

# INTERNATIONAL STANDARD

**Electrical installations in ships –  
Part 304: Equipment – Semiconductor converters**

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# INTERNATIONAL STANDARD

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**Electrical installations in ships –  
Part 304: Equipment – Semiconductor converters**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

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**ELECTRICAL INSTALLATIONS IN SHIPS –****Part 304: Equipment – Semiconductor converters**

## FOREWORD

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IEC 60092-304 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 1980 and Amendment 1:1995. This edition constitutes a technical revision.

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

- a) scope limited to converters greater than 1 kW;
- b) terms and definitions: essential services added;
- c) deleted selenium rectifier;
- d) changed service conditions to 6. Effects from and on supply system new text added with parts from Clause 7 of IEC 60092-304:1980;
- e) Clause 7: application changed to converters for essential services construction and documentation new text added;

- f) Clause 8: application added;
- g) Clause 9: test added;

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

Draft	Report on voting
18/1780/FDIS	18/1782/RVD

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

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

A list of all parts in the IEC 60092 series, published under the general title *Electrical installations in ships*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under [webstore.iec.ch](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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## INTRODUCTION

IEC 60092 (all parts) forms a series of 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 Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by shipowners, shipbuilders and appropriate organizations.

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## ELECTRICAL INSTALLATIONS IN SHIPS –

### Part 304: Equipment – Semiconductor converters

#### 1 Scope

This part of IEC 60092 specifies special provisions to power electronic converters and systems, using semiconductor elements for use in ships. The conversion may be from AC to DC, from DC to AC, from DC to DC or from AC to AC with a rated output power greater than 1 kW.

This document does not apply to semiconductor converters used in electrical propulsion plant. For semiconductor converters used in electrical propulsion plant, see IEC 60092-501.

#### 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 60092-101:2018, *Electrical installations in ships – Part 101: Definitions and general requirements*

IEC 60092-202, *Electrical installations in ships – Part 202: System design – Protection*

IEC 60092-504:2016, *Electrical installations in ships – Part 504: Automation, control and instrumentation*

IEC 60146-1 (all parts), *Semiconductor converters – General requirements and line commutated converters*

IEC 60146-1-1, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC TR 60146-1-2, *Semiconductor converters – General requirements and line commutated converters – Part 1-2: Application guidelines*

IEC 60146-1-3, *Semiconductor converters – General requirements and line commutated converters – Part 1-3: transformers and reactors*

IEC 60146-2, *Semiconductor converters – Part 2: Self-commutated converters including direct d.c. converters*

IEC 60533, *Electrical and electronic installations in ships – Electromagnetic compatibility (EMC) – Ships with a metallic hull*

IEC 60947-4-2, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – Semiconductor motor controllers, starters and soft-starters*

IEC 61204 (all parts), *Low voltage switch mode power supplies*

IEC 61378-1, *Converter transformers – Part 1: Transformers for industrial applications*

IEC 61800 (all parts), *Adjustable speed electrical power drive systems*

IEC 62040 (all parts), *Uninterruptible power systems (UPS)*

IEC 62271-200, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62310 (all parts), *Static transfer systems (STS)*

IEC 62477-1, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

IEC 62477-2, *Safety requirements for power electronic converter systems and equipment – Part 2: Power electronic converters from 1000 V AC or 1500 V DC up to 36 kV AC or 54 kV DC*

IEC 62909 (all parts), *Bi-directional grid connected power converters*

### 3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1 essential services

services essential for propulsion and steering, and safety of the ship, which are made up of "primary essential services" and "secondary essential services"

Note 1 to entry: These essential services include supplies to such consumers or power supply systems for such consumers.

[SOURCE: IAC UI SC134:2002]

#### 3.2 primary essential services

services which need to be in continuous operation to maintain propulsion and steering

[SOURCE: IACS UI SC134:2002]

#### 3.3 secondary essential services

services essential which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel's safety

[SOURCE: IACS UI SC134:2002]

### **3.4 converter**

operating unit for electronic power conversion, changing one or more electrical characteristics and comprising one or more electronic switching devices and associated components, such as transformers, filters, commutation aids, controls, protections and auxiliaries, if any

Note 1 to entry: The above wording is covering the definitions of power electronic converter PEC and power electronic converter system PECS as per IEC 62477-2 or corresponding definitions for drive modules (BDM and CDM) as per IEC 61800-1 or IEC 61800-2.

### **3.5 high-voltage converter**

semiconductor converter with a rated line-to-line voltage exceeding 1 000 V AC or 1 500 V DC

### **3.6 alert**

announcement of abnormal situations and conditions requiring attention

Note 1 to entry: Alerts are divided in three priorities: alarms, warnings and cautions.

[SOURCE: IMO Resolution A.1021(26):2009, 3.1, modified – The priorities of alarm have been reduced to three.]

### **3.7 uninterruptible power system UPS**

combination of converters, switches and energy storage devices (such as batteries), constituting a power system for maintaining continuity of load power in case of input power failure

[SOURCE: IEC 62040-1:2017, 3.101, modified – Note to entry deleted.]

## **4 General requirement**

Semiconductor converters and soft-starters shall, in the addition to the requirements given in this document, comply with the relevant requirements of the following as applicable:

- IEC 60146-1-1;
- IEC TR 60146-1-2;
- IEC 60146-1-3;
- IEC 60146-2;
- IEC 60947-4-2;
- IEC 61204 (all parts);
- IEC 61800 (all parts);
- IEC 62040 (all parts);
- IEC 62310 (all parts);
- IEC 62477-1;
- IEC 62477-2;
- IEC 62909 (all parts).

## 5 Service conditions

### 5.1 Voltage and frequency

The converter equipment shall be suitable for operation, with nominal power output, under steady state and transient variations of input voltage and frequency according to IEC 60092-101.

### 5.2 Inclination

Converters shall be suitable for use at all inclinations specified in IEC 60092-101.

### 5.3 Vibration

The converter shall withstand the vibrations at the place of installation according to requirements to vibrations in IEC 60092-101.

The use of anti-vibration mountings may be considered as an acceptable mitigation measure.

### 5.4 Ambient temperature

Converters shall be designed to operate under ambient temperature as stated in IEC 60092-101. Where equipment is designed to operate under other ambient temperatures than stated in IEC 60092-101, this shall be clearly marked, and manufacturer shall document additional precautions for installation.

### 5.5 Pollution

Converters shall be designed according to IEC 60092-101:2018, 4.11. Where a lower pollution degree is used in the converter design, special measures shall be taken to ensure the design conditions.

## 6 Effects from and on the supply or load system

### 6.1 Supply- or load side disturbance

The converter equipment shall be protected against permanent outage (IEV 692-04-09) from under- or over-voltage on the supply side, and from overload (including short circuit) or reverse power on the load side. Converters shall comply with the requirements to overvoltage in IEC 60092-101.

### 6.2 Converter-internal fault or disturbance

Faults or disturbance in the converter (hardware or software induced) shall not cause any sustained outage (IEV 692-04-08) in the supply side. Converters shall be equipped with suitable devices to accomplish this, either internally or externally.

### 6.3 EMC requirements

The electromagnetic compatibility considerations shall be addressed in accordance with IEC 60533 as they pertain to grid-configuration (earthed or insulated distribution systems), filter arrangements, harmonics, radiated and conducted emission limits and place of installation.

### 6.4 Insulation monitoring

IT distribution systems with predominately converter load(s) shall have suitable insulation monitoring devices installed. Where this is not possible, further separation by isolating transformers or TN-S distribution system may be required.

Where a converter with an earthed neutral connection is installed on a vessel with an IT distribution system, it shall be separated from the IT network by isolating transformers.

NOTE For definition of IT-TN distribution systems, see IEC 60092-201.

## **7 Converters for essential services construction and documentation requirements**

### **7.1 Cooling arrangements for essential services**

#### **7.1.1 General**

Where converters serve secondary or primary essential services, the requirements of 7.1.2 and 7.1.3 shall apply.

#### **7.1.2 Cooling arrangements for secondary essential services**

Where a cooling medium is used, an alert shall be triggered in the event of a malfunction that reduces the effectiveness of cooling (i.e. loss of flow) or endanger the equipment (i.e. leakage in the case of liquid cooling for electrical equipment).

Where forced air cooling or liquid cooling is utilized, the circuit shall be so designed that power cannot be applied to, or retained on the converter, unless effective cooling is maintained or restored.

Operation of the converter with reduced power and reduced cooling is permissible.

Cooling circuits of converters shall be protected against unacceptable levels of pollution in the cooling system.

#### **7.1.3 Cooling arrangements for primary essential services**

In addition to the requirements of 7.1.2, cooling circuits of liquid cooled converters serving primary essential services shall be separated from other systems by a dedicated heat-exchanger.

The failure of any fan or any pump in cooling circuitry shall not impair the functioning of the converter.

### **7.2 Alarm and monitoring**

A failure or malfunction of converter equipment serving essential services shall be monitored and the proper type of alert shall be given.

### **7.3 Low voltage converter**

Converters shall comply with relevant product standard's safety requirements, as referenced in Clause 4, and manufacturer's instructions shall be observed.

### **7.4 High-voltage converter**

Access to the high-voltage section of converters, or parts thereof, shall be only possible when the unit is dead and earthed down.

Converters shall be arc tested according to IEC 62271-200 when local control and operation of HV converters is permitted. Otherwise, the local control and operation panels shall be separated from the HV section of the converter.

## 7.5 Documentation requirements

All applications shall be delivered with documentation containing schematics and wiring diagrams. Instruction/operating manuals including trouble shooting guidance shall be provided.

## 7.6 Marking

The marking to a relevant product standard shall be large enough to identify the manufacturer's name and identification number of the equipment. The rating plate shall be visible on the outside of the converter enclosure. Where no relevant product standard exists, marking shall be in accordance with IEC 60146-1 (all parts).

# 8 Application

## 8.1 Parallel operation of converters

Where two or more converters modules are connected in parallel to supply primary essential services, the failure of a module shall not impair the correct operation or performance of the other modules. A load reduction due to a module failure may be acceptable where feasible.

## 8.2 Accessibility

The converter shall be positioned in such way that necessary access for maintenance and repairs is possible.

## 8.3 Bypass circuits

UPS or softstarters supplying primary or secondary essential equipment shall be provided with an (external) bypass to assure supply to the load in case of failure or maintenance of converter equipment.

Where a bypass is not possible due to technical reasons (e.g. different voltages at input and output), a redundancy should be foreseen for primary essential equipment.

## 8.4 Means of control

For essential services, local control shall be possible and be in accordance with 9.6.4.7 of IEC 60092-504:2016.

## 8.5 Selectivity or discrimination

Where converters supply essential services, downstream selectivity with continuity of supply shall be maintained in accordance with 8.5.1 of IEC 60092-202:2016.

**EXAMPLE** In case of a short circuit at the secondary side of an UPS supplying multiple essential services, the fault is cleared by its dedicated circuit breaker.

## 8.6 Converter transformers

If transformers are used in combination with semiconductor converters on the supply side or the load side of the converter, these transformers shall comply with IEC 61378-1.

In case of systems where harmonic contents are expected, transformers shall be sized with consideration to the recommended derating according to IEC Standards.

## 8.7 Harmonic filters

Harmonic filters, if fitted, shall not decrease the insulation resistance between the phases and earth or the measured value of the insulation monitoring device (IMD) of completed installation below the value of 1M $\Omega$ .

NOTE 1 Current harmonics interacting with the impedance of the supply will generate voltage harmonics. Both the current and voltage harmonics can cause malfunction and overheating in other items of equipment in the unit, if their possible presence has not been taken into account in the equipment design. For systems where a converter rating is large and a significant proportion of the system rating, there is a possibility that the suppression of such harmonics at the source is not feasible. Consequently, appropriate measures will have to be taken to attenuate these effects on critical equipment.

NOTE 2 General guidance is given in IEC 60092-101.

NOTE 3 High capacitances to earth can impair the proper function of earth fault detection systems and, under fault conditions (asymmetric grid conditions), these can lead to fire hazards.

NOTE 4 For harmonic filters installed on main busbars of electrical distribution systems, additional requirements are given in IACS UR E24.

## 8.8 Uninterruptible power supplies

In some cases, SOLAS requires UPS systems to maintain supply to essential services for a prescribed time. Then, the UPS type (online/offline UPS according to the IEC 62040 series) and output voltage selection shall consider the characteristics of the main power source and the power supply requirements of the various consumers.

NOTE See also IACS UR E21 on UPS units as alternative and/or transitional power.

## 8.9 Soft-starters

For essential services, duty cycle values and sequences according to IEC 60947-4-2 shall be aligned based on the requirements of the application. Normal load and overload characteristics shall be considered.

## 9 Tests

Converters shall be individually tested at the manufacturer's premises.

Converters for essential equipment shall be tested with project related settings with respect to all protections, limiting functions and alerts.