluated as a function of its characteristics.~~

~~In the absence of precise information, the contribution of motors in the determination of the maximum value reached by the short-circuit current can be taken as equal to six times the sum of the rated currents of the motors estimated to be normally in se rvice simultaneously.~~

7 Protection discrimination study

7.1 General

A coordination study shall be carried out to determine the setting of the protective relays and direct acting circuit-breakers (see Clause 4).

In general, the two protection schemes described in 7.2 and 7.3 are possible.

7.2 Current selectivity

This type of selectivity is based on the observation that the closer the fault point is to the power supply of the installation, the higher the short-circuit current is. It is therefore possible to discriminate the zone the fault occurred in by setting the instantaneous protections to different current values.

The coordination of protection devices shall consider tolerances and accuracies.

Because of the large variation in short currents due to different operational conditions, current selectivity shall be used with caution and may not be achievable in all instances.

7.3 Time-current selectivity

Time-current selectivity makes trip selectivity by adjusting the protections so that the load-side protection, for all possible over-current values, trips more rapidly than the supply-side circuit-breaker. When the trip times of the two circuit-breakers are analysed, it is necessary to consider

– the tolerances over the thresholds and trip times, and

– the real currents circulating in the circuit-breakers.

7.4 Alternative protection schemes

Alternative protection schemes are permissible provided that the same level of protection is achieved.

8 Characteristics and choice of protective devices with reference to short-circuit rating

8.1 General

Protection against short-circuit shall be provided by circuit-breakers or fuses. For AC systems with a voltage higher than 1 kV, special consideration of fuses shall be made regarding their characteristics.

The use of a protective device not having a short-circuit breaking or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is allowed, provided that it is backed-up by a fuse or by a circuit-breaker on the generator side, having at least the necessary short-circuit rating and not being the generator circuit-breaker. The same fuse or circuit-breaker may back up more than one circuit-breaker when essential services are not involved.

A separate current limiter to increase the short-circuit breaking capacity of a circuit-breaker may be used according to the manufacturer's instructions. The same current limiter can back up more than one circuit-breaker. The connection between current limiter and circuit-breaker(s) shall be made in such a way as to minimize the risk of short-circuit.

For low voltage systems, the short-circuit performance of the arrangement shall at least be equal to the requirements of IEC 60947-2.

NOTE For low voltage switchgear, further information can be found in IEC 60947-2:2006/AMD2:2013, Annex A.

For high voltage systems, the short-circuit performance of the arrangement shall at least be equal to the requirements of IEC 62271-100.

8.2 Protective devices

~~6.1.1~~ Protective devices for short-circuit protection shall conform to the requirements of the IEC standards concerning circuit-breakers and fuses, but it shall be taken into account that the conditions of the ship's installations may differ from the conditions foreseen in those publications, in particular with reference to the following.

– The short-circuit power factor in an ~~a.c.~~ AC system~~s~~ in a ship~~s~~, which may be lower than that assumed as a basis for short-circuit rating of normal distribution circuit-breakers. Where no data are available, a short-circuit power factor of 0,2 shall be assumed.

– The sub-transient and transient component of the ~~a.c.~~ AC short-circuit current.

– The AC and DC decrement of short-circuit current.

As a consequence, the ratio between rated breaking capacity and the correlated making capacity of circuit-breakers corresponding to the normal conditions of distribution systems ~~(see IEC 947-2),~~ may be ~~substantially~~ inadequate.

In such cases, the circuit-breakers shall be chosen with regard to their short-circuit making capacity, even though their available short-circuit breaking capacity, which complies with normal conditions, may be in excess of the one required for the actual application.

~~P2 category circuit-breakers shall be used for generator circuits and preferably for other circuits.~~

~~P1 category circuit-breakers may be used where the system arrangements are such, for example by duplication and separation of supplies, that failure of the circuit-breakers will not jeopardize the safety of the vessel.~~

~~6.1.2 Protection against short circuit shall be provided by circuit-breakers or fuses~~

~~In some cases, and particularly for high-voltage a.c. systems, it shall be noted that certain types of fuses have such characteristics for ce rtain overcurrents that they shall be arranged to cause an associated switch to trip for these overcurrents.~~

~~6.1.3 The use of a circuit-breaker not having a short-circuit breaking and/or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is allowed, provided that it is backed up by a fuse or by a circuit-breaker on the generator side, having at least the necessary short-circuit rating and not being the generator circuit-breaker.~~

~~The same fuse or circuit-breaker may back up more than one circuit-breaker when essential services are not involved.~~

~~The short-circuit performance of the arrangement shall at least be equal to the requirements of IEC 947-2 for a single circuit-breaker having the same short-circuit performance category as the backed-up circuit-breaker and rated for the maximum prospective short-circuit level at the supply terminals of the arrangement.~~

~~Circuit-breakers with fuses connected to the load side may be used, provided the back-up fuses and the circuit-breakers are of co-ordinated design, in order to ensure that the operation of the fuses takes place in due time so as to prevent arcing between poles or against metal parts of the circuit-breakers when they are submitted to overcurrents involving the operation of the fuse.~~

~~When determining the performance requirements for the above-mentioned back-up protection arrangement, it is permitted to take into account the impedance of the various circuit elements of the arrangement, such as the impedance of a cable connection when the backed-up circuit-breaker is located away from the back-up breaker or fuse.~~

When current selectivity according to 7.2 is chosen, circuit-breakers with utilisation category A according to IEC 60947-2:2006 are acceptable.

When time current selectivity according to 7.3 is chosen, circuit-breakers shall be selected according to their rated short-time withstand current capacity I_{CW}.

Utilisation category B according to IEC 60947-2:2006 shall be used for all low voltage circuit-breakers with delayed tripping during short-circuit conditions.

High voltage circuit-breakers shall comply with IEC 62271-100.

8.3 Rated short-circuit breaking capacity

The rated short-circuit breaking capacity of every device intended for short-circuit protection shall be not less than the maximum prospective current to be broken at that point in the installation, unless a method according to 8.1 is used.

~~For a.c., the rated short-circuit breaking capacity shall be not less than the r.m.s. value of the a.c. component of the prospective short-circuit current at the point of application (for exceptions, see 6.1.3).~~

~~This implies the ability of the circuit-breaker to break any current having an a.c. component not exceeding its rated breaking capacity, whatever may be the possible value of the inherent d.c. component at the beginning of the interruption.~~

~~The conditions of the circuit which determine the inherent d.c. component may be more severe in systems on board than those assumed as normal (see IEC 947-2) for distribution circuit-breakers. In such an event, the ability of the circuit-breaker to break the current corresponding to its rated breaking capacity, irrespective of the possible value of the d.c. component, shall be ascertained under the conditions of the actual installation.~~

Circuit-breakers with breaking capacity identified by rated service short-circuit breaking capacity I_{CS} (IEC 60947-2:2006(AMD1:2009/AMD2:2013 4.3.5.2.2) shall be used for all generator circuits and preferably for other circuits.

Circuit-breakers with breaking capacity identified by rated ultimate service short-circuit breaking capacity I_{CU} (IEC 60947-2:2006/AMD1:2009/AMD2:2013 4.3.5.2.1) may be used where the system arrangements are such, for example by duplication and separation of supplies, that failure of the circuit-breakers will not jeopardize the safety of the vessel.

When circuit-breakers with rated ultimate short-circuit breaking capacity I_{CU} are used on main or emergency switchboards, they are to be of plug-in type.

8.4 Rated short-circuit making capacity

The rated short-circuit making capacity of every mechanical switching device intended to be closed on a short-circuit shall be adequate for the maximum peak value of the prospective short-circuit current at the point of installation (for exceptions, see 8.1).

When closing on a short-circuit, the circuit breaker shall be able to withstand the short-circuit current during the time delay required due to selectivity/discrimination reasons.

~~NOTE The circuit-breaker should be able to make the current corresponding to its making capacity without opening within a time corresponding to the maximum time delay required.~~

8.5 ~~Co-ordination of short-circuit ratings with regard to continuity of service requirements~~ Co-ordinated choice of protective devices with regard to discrimination requirements

8.5.1 Continuity of ~~service~~ supply of healthy circuits under short-circuit conditions ~~may~~ shall be achieved by total discrimination ~~or by a different system of co-ordinated action of the protective devices~~.

~~All systems require:~~

~~– the tripping characteristics of protective devices in series to be properly co-ordinated;~~

~~– all protective devices carrying the fault current shall withstand, without damage, currents up to the maximum level at the point of application in the relevant installation, until complete fault clearance.~~

~~Discrimination requires in addition~~

~~– only the protective device nearest to the fault shall open the faulty circuit;~~

~~– the protective devices shall be capable of carrying, without opening, a current not mless than the short-circuit current at the point of application for a time corresponding to the opening of the breaker, increased by the time delay required for discrimination.~~

~~Other systems require:~~

~~– the tripping characteristics as well as the short-circuit capacities of the protective devices in series to be properly co-ordinated and, unless already proven to conform with an IEC standard, tested according to a testing method agreed between manufacturer and purchaser.~~

~~6.4.2 The tripping characteristics of protective devices in series shall be properly co-ordinated.~~

~~6.4.3 The protective devices shall be capable of carrying, without opening, a current not less than the short-circuit current at the point of application for a time corresponding to the opening of the breaker increased by the time delay required for discrimination.~~

The requirement of total discrimination versus backup protection has to be decided as a part of the system study. The requirement will, among others, depend on the criticality of the individual consumer.

The protective devices shall be capable of carrying, without opening, a current no less than the short-circuit current at the point of application for a time required by total discrimination, and, by partial discrimination, up to the given short-circuit current level (see Figure 1).

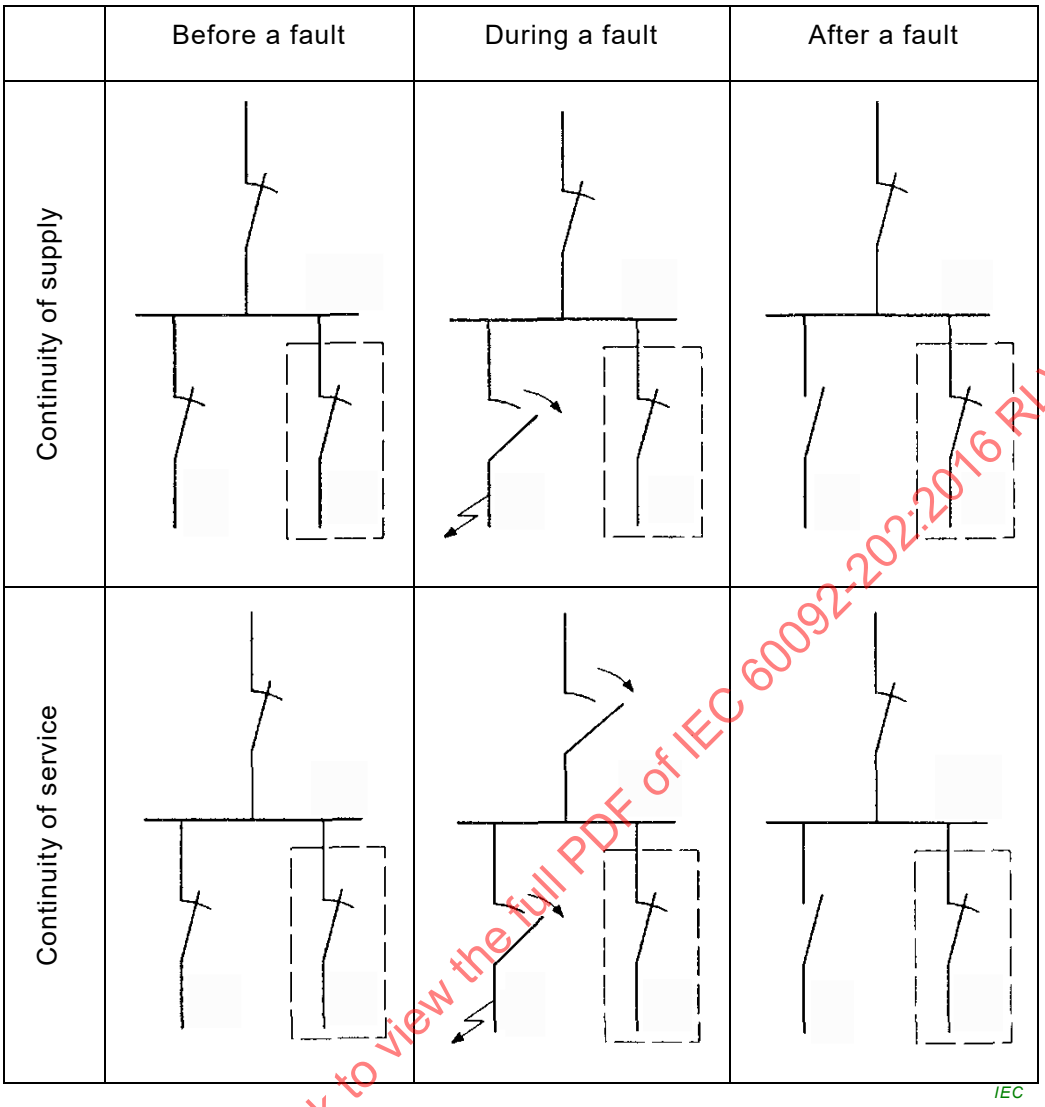

Figure 1– Continuity of supply and service

8.5.2 The preferred power supply method is continuity of supply. Where continuity of service is allowed, the operating characteristic of protective devices and of the user equipment shall be co-ordinated and verified.

9 Choice of protective devices with reference to overload

9.1 Mechanical switching devices

Mechanical switching devices provided for overload protection ~~should~~ shall have a tripping characteristic (over-current trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

9.2 Fuses for overload protection

The use of fuses for overload protection is ~~admissible~~ permitted up to 320 A, provided they have suitable characteristics, but the use of circuit-breakers or similar devices is recommended above 200 A. For high-voltage ~~a.c.~~ AC systems, the use of fuses for overload protection is not ~~admissible~~ acceptable.

9.3 Static or solid state switching devices

Static or solid state switching devices do not provide isolation for personal protection. Static or solid state devices provided for overload protection should have a tripping characteristic (over-current trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

10 Choice of protective devices with regard to their application

10.1 General

Short-circuit protection shall be provided in each non-earthed line.

Overload protection shall be provided in each non-earthed line of a circuit, except that for insulated ~~d.c.~~ DC circuits, insulated single-phase circuits and insulated three-phase circuits with substantially balanced loads, the overload protection may be omitted in one line.

Short-circuit or overload protective devices shall not interrupt earthed lines, unless all the non-earthed lines are disconnected at the same time by multipole switching devices.

10.2 Generator protection

10.2.1 General

Generators shall be protected against short-circuits and ~~overloads~~ over-currents by multipole circuit-breakers.

In particular, the ~~overload~~ over-current protection shall be adequate for the thermal capacity of the generator and within the following requirements.

a) For ~~overloads~~ over-currents of less than 10 %, consideration may be given to include an ~~aural~~ audible alarm signal, operated by a time-delay relay set at a maximum of 1,1 times the rated current of the generator and with a time delay of not more than 15 min.

   A time delay of over 15 min may be adopted if this is required by operating conditions and permitted by the generator design.

b) For ~~overloads~~ over-currents between 10 % and 50 %, the circuit-breaker shall be tripped with a time delay corresponding to a maximum of ~~2 min~~ 30 s at not more than 1,5 times the rated current of the generator; however, the figure of 50 % and the time delay of ~~2 min~~ 30 s may be exceeded if this is required by the operating conditions, and if the construction of the generator permits it.

c) For over-currents in excess of 50 %, "instantaneous" tripping shall be co-ordinated with the discriminative protection of the system. Short time delays may be introduced for discrimination requirements in "instantaneous" tripping devices designed for short-circuit protection. For large generators and for all high-voltage generators, protection should be provided against faults on the generator side of the circuit-breaker.

d) Emergency generators shall be protected against short-circuit. Over-currents should not switch off the emergency generator and give an alarm only.

~~NOTES~~

~~1~~ Consideration should be given to the protective arrangements associated with generators to ensure that they are maintained effectively even in the case of substantial reduction of speed.

~~2~~ Consideration should be given to the choice of protective devices used for ~~overload~~ over-current protection of generators, which will permit the power to be restored immediately after operation of the ~~overload~~ over-current protective device.

Settings and adjustments of automatic voltage regulators (AVR) shall not interfere with or replace generator protection devices.

10.2.2 Protection against short-circuits and fault currents on the generator side

When generators are intended to operate in parallel, it is necessary to take account of fault currents~~, which would need to be handled by the generator circuit-breakers if a short-circuit were to~~ occurring from short circuit between the generator and its circuit-breaker.

~~NOTE — Consideration should be given to the possible danger of closing a circuit-breaker controlling a generator when this is out of synchronism with the system to which it is to be connected.~~

Generators having a capacity of 1 500 kVA or above shall be equipped with a suitable protective device or system which, in the case of a short-circuit in the generator or in the supply cable between the generator and its circuit-breaker, will de-excite the generator and open the circuit-breaker. This does not apply to emergency generators.

~~NOTE~~ Specific circumstances may require similar protection for lower capacity generators, for example for the protection of personnel and excessive lengths of supply cable~~, etc~~.

~~**8.2.3 Protective devices for level-compounded d.c. two-wire and three-wire generators**~~

~~For d.c. generators arranged to operate in parallel, the following protective devices should be provided in addition to the protection against overload and sho rt circuits:~~

~~a) for level-compounded generators, an equalizer switch for each generator, so interlocked that it closes before and opens after the contacts of the circuit-breaker with which it is associated or a multipole circuit-breaker breaking all poles simultaneously;~~

~~b) in three-wire systems, a switch in the middle wire so interlocked with the generator switch or circuit-breaker connected to the "outers" as to operate simultaneously with them.~~

10.3 Protection of essential services

Where the load consists of essential services and non-essential services, consideration shall be given to an arrangement which will automatically exclude non-essential services when any one generator becomes overloaded ~~and which will function to prevent sustained loss of speed~~ by power or current.

This load-shedding may be carried out in one or more stages, according to the overload ability of the generating sets.

10.4 Protection of transformers

The primary winding of transformers shall be protected against short-circuits by multipole circuit-breakers or by fuses against short-circuits according to the requirements of Clause 8. Disconnecting links for secondary windings shall be provided when transformers are arranged for parallel operation.

Overload protection shall as a minimum be provided on one winding side of the transformer.

Oil-cooled transformers shall be protected by a Buchholz relay or equivalent protection systems. Special considerations are to be given to the correct operation of such relays and systems in inclined static and dynamic conditions.

~~NOTE~~ Where power can be fed into secondary windings, short-circuit protection ~~will need to~~ shall be considered in the secondary connections.

10.5 Circuit protection

10.5.1 Each distribution circuit shall be protected against overload and short-circuits by means of multipole circuit-breakers or fuses, according to the requirements of 8.4 and 8.5.

~~NOTE~~ Care ~~should~~ shall be taken to ensure that the protective arrangements remain effective in the case of the smallest generator supplying power in a system using generators arranged for parallel operation.

10.5.2 Cables in parallel which are formed of conductors of nominal cross-section not less than 50 mm^2 may be considered, from the point of view of protection, as a single cable.

10.5.3 Circuits supplying consuming devices having individual overload protection (e.g. motors, see 10.6.5), or consuming devices which cannot be overloaded (e.g. permanently wired heating circuits) may be provided with short-circuit protection only.

10.5.4 In domestic wet areas (e.g. sanitary spaces, galleys, laundries), socket-outlet shall be additionally protected by a residual current device (RCD) with rated residual operating current not exceeding 30 mA, or shall be individually supplied by a dedicated isolation transformer.

10.6 Motor protection

10.6.1 Motors having a power rating exceeding ~~0,5~~ 1,0 kW shall be individually protected against overload.

10.6.2 For motors intended for essential services, the protection against overload may be replaced by an alarm device. For steering gear motors and fire pumps, the protection against overload shall be replaced by an alarm device.

10.6.3 The protective devices shall be designed to allow current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use. When the time-current characteristics of the overload protective device of a motor are not adequate for the starting period of the motor, the overload protecting device may be rendered inoperative during the accelerating period provided that the protection against short-circuits remains operative and that the suppression of the overload protection is only temporary.

10.6.4 Protective devices for continuous duty motors shall have a time-delay characteristic which ensures reliable thermal protection of the motors for overload conditions.

10.6.5 The protective devices shall be set to limit the maximum continuous current to between ~~105~~ 100 % and 120 % of the rated current of the protected motor.

10.6.6 For intermittent duty motors, the current setting and the delay characteristics (as a function of time) for protective devices shall be chosen after considering the actual service conditions.

10.6.7 When fuses are used to protect polyphase motor circuits, consideration shall be given to protection against single-phasing.

~~**8.7 Protection of lighting power**~~

~~Each lighting circuit shall be protected against overload and sho rt circuit by suitable devices.~~

~~**8.8 Protection of shore power connection**~~

~~Permanently fixed cables from the shore connection box to the main switchboard shall be protected by fuses or circuit-breakers. In no case shall the protection at the shore connection box be omitted.~~

10.7 Accumulator (storage) battery protection

Accumulator (storage) batteries other than engine-starting batteries shall be protected against overload and short-circuits with devices placed as near as practicable to the batteries unless short-circuit-proof cable is used.

Emergency batteries supplying essential services shall have short-circuit protection only.

10.8 Protection of meters, pilot lamps and control circuits

Protection shall be ensured for indicating and measuring devices by means of fuses or ~~current-limiting devices~~ circuit-breakers.

For other circuits, ~~fuses~~ over-current protection in circuits such as those of voltage regulators should be omitted where loss of voltage might have serious consequences. If ~~fuses are~~ over-current protection is omitted, means shall be provided to prevent risk of fire in the unprotected part of the installation.

Voltage regulators should be protected separately from all other instrument circuits.

~~Fuses~~ Over-current protection shall be placed as near as practicable to the tapping from the supply.

10.9 Protection of static or solid-state devices

Appropriate ~~current-limiting fuses~~ protection shall be incorporated in the static or solid-state devices for protection of the cells and to protect against the effects of internal short-circuits in the cells.

Protection of the distribution circuit which connects the static or solid-state device to the source of power shall be given by means of a circuit-breaker whose tripping characteristics are selected to co-ordinate with the melting characteristics of the fuse~~s~~ if used, so as to ensure protection of the cells against all injurious over-currents.

11 Reverse power and reverse current protection for AC generators

~~9.1 *Reverse power protection for a.c. generators*~~

A.C. generators arranged for parallel operation shall be provided with time-delayed reverse active power protection.

The setting of protection devices is recommended in the range 2 % to 6 % of the rated power for turbines and in the range 8 % to 15 % of the rated power for diesel engines.

A fall of 50 % in the applied voltage shall not render the reverse power protection inoperative, although it may alter the amount of reverse power required to open the breaker.

~~NOTE — The reverse power protection may be replaced by other devices ensuring an adequate protection.~~

~~9.2 *Reverse current protection for d.c. generators*~~

~~D.C. generators arranged for parallel operation with one another or with a storage battery shall be provided with instantaneous or short-time delayed reverse current protection.~~

~~The setting of protection devices is recommended in the range 2 % to 6 % of the rated power for turbines and in the range 8 % to 15 % of the rated power for diesel engines.~~

~~A fall of 50 % in the applied voltage shall not render the reverse current protection inoperative, although it may alter the amount of reverse power required to open the breaker.~~

~~When an equalizer connection is provided, the reverse current device shall be connected on the pole opposite to that in which the series compounding winding is connected.~~

~~NOTES~~

~~1 The reverse current protection should be adequate to deal effectively with reverse current conditions emanating from the ship's network (e.g. cargo winches).~~

~~2 See also IEC 92-301.~~

12 Undervoltage protection

12.1 A.C. and ~~d.c.~~ DC generators

For generators arranged for parallel operation with one another or with a shore power feeder, measures shall be taken to prevent the generator circuit-breaker from closing if the generator is not generating and to prevent the generator circuit-breaker remaining connected to the busbar~~s~~ if the voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation shall be instantaneous when preventing closure of the circuit-breaker, but shall be delayed for discrimination purposes ~~when tripping a breaker~~ for the time required by the short-circuit protection device to clear the fault (backup protection).

12.2 A.C. and ~~d.c.~~ DC motors

12.2.1 Motors rated above ~~0,5~~ 1,0 kW shall be provided with either:

a) undervoltage protection, ~~operative~~ operating on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted, or

b) undervoltage release, ~~operative~~ operating on the reduction or failure of voltage, but so arranged that the motor restarts automatically and without excessive starting current on restoration of voltage, provided that the starter (which may be controlled, e.g. by thermostatic, pneumatic or hydraulic devices) still makes the requisite connections for a

restart and that the restarting of all motors does not occur simultaneously if it is necessary to avoid, for example, too large a voltage ~~drop~~ dip or current surge.

12.2.2 The protective devices shall allow the motor to start when the voltage is above 85 % of the rated voltage, and shall without fail intervene when the voltage is lower than approximately 20 % of the rated voltage, at rated frequency, and with time delay when necessary.

~~NOTE~~ Undervoltage protection need not necessarily be provided for steering gear motors and other motors which have to be continuously available.

13 Overvoltage protection

13.1 General

Circuits such as generator and external power sources shall be provided with overvoltage protection to avoid damage to the connected equipment.

13.2 Transformers

Adequate precautions shall be taken to prevent any low-voltage system supplied through transformers from being charged by leakage from a high-voltage system of the transformer. ~~Earthing of the low-voltage system~~ An earthed screen winding is regarded as adequate precaution.

13.3 AC machines

Adequate precautions shall be taken in high-voltage ~~a.c.~~ AC systems to limit and/or cope with overvoltage due to switching ~~etc.,~~ to ensure protection of ~~a.c.~~ AC machines.

14 Protection against under- and over-frequency

Each generator shall be protected against over- and under-frequencies. Over- and under-frequency settings are to be co-ordinated within the system design (e.g. power management system and/or grid configuration).

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 60092-202

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electrical installations in ships – Part 202: System design – Protection

Installations électriques à bord des navires – Partie 202: Conception des systèmes – Protection

IEC 60092-202:2016-09(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL INSTALLATIONS IN SHIPS –

Part 202: System design – Protection

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 60092-202 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This fifth edition cancels and replaces the fourth edition published in 1994 and Amendment 1:1996. This edition constitutes a technical revision.

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

This document: Clause/subclause No. and heading	Previous document: Corresponding clause/subclause No., remark
1 Scope	1, No change
2 Normative references	2, Updated
3 Definitions	3, Several definitions changed and added
4 General requirements	4, Text changed
4.1 General	New clause/subclause
4.2 Basic protection	New clause/subclause
4.3 Studies and calculations	New clause/subclause
5 Electrical load study	New clause/subclause
6 Short-circuit current calculations	5, Heading change
-	5.1, Text changed and moved to new Clause 6
-	5.2, Text deleted, for DC-Systems reference to IEC 61660-1 added
7 Protection discrimination study	New clause/subclause
7.1 General	New clause/subclause
7.2 Current selectivity	New clause/subclause
7.3 Time-current selectivity	New clause/subclause
8 Characteristics and choice of protective devices with reference to short-circuit rating	6, Text completely revised and extended
8.1 General	6.1
8.2 Protective devices	New clause/subclause
8.3 Rated short-circuit breaking capacity	6.2
8.4 Rated short-circuit making capacity	6.3
8.5 Co-ordinated choice of protective devices with regard to discrimination requirements	6.4, Heading changed, new text
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13.3 AC machines	11.2
14 Protection against under- and over-frequency	New clause/subclause

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

FDIS	Report on voting
18/1538/FDIS	18/1542/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.

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

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

INTRODUCTION

The IEC 60092 series includes international standards for electrical installations in sea-going ships, 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 for the safety of life at sea, a guide for future regulations which may be prepared and a statement of practice for use by ship owners, ship builders and appropriate organizations.

ELECTRICAL INSTALLATIONS IN SHIPS –

Part 202: System design – Protection

1 Scope

This part of IEC 60092 is applicable to the main features of the electrical protective system to be applied to electrical installations for use in ships.

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 60909 (all parts), *Short-circuit currents in three-phase a.c. systems*

IEC 60909-0, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

IEC TR 60909-1, *Short-circuit currents in three-phase a.c. systems – Part 1: Factors for the calculation of short-circuit currents according to IEC 60909-0*

IEC 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2006/AMD1:2009
IEC 60947-2:2006/AMD2:2013

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61363-1, *Electrical installations of ships and mobile and fixed offshore units – Part 1: Procedures for calculating short-circuit currents in three-phase a.c.*

IEC 61660-1, *Short-circuit currents in d.c. auxiliary installations in power plants and substations – Part 1: Calculation of short-circuit currents*

IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers*

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
rated load
the highest value of load specified for rated conditions

3.2
overload
operating conditions in an electrically undamaged circuit, which cause an overload above the rated load

[SOURCE: IEC 60050-441:1984, 441-11-08, modified — The words "which cause an over-current" has been replaced with "which cause an overload above the rated load".]

3.3
over-current
current exceeding the rated current

[SOURCE IEC 60050-441:1984, 441-11-06]

3.4
short-circuit
accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal to or close to zero

[SOURCE IEC 60050-195:1998, 195-04-11]

3.5
backup protection
protection equipment or system which is intended to operate when a system fault is not cleared in due time because of:

– failure or inability of a protective device closest to the fault to operate or

– failure of a protective device other than the protective device closest to the fault to operate

Note 1 to entry: This definition differs from the one given in IEC 60050-448:1995, 448-11-14.

3.6
over-current discrimination
selectivity
co-ordination of the operating characteristics of two or more over-current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the other(s) does (do) not

Note 1 to entry: Distinction is made between series discrimination, involving different over-current protective devices passing substantially the same over-current, and network discrimination involving identical protective devices passing different proportions of the over-current.

[SOURCE 60050-441:1984, 441-17-15, modified — The term "selectivity" has been added as an equivalent term.]

3.7
total discrimination
total selectivity
selectivity (over-current discrimination) where, in the presence of two over-current protective devices in series, the protective device on the load side effects the protection without causing the other protective device to operate

[SOURCE IEC 60947-2:2006/AMD2:2013, 2.17.2, modified — The term "total discrimination" has been added as an equivalent term and the term "over-current discrimination" has been replaced by "selectivity (over-current discrimination)" in the definition.]

3.8
partial discrimination
partial selectivity
selectivity (over-current discrimination) where, in the presence of two or more over-current protective devices in series, the protective device closest to the fault at the load side effects the protection up to a given level of short-circuit current without causing the other protective devices to operate

[SOURCE IEC 60947-2:2006/AMD2:2013, 2.17.3, modified —The term "partial discrimination" has been added as an equivalent term and the definition has been rephrased..]

3.9
continuity of service
condition where, after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established

3.10
continuity of supply

condition where during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured

Note 1 to entry: This definition is different from that given in IEC 60050-614:2016, 614-01-22.

3.11
basic protection
minimum required protection for equipment

3.12
electrical load study
study reflecting the different operational modes and their respective load requirements

Note 1 to entry: Typical examples of operational modes are harbour, manoeuvre, seagoing mode.

4 General requirements

4.1 General

Electrical installations shall be protected against accidental over-currents, up to and including short-circuit, by appropriate devices. Choice, arrangement and performance of the various protective devices shall provide complete and co-ordinated automatic protection in order to obtain

– elimination of the effects of faults to reduce damage to the system and the hazard of fire, and
– continuity of supply.

Under these conditions, the elements of the healthy system shall be designed and constructed to withstand the thermal and electrodynamic stresses caused by the possible over-current, including short-circuit, for the admissible durations.

4.2 Basic protection

Devices provided for basic protection shall be suitable for the equipment they are protecting, especially with regard to

– over-current,
– short-circuit, and
– earth fault, as appropriate.

The complexity of the protections is driven by a number of factors such as improved system performance, reliability, and reduction of the damage to the equipment for economical reason. Additional protection features shall not interfere with the basic protection requirements of this standard.

Electrical installation shall be provided with protections against electric shock in accordance with IEC 61140.

4.3 Studies and calculations

Studies and calculations shall demonstrate the proper coordination of power ratings, load requirements, system dynamics and protection.

In order to confirm the design of the electrical system and to confirm the ratings of the equipment selected, system studies shall be carried out. The system studies and calculation shall include

– an electrical load study (see Clause 5),
– short-circuit current calculations (see Clause 6), and
– a protection discrimination study (see Clause 7).

5 Electrical load study

An electrical load list shall be prepared to establish the electrical power requirements throughout the installation.

Based on analysis, load shedding shall be applied when required in order to avoid a blackout. Load shedding can be implemented by shedding of individual/groups of consumers or by appropriate separation of switchboard busbars.

Care should be taken to ensure that the response time is sufficient to enable the load shedding system to perform its function and maintain a stable electrical system.

Load estimates should be carried out for all operational conditions, for example

– navigation at sea,
– estuary trading and navigation close to port, and
– emergency power supply.

6 Short-circuit current calculations

The fault currents that flow as a result of short-circuits shall be calculated at each system voltage under three-phase fault conditions. These calculated currents shall be used to select suitably rated equipment and to allow the selection and setting of protective devices to ensure that successful discriminatory fault clearance is achieved.

The fault current shall be calculated for maximum and minimum system supply. The contribution of induction motors should be included in the study.

For general information regarding short-circuit calculations, reference shall be made to IEC 61363-1, IEC 60909-0 and IEC TR 60909-1 for AC systems, and IEC 61660-1 for DC systems.

IEC 60909 (all parts) is written for installations in which the short-circuit behaviour is predominantly ruled by passive elements (e.g. transformers, cables). It shall therefore only be applied for small transformer-fed low voltage installations. In all other cases, IEC 61363-1, which takes generator short-circuit behaviour into account, shall be applied.

Where precise information of their characteristics is lacking, the contribution of induction motors for determining the maximum peak value attainable by the short-circuit current (i.e. the value of the current to be added to the maximum peak value of the short-circuit due to the generators) can be taken as equal to 8 I_n where I_n is the sum of the rated currents of the motors estimated normally when simultaneously in service (I_n is an RMS value).

For more precise calculation, the following RMS values may be used:

– at the instant of short-circuit occurrence (sub-transient value): 6,25 I_n
– at the instant T, i.e. after one cycle from short-circuit inception: 2,5 I_n
– at the instant $2T$, i.e. after two cycles from short-circuit inception: 1,0 I_n

7 Protection discrimination study

7.1 General

A coordination study shall be carried out to determine the setting of the protective relays and direct acting circuit-breakers (see Clause 4).

In general, the two protection schemes described in 7.2 and 7.3 are possible.

7.2 Current selectivity

This type of selectivity is based on the observation that the closer the fault point is to the power supply of the installation, the higher the short-circuit current is. It is therefore possible to discriminate the zone the fault occurred in by setting the instantaneous protections to different current values.

The coordination of protection devices shall consider tolerances and accuracies.

Because of the large variation in short currents due to different operational conditions, current selectivity shall be used with caution and may not be achievable in all instances.

7.3 Time-current selectivity

Time-current selectivity makes trip selectivity by adjusting the protections so that the load-side protection, for all possible over-current values, trips more rapidly than the supply-side circuit-breaker. When the trip times of the two circuit-breakers are analysed, it is necessary to consider

– the tolerances over the thresholds and trip times, and

– the real currents circulating in the circuit-breakers.

7.4 Alternative protection schemes

Alternative protection schemes are permissible provided that the same level of protection is achieved.

8 Characteristics and choice of protective devices with reference to short-circuit rating

8.1 General

Protection against short-circuit shall be provided by circuit-breakers or fuses. For AC systems with a voltage higher than 1 kV, special consideration of fuses shall be made regarding their characteristics.

The use of a protective device not having a short-circuit breaking or making capacity at least equal to the maximum prospective short-circuit current at the point where it is installed is allowed, provided that it is backed-up by a fuse or by a circuit-breaker on the generator side, having at least the necessary short-circuit rating and not being the generator circuit-breaker. The same fuse or circuit-breaker may back up more than one circuit-breaker when essential services are not involved.

A separate current limiter to increase the short-circuit breaking capacity of a circuit-breaker may be used according to the manufacturer's instructions. The same current limiter can back up more than one circuit-breaker. The connection between current limiter and circuit-breaker(s) shall be made in such a way as to minimize the risk of short-circuit.

For low voltage systems, the short-circuit performance of the arrangement shall at least be equal to the requirements of IEC 60947-2.

NOTE For low voltage switchgear, further information can be found in IEC 60947-2:2006/AMD2:2013, Annex A.

For high voltage systems, the short-circuit performance of the arrangement shall at least be equal to the requirements of IEC 62271-100.

8.2 Protective devices

Protective devices for short-circuit protection shall conform to the requirements of the IEC standards concerning circuit-breakers and fuses, but it shall be taken into account that the conditions of the ship's installations may differ from the conditions foreseen in those publications, in particular with reference to the following.

– The short-circuit power factor in an AC system in a ship, which may be lower than that assumed as a basis for short-circuit rating of normal distribution circuit-breakers. Where no data are available, a short-circuit power factor of 0,2 shall be assumed.
– The sub-transient and transient component of the AC short-circuit current.
– The AC and DC decrement of short-circuit current.

As a consequence, the ratio between rated breaking capacity and the correlated making capacity of circuit-breakers corresponding to the normal conditions of distribution systems may be inadequate.

In such cases, the circuit-breakers shall be chosen with regard to their short-circuit making capacity, even though their available short-circuit breaking capacity, which complies with normal conditions, may be in excess of the one required for the actual application.

When current selectivity according to 7.2 is chosen, circuit-breakers with utilisation category A according to IEC 60947-2:2006 are acceptable.

When time current selectivity according to 7.3 is chosen, circuit-breakers shall be selected according to their rated short-time withstand current capacity I_{CW}.

Utilisation category B according to IEC 60947-2:2006 shall be used for all low voltage circuit-breakers with delayed tripping during short-circuit conditions.

High voltage circuit-breakers shall comply with IEC 62271-100.

8.3 Rated short-circuit breaking capacity

The rated short-circuit breaking capacity of every device intended for short-circuit protection shall be not less than the maximum prospective current to be broken at that point in the installation, unless a method according to 8.1 is used.

Circuit-breakers with breaking capacity identified by rated service short-circuit breaking capacity I_{CS} (IEC 60947-2:2006(AMD1:2009/AMD2:2013 4.3.5.2.2) shall be used for all generator circuits and preferably for other circuits.

Circuit-breakers with breaking capacity identified by rated ultimate service short-circuit breaking capacity I_{CU} (IEC 60947-2:2006/AMD1:2009/AMD2:2013 4.3.5.2.1) may be used where the system arrangements are such, for example by duplication and separation of supplies, that failure of the circuit-breakers will not jeopardize the safety of the vessel.

When circuit-breakers with rated ultimate short-circuit breaking capacity I_{CU} are used on main or emergency switchboards, they are to be of plug-in type.

8.4 Rated short-circuit making capacity

The rated short-circuit making capacity of every mechanical switching device intended to be closed on a short-circuit shall be adequate for the maximum peak value of the prospective short-circuit current at the point of installation (for exceptions, see 8.1).

When closing on a short-circuit, the circuit breaker shall be able to withstand the short-circuit current during the time delay required due to selectivity/discrimination reasons.

8.5 Co-ordinated choice of protective devices with regard to discrimination requirements

8.5.1 Continuity of supply of healthy circuits under short-circuit conditions shall be achieved by total discrimination.

The requirement of total discrimination versus backup protection has to be decided as a part of the system study. The requirement will, among others, depend on the criticality of the individual consumer.

The protective devices shall be capable of carrying, without opening, a current no less than the short-circuit current at the point of application for a time required by total discrimination, and, by partial discrimination, up to the given short-circuit current level (see Figure 1).

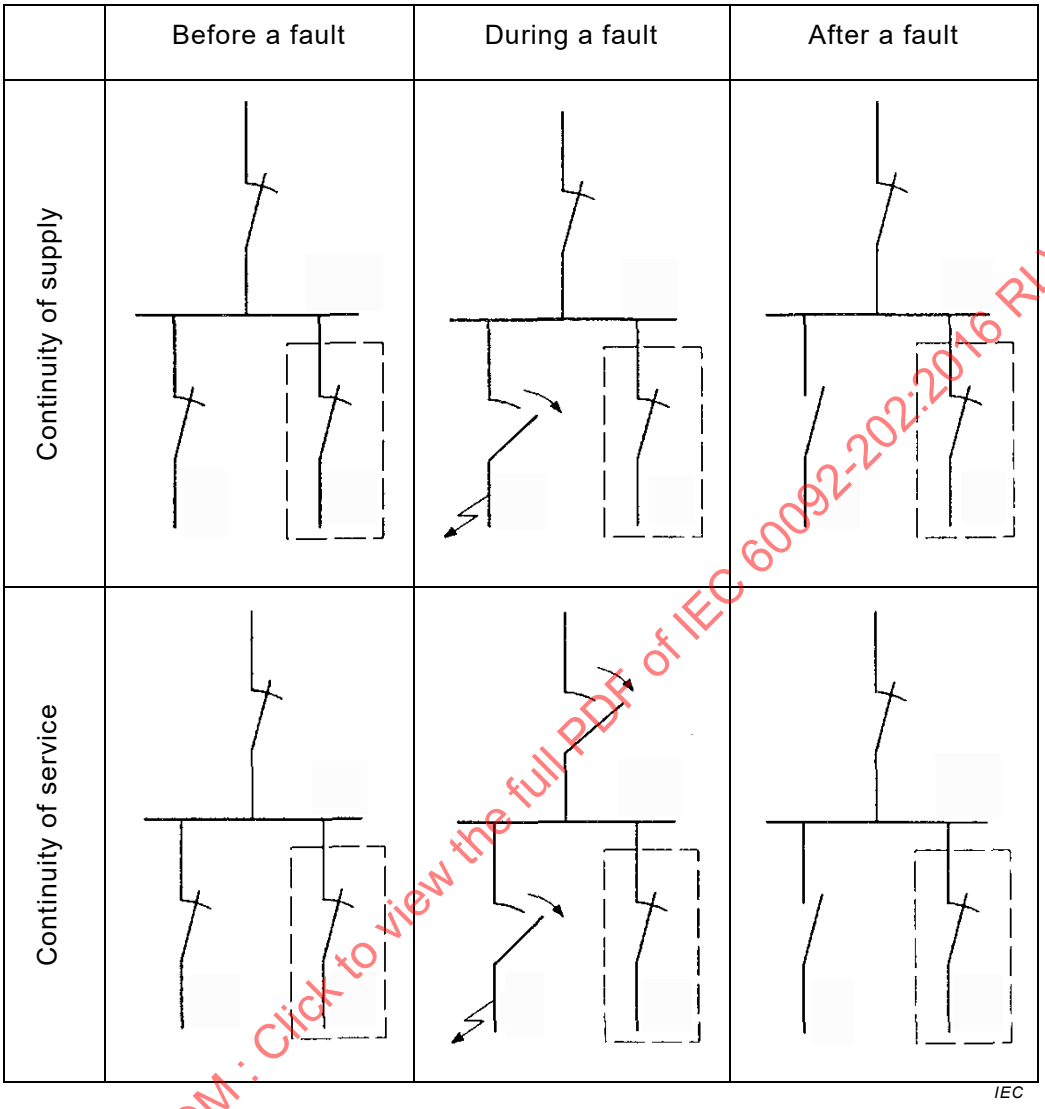

Figure 1 – Continuity of supply and service

8.5.2 The preferred power supply method is continuity of supply. Where continuity of service is allowed, the operating characteristic of protective devices and of the user equipment shall be co-ordinated and verified.

9 Choice of protective devices with reference to overload

9.1 Mechanical switching devices

Mechanical switching devices provided for overload protection shall have a tripping characteristic (over-current trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

9.2 Fuses for overload protection

The use of fuses for overload protection is permitted up to 320 A, provided they have suitable characteristics, but the use of circuit-breakers or similar devices is recommended above 200 A. For high-voltage AC systems, the use of fuses for overload protection is not acceptable.

9.3 Static or solid state switching devices

Static or solid state switching devices do not provide isolation for personal protection. Static or solid state devices provided for overload protection should have a tripping characteristic (over-current trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

10 Choice of protective devices with regard to their application

10.1 General

Short-circuit protection shall be provided in each non-earthed line.

Overload protection shall be provided in each non-earthed line of a circuit, except that for insulated DC circuits, insulated single-phase circuits and insulated three-phase circuits with substantially balanced loads, the overload protection may be omitted in one line.

Short-circuit or overload protective devices shall not interrupt earthed lines, unless all the non-earthed lines are disconnected at the same time by multipole switching devices.

10.2 Generator protection

10.2.1 General

Generators shall be protected against short-circuits and over-currents by multipole circuit-breakers.

In particular, the over-current protection shall be adequate for the thermal capacity of the generator and within the following requirements.

a) For over-currents of less than 10 %, consideration may be given to include an audible alarm signal, operated by a time-delay relay set at a maximum of 1,1 times the rated current of the generator and with a time delay of not more than 15 min.

   A time delay of over 15 min may be adopted if this is required by operating conditions and permitted by the generator design.

b) For over-currents between 10 % and 50 %, the circuit-breaker shall be tripped with a time delay corresponding to a maximum of 30 s at not more than 1,5 times the rated current of the generator; however, the figure of 50 % and the time delay of 30 s may be exceeded if this is required by the operating conditions, and if the construction of the generator permits it.

c) For over-currents in excess of 50 %, "instantaneous" tripping shall be co-ordinated with the discriminative protection of the system. Short time delays may be introduced for discrimination requirements in "instantaneous" tripping devices designed for short-circuit protection. For large generators and for all high-voltage generators, protection should be provided against faults on the generator side of the circuit-breaker.

d) Emergency generators shall be protected against short-circuit. Over-currents should not switch off the emergency generator and give an alarm only.

Consideration should be given to the protective arrangements associated with generators to ensure that they are maintained effectively even in the case of substantial reduction of speed.

Consideration should be given to the choice of protective devices used for over-current protection of generators, which will permit the power to be restored immediately after operation of the over-current protective device.

Settings and adjustments of automatic voltage regulators (AVR) shall not interfere with or replace generator protection devices.

10.2.2 Protection against short-circuits and fault currents on the generator side

When generators are intended to operate in parallel, it is necessary to take account of fault currents occurring from short circuit between the generator and its circuit-breaker.

Generators having a capacity of 1 500 kVA or above shall be equipped with a suitable protective device or system which, in the case of a short-circuit in the generator or in the

supply cable between the generator and its circuit-breaker, will de-excite the generator and open the circuit-breaker. This does not apply to emergency generators.

Specific circumstances may require similar protection for lower capacity generators, for example for the protection of personnel and excessive lengths of supply cable.

10.3 Protection of essential services

Where the load consists of essential services and non-essential services, consideration shall be given to an arrangement which will automatically exclude non-essential services when any one generator becomes overloaded by power or current. This load-shedding may be carried out in one or more stages, according to the overload ability of the generating sets.

10.4 Protection of transformers

The primary winding of transformers shall be protected against short-circuits by multipole circuit-breakers or by fuses against short-circuits according to the requirements of Clause 8. Disconnecting links for secondary windings shall be provided when transformers are arranged for parallel operation.

Overload protection shall as a minimum be provided on one winding side of the transformer.

Oil-cooled transformers shall be protected by a Buchholz relay or equivalent protection systems. Special considerations are to be given to the correct operation of such relays and systems in inclined static and dynamic conditions.

Where power can be fed into secondary windings, short-circuit protection shall be considered in the secondary connections.

10.5 Circuit protection

10.5.1 Each distribution circuit shall be protected against overload and short-circuits by means of multipole circuit-breakers or fuses, according to the requirements of 8.4 and 8.5.

Care shall be taken to ensure that the protective arrangements remain effective in the case of the smallest generator supplying power in a system using generators arranged for parallel operation.

10.5.2 Cables in parallel which are formed of conductors of nominal cross-section not less than 50 mm^2 may be considered, from the point of view of protection, as a single cable.

10.5.3 Circuits supplying consuming devices having individual overload protection (e.g. motors, see 10.6.5), or consuming devices which cannot be overloaded (e.g. permanently wired heating circuits) may be provided with short-circuit protection only.

10.5.4 In domestic wet areas (e.g. sanitary spaces, galleys, laundries), socket-outlet shall be additionally protected by a residual current device (RCD) with rated residual operating current not exceeding 30 mA, or shall be individually supplied by a dedicated isolation transformer.

10.6 Motor protection

10.6.1 Motors having a power rating exceeding 1,0 kW shall be individually protected against overload.

10.6.2 For motors intended for essential services, the protection against overload may be replaced by an alarm device. For steering gear motors and fire pumps, the protection against overload shall be replaced by an alarm device.

10.6.3 The protective devices shall be designed to allow current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use. When the time-current characteristics of the overload protective device of a motor are not adequate for the starting period of the motor, the overload protecting device may be rendered inoperative during the accelerating period provided that the protection against short-circuits remains operative and that the suppression of the overload protection is only temporary.

10.6.4 Protective devices for continuous duty motors shall have a time-delay characteristic which ensures reliable thermal protection of the motors for overload conditions.

10.6.5 The protective devices shall be set to limit the maximum continuous current to between 100 % and 120 % of the rated current of the protected motor.

10.6.6 For intermittent duty motors, the current setting and the delay characteristics (as a function of time) for protective devices shall be chosen after considering the actual service conditions.

10.6.7 When fuses are used to protect polyphase motor circuits, consideration shall be given to protection against single-phasing.

10.7 Accumulator (storage) battery protection

Accumulator (storage) batteries other than engine-starting batteries shall be protected against overload and short-circuits with devices placed as near as practicable to the batteries unless short-circuit-proof cable is used.

Emergency batteries supplying essential services shall have short-circuit protection only.

10.8 Protection of meters, pilot lamps and control circuits

Protection shall be ensured for indicating and measuring devices by means of fuses or circuit-breakers.

For other circuits, over-current protection in circuits such as those of voltage regulators should be omitted where loss of voltage might have serious consequences. If over-current protection is omitted, means shall be provided to prevent risk of fire in the unprotected part of the installation.

Voltage regulators should be protected separately from all other instrument circuits.

Over-current protection shall be placed as near as practicable to the tapping from the supply.

10.9 Protection of static or solid-state devices

Appropriate protection shall be incorporated in the static or solid-state devices for protection of the cells and to protect against the effects of internal short-circuits in the cells.

Protection of the distribution circuit which connects the static or solid-state device to the source of power shall be given by means of a circuit-breaker whose tripping characteristics are selected to co-ordinate with the melting characteristics of the fuse if used, so as to ensure protection of the cells against all injurious over-currents.

11 Reverse power and reverse current protection for AC generators

A.C. generators arranged for parallel operation shall be provided with time-delayed reverse active power protection.

The setting of protection devices is recommended in the range 2 % to 6 % of the rated power for turbines and in the range 8 % to 15 % of the rated power for diesel engines.

A fall of 50 % in the applied voltage shall not render the reverse power protection inoperative, although it may alter the amount of reverse power required to open the breaker.

12 Undervoltage protection

12.1 A.C. and DC generators

For generators arranged for parallel operation with one another or with a shore power feeder, measures shall be taken to prevent the generator circuit-breaker from closing if the generator is not generating and to prevent the generator circuit-breaker remaining connected to the busbar if the voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation shall be instantaneous when preventing closure of the circuit-breaker, but shall be delayed for discrimination purposes for the time required by the short-circuit protection device to clear the fault (backup protection).

12.2 A.C. and DC motors

12.2.1 Motors rated above 1,0 kW shall be provided with either:

a) undervoltage protection, operating on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted, or

b) undervoltage release, operating on the reduction or failure of voltage, but so arranged that the motor restarts automatically and without excessive starting current on restoration of voltage, provided that the starter (which may be controlled, e.g. by thermostatic, pneumatic or hydraulic devices) still makes the requisite connections for a restart and that the restarting of all motors does not occur simultaneously if it is necessary to avoid, for example, too large a voltage dip or current surge.

12.2.2 The protective devices shall allow the motor to start when the voltage is above 85 % of the rated voltage, and shall without fail intervene when the voltage is lower than approximately 20 % of the rated voltage, at rated frequency, and with time delay when necessary.

Undervoltage protection need not necessarily be provided for steering gear motors and other motors which have to be continuously available.

13 Overvoltage protection

13.1 General

Circuits such as generator and external power sources shall be provided with overvoltage protection to avoid damage to the connected equipment.

13.2 Transformers

Adequate precautions shall be taken to prevent any low-voltage system supplied through transformers from being charged by leakage from a high-voltage system of the transformer. An earthed screen winding is regarded as adequate precaution.

13.3 AC machines

Adequate precautions shall be taken in high-voltage AC systems to limit and/or cope with overvoltage due to switching to ensure protection of AC machines.

14 Protection against under- and over-frequency

Each generator shall be protected against over- and under-frequencies. Over- and under-frequency settings are to be co-ordinated within the system design (e.g. power management system and/or grid configuration).

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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INSTALLATIONS ÉLECTRIQUES À BORD DES NAVIRES –

Partie 202: Conception des systèmes – Protection

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La présente Norme internationale IEC 60092-202 a été établie par le comité d'études 18 de l'IEC: Installations électriques des navires et des unités mobiles et fixes en mer.

Cette cinquième édition annule et remplace la quatrième édition parue en 1994 et l'Amendement 1:1996. Cette édition constitue une révision technique.

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

Le présent document: N° d'article/de paragraphe et intitulé	Document précédent: N° d'article/de paragraphe, remarque
1 Domaine d'application	1, Aucune modification
2 Références normatives	2, Mis à jour
3 Définitions	3, Modification et ajout de plusieurs définitions
4 Exigences générales	4, Texte modifié
4.1 Généralités	Nouvel article/Nouveau paragraphe
4.2 Protection principale	Nouvel article/Nouveau paragraphe
4.3 Études et calculs	Nouvel article/Nouveau paragraphe
5 Étude de charge électrique	Nouvel article/Nouveau paragraphe
6 Calculs des courants de courts-circuits	5, Intitulé modifié
-	5.1, Texte modifié et déplacé vers un nouvel Article 6
-	5.2, Texte supprimé, pour les systèmes à courant continu ajout de la référence à l'IEC 61660-1
7 Étude de sélectivité des protections	Nouvel article/Nouveau paragraphe
7.1 Généralités	Nouvel article/Nouveau paragraphe
7.2 Sélectivité du courant	Nouvel article/Nouveau paragraphe
7.3 Sélectivité temps-courant	Nouvel article/Nouveau paragraphe
8 Caractéristiques et choix des dispositifs de protection selon les caractéristiques assignées de court-circuit	6, Texte entièrement révisé et complété
8.1 Généralités	6.1
8.2 Dispositifs de protection	Nouvel article/Nouveau paragraphe
8.3 Pouvoir de coupure assigné en court-circuit	6.2
8.4 Pouvoir de fermeture assigné en court-circuit	6.3
8.5 Choix coordonné des dispositifs de protection en fonction des exigences de sélectivité	6.4, Intitulé modifié, nouveau texte
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13.3 Machines à courant alternatif	11.2
14 Protection contre les sous-fréquences et les surfréquences	Nouvel article/Nouveau paragraphe

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
18/1538/FDIS	18/1542/RVD

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

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

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

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

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

INTRODUCTION

La série IEC 60092 comprend des normes internationales relatives aux installations électriques à bord des navires pour la navigation maritime, comprenant les règles de bonne pratique et coordonnant entre elles, dans la mesure du possible, les règles existantes.

Ces normes constituent un code pour l'interprétation pratique et le renforcement des exigences de la Convention internationale sur la sauvegarde de la vie humaine en mer, un guide pour l'établissement des futures réglementations susceptibles d'être rédigées et un énoncé de la pratique en vigueur destiné aux armateurs, aux constructeurs de navires et aux organismes compétents.

INSTALLATIONS ÉLECTRIQUES À BORD DES NAVIRES –

Partie 202: Conception des systèmes – Protection

1 Domaine d'application

La présente partie de l'IEC 60092 s'applique aux principales caractéristiques du système de protection électrique à appliquer aux installations électriques à bord des navires.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60909 (toutes les parties), *Courants de court-circuit dans les réseaux triphasés à courant alternatif*

IEC 60909-0, *Courants de court-circuit dans les réseaux triphasés à courant alternatif – Partie 0: Calcul des courants*

IEC TR 60909-1, *Courants de court-circuit dans les réseaux triphasés à courant alternatif – Partie 1: Facteurs pour le calcul des courants de court-circuit conformément à la CEI 60909-0*

IEC 60947-2:2006, *Appareillage à basse tension – Partie 2: Disjoncteurs*
IEC 60947-2:2006/AMD1:2009
IEC 60947-2:2006/AMD2:2013

IEC 61140, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*

IEC 61363-1, *Installations électriques à bord des navires et des plates-formes mobiles et fixes en mer – Partie 1: Évaluation des courants de court-circuit en c.a. triphasé*

IEC 61660-1, *Courants de court-circuit dans les installations auxiliaires alimentées en courant continu dans les centrales et les postes – Partie 1: Calcul des courants de court-circuit*

IEC 62271-100, *Appareillage à haute tension – Partie 100: Disjoncteurs à courant alternatif*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

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

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

3.1
charge assignée
valeur de charge la plus élevée spécifiée pour les conditions assignées

3.2
surcharge
conditions de fonctionnement d'un circuit électriquement sain, qui provoquent une surcharge supérieure à la charge assignée

[SOURCE: IEC 60050-441:1984, 441-11-08, modifiée – Les mots "qui provoquent une surintensité" ont été remplacés par "qui provoquent une surcharge supérieure à la charge assignée".]

3.3
surintensité
courant supérieur au courant assigné

[SOURCE IEC 60050-441:1984, 441-11-06]

3.4
court-circuit
chemin conducteur accidentel ou intentionnel entre deux ou plusieurs parties conductrices forçant les différences de potentiel électriques entre ces parties conductrices à être nulles ou proches de zéro

[SOURCE IEC 60050-195:1998, 195-04-11]

3.5
protection de secours
équipement ou système de protection destiné à fonctionner lorsqu'un défaut du système n'est pas éliminé à temps à cause:

– d'une défaillance ou d'une inaptitude à fonctionner du dispositif de protection le plus proche du défaut, ou
– d'une défaillance de fonctionnement d'un dispositif de protection autre que le dispositif de protection le plus proche du défaut

Note 1 à l'article: Cette définition est différente de celle indiquée dans l'IEC 60050-448:1995, 448-11-14.

3.6
sélectivité lors d'une surintensité
coordination entre les caractéristiques de fonctionnement de plusieurs dispositifs de protection à maximum de courant de telle façon qu'à l'apparition de surintensités comprises dans des limites données, le dispositif prévu pour fonctionner dans ces limites fonctionne, tandis que le ou les autres demeurent pratiquement intacts

Note 1 à l'article: On distingue la sélectivité série réalisée par différents dispositifs de protection à maximum de courant soumis pratiquement à la même surintensité et la sélectivité de réseau réalisée par des dispositifs de protection à maximum de courant identiques soumis à des fractions différentes de la surintensité.

[SOURCE 60050-441:1984, 441-17-15]

3.7
sélectivité totale
sélectivité lors d'une surintensité dans laquelle, en présence de deux dispositifs de protection à maximum de courant placés en série, le dispositif de protection aval assure la protection sans provoquer le fonctionnement de l'autre dispositif de protection

[SOURCE IEC 60947-2:2006, 2.17.2

3.8
sélectivité partielle
sélectivité lors d'une surintensité dans laquelle, en présence de deux dispositifs de protection ou plus à maximum de courant placés en série, le dispositif de protection le plus proche du défaut en aval assure la protection jusqu'à un niveau donné de courant de court-circuit sans provoquer le fonctionnement des autres dispositifs de protection

[SOURCE IEC 60947-2:2006, 2.17.3, modifiée — La définition a été reformulée.]

3.9
continuité de service
condition dans laquelle, après l'élimination d'un défaut dans un circuit, l'alimentation des circuits sains est rétablie

3.10
continuité d'alimentation

condition dans laquelle, pendant et après l'apparition d'un défaut dans un circuit, l'alimentation des circuits sains est assurée de façon permanente

Note 1 à l'article: Cette définition est différente de celle indiquée dans l'IEC 60050-614:2016, 614-01-22.

3.11
protection principale
protection minimale exigée pour l'équipement

3.12
étude de charge électrique
étude reflétant les différents modes de fonctionnement et leurs exigences respectives de charge

Note 1 à l'article: Les modes de fonctionnement sont par exemple le mode port, le mode manœuvre et le mode mer.

4 Exigences générales

4.1 Généralités

Les installations électriques doivent être protégées contre des surintensités accidentelles, y compris le court-circuit, par des dispositifs appropriés. Le choix, la disposition et les performances des différents dispositifs de protection doivent assurer une protection automatique complète et coordonnée afin de garantir

– l'élimination des effets des défauts, afin de réduire les dommages causés au système et le danger d'incendie, et
– la continuité d'alimentation.

Dans ces conditions, les éléments d'un système sain doivent être conçus et construits pour résister aux contraintes thermiques et électrodynamiques provoquées par la surintensité potentielle, y compris le court-circuit, pendant les durées admissibles.

4.2 Protection principale

Les dispositifs fournis pour la protection principale doivent être adaptés à l'équipement qu'ils protègent, en particulier en ce qui concerne

– les surintensités,
– les courts-circuits, et
– les défauts à la terre, selon le cas.