

INTERNATIONAL STANDARD

**Electrical installations in ships –
Part 303: Equipment – Power transformers and reactors**

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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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IEC 60092-303

Edition 4.0 2023-08

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 47.020.60

ISBN 978-2-8322-7335-7

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CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	6
2 Normative references	6
3 Terms and definitions	7
4 Service conditions	7
4.1 Voltage and frequency	7
4.2 Environmental condition.....	8
4.2.1 General	8
4.2.2 Vibration.....	8
4.2.3 Ambient temperature	8
4.3 Load current harmonic content.....	8
4.4 Transformers for special applications.....	8
4.4.1 Propulsion transformers.....	8
4.4.2 Transformers for shore-connection	8
5 Design and construction	9
5.1 General.....	9
5.2 Materials.....	9
5.3 Insulation level, clearance and creepage distances.....	9
5.4 Degrees of protection of enclosures.....	9
5.5 Transformer winding arrangement.....	9
5.6 Terminals.....	10
5.7 Cooling arrangements.....	10
6 Voltage regulation	10
7 Parallel operation	10
8 Transformers for essential services – Construction and documentation requirements	10
8.1 Cooling arrangements for essential services	10
8.1.1 General.....	10
8.1.2 Cooling arrangements for secondary essential services.....	11
8.1.3 Cooling arrangements for primary essential services	11
8.2 Alert and monitoring.....	11
8.3 High voltage transformer.....	11
8.4 Documentation requirements	11
9 Tests	11
Annex A (informative) Method for reducing harmonics disturbances.....	12
Bibliography.....	13
Figure A.1 – Screen between primary and secondary winding.....	12
Figure A.2 – Phase shifting in transformers with multiple windings.....	12

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL INSTALLATIONS IN SHIPS –**Part 303: Equipment – Power transformers and reactors**

FOREWORD

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IEC 60092-303 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 1:1997. This edition constitutes a technical revision.

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

- a) environmental conditions were added as 4.2;
- b) 4.3 for load harmonic content was added;
- c) 4.4 transformers for special applications was added;
- d) Clause 5 for design and construction of transformers was added;
- e) definitions for "essential services" were added and described in the new Clause 8.

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

Draft	Report on voting
18/1831/FDIS	18/1851/RVD

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

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

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

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

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

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INTRODUCTION

The IEC 60092 series contains 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 303: Equipment – Power transformers and reactors

1 Scope

This part of IEC 60092 is applicable to all transformers used for power and lighting and, where appropriate, to static convertors, starting transformers, static balancers, earthing transformers, saturable reactors and transducers for use in ships, including single-phase transformers rated higher than 1 kVA, and three-phase transformers rated higher than 5 kVA, unless special requirements are specified.

This document applies to transformers with rated voltage up to and including 36 kV.

This document is not applicable to instrument transformers.

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 60076 (all parts), *Power transformers*

IEC 60076-1:2011, *Power transformers – Part 1: General*

IEC 60076-2, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3:2013, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-3:2018/AMD1:2018

IEC 60076-5, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-6, *Power transformers – Part 6: Reactors*

IEC 60076-8, *Power transformers – Part 8: Application guide*

IEC 60076-11, *Power transformers – Part 11: Dry-type transformers*

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

IEC 60092-101, *Electrical installations in ship – Part 101: Definitions and general requirements*

IEC 60092-201, *Electrical installations in ship – Part 201: System design – General*

IEC 60092-304, *Electrical installations in ships – Part 304: Equipment – Semiconductor converters*

IEC 60092-401, *Electrical installations in ships – Part 401: Installation and tests for completed installation*

IEC 60092-501, *Electrical installations in ships – Part 501: Special features – Electric propulsion plant*

IEC 60092-509:2011, *Electrical installations in ships – Part 509: Operation of electrical installations*

IEC 60092-503, *Electrical installations in ships – Part 503: Special features – AC supply systems with voltages in the range of above 1 kV up to and including 36 kV*

IEC/IEEE 80005 (all parts), *Utility connections in port*

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 terminology databases for use in standardization at the following addresses:

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

Note 2 to entry: More information related to this definition can also be found in IACS UI SC 134.

3.2

primary essential services

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

Note 1 to entry: More information related to this definition can also be found in IACS UI SC 134.

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

Note 1 to entry: More information related to this definition can also be found in IACS UI SC 134.

4 Service conditions

4.1 Voltage and frequency

The 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.

4.2 Environmental condition

4.2.1 General

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

4.2.2 Vibration

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

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

4.2.3 Ambient temperature

The equipment shall be designed to operate under ambient temperatures according to IEC 60092-101. Where equipment is designed to operate under other ambient temperatures, this shall be clearly marked, and necessary precautions shall be taken with regards to the installation.

According to the installation space, considerations to restricted ventilation may be necessary when designing the equipment.

NOTE Requirements to considerations are specified in IEC 60076-1:2011, 4.1, 5.5 and Annex A.

Temperature-rise limits for oil-immersed transformers shall be defined in accordance with IEC 60076-2 and for dry-type transformers in accordance with IEC 60076-11.

4.3 Load current harmonic content

Converter transformers shall be in accordance with IEC 61378-1.

NOTE 1 See also IEC 60092-304.

For transformers intended to supply network with a total harmonic distortion of current higher than 5 %, the temperature rise should be specified according to the IEC 61378 series as appropriate.

NOTE 2 IEC 60076-1 refers to the IEC 61378 series for transformers with THD above 5 %.

NOTE 3 Annex A gives some informative recommendations for transformers used to reduce total and single harmonic distortion.

4.4 Transformers for special applications

4.4.1 Propulsion transformers

Propulsion transformers shall be designed according to IEC 60092-501.

4.4.2 Transformers for shore-connection

On board transformers used for shore connection shall be designed according to the IEC/IEEE 80005 series.

5 Design and construction

5.1 General

All transformers within the scope of this document shall comply with the following standards as appropriate:

- IEC 60076-1;
- IEC 60076-2;
- IEC 60076-3;
- IEC 60076-5;
- IEC 60076-6;
- IEC 60076-8;
- IEC 60076-11;
- IEC 61378-1;
- IEC 60092-101;
- IEC 60092-201;
- IEC 60092-304;
- IEC 60092-401;
- IEC 60092-501;
- IEC/IEEE 80005 (all parts).

Transformers, reactors or windings with a rated voltage 1 kV to 36 kV shall also comply with IEC 60092-503.

5.2 Materials

Materials shall comply with the requirements of IEC 60092-101 as appropriate.

If winding materials other than copper are used, considerations additional to this document should be made.

5.3 Insulation level, clearance and creepage distances

For transformers (or reactors) intended to be used on AC supply systems, with rating up to and including 1 000 V, or with windings rated up to and including 1 000 V, insulation level, clearance and creepage distances shall be defined according to the IEC 60076 series as appropriate, taking into account the rated voltage, the overvoltage category and the pollution degree as defined in IEC 60092-101.

For transformers or reactors intended to be used on AC supply systems with voltages higher than 1 000 V, or with windings rated higher than 1 000 V, IEC 60092-503 applies.

5.4 Degrees of protection of enclosures

Transformers and reactors shall as a minimum have the degree of protection defined in IEC 60092-201 for low voltage transformers or IEC 60092-503 for high voltage transformers.

5.5 Transformer winding arrangement

Transformers shall be double-wound with two separate windings. Starting transformers may be of the auto-transformer type.

5.6 Terminals

Suitable terminals, clearly marked with the voltage level, shall be provided in an accessible position, convenient for external connections. The terminals shall be effectively secured and shall be so spaced and/or shielded so that they cannot be accidentally earthed, short-circuited or touched.

Terminals for different voltage levels shall be clearly separated from each other.

Bus bars and terminal boxes shall be designed for maximum cable temperature at cable connection.

5.7 Cooling arrangements

Transformers and reactors shall preferably be of the dry, air-cooled type.

Transformers of the liquid-immersed type shall preferably be hermetically sealed. If of the conservator type, they shall be so designed that, under all conditions with the ship inclined from the normal as specified in IEC 60092-101, they operate without risk of spilling liquid. If provision is made for breathing, a suitable dehydrator shall be provided.

For liquid-immersed type transformers, consideration shall be given to provide liquid over-temperature alarm and gas-actuated protection devices.

NOTE See IEC 60092-401 for installation precautions.

6 Voltage regulation

The voltage drop in the secondary voltage between no load and rated load, under resistive load, shall comply with definition and calculation methodology in IEC 60076-8. For starting transformers, the voltage shall be subject to agreement between manufacturer and purchaser.

When determining the transformer ratio and the short-circuit impedance, consideration shall be given to total voltage drop to be expected in the supply and distribution system. In this respect, reference is also made to IEC 60092-101.

NOTE Clause 6 contains requirements to be agreed between manufacturer and purchaser.

7 Parallel operation

When transformers (except converter transformer feeding a variable speed drive system) are so arranged that their secondary windings may be connected in parallel, their winding connections (vector groups) shall be same, their rated voltage ratios shall be equal (with tolerances < 1 %) and their short-circuit impedance values, expressed in percentage, shall have a ratio within 0,9 to 1,1.

8 Transformers for essential services – Construction and documentation requirements

8.1 Cooling arrangements for essential services

8.1.1 General

Where transformers serve secondary or primary essential services, the requirements of 8.1.2 and 8.1.3 applies.

8.1.2 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).

Cooling circuits of transformers shall be protected against unacceptable levels of pollution in the cooling system, such as to prevent corrosion.

NOTE For further information regarding environmental conditions, refer to IEC 60092-101:2018, 4.6 and Annex A, and IEC 60721-3-6.

8.1.3 Cooling arrangements for primary essential services

In addition to the requirements of 8.1.2, cooling circuits of liquid cooled transformers 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 circuit shall not impair the functioning of the transformer unit, except if there is a fully redundant transformer system for supplying the primary essential service. In any case, a single failure shall not impair the supply of the essential service.

8.2 Alert and monitoring

Temperature of transformer equipment serving essential services shall be monitored and the proper type of alert shall be given.

8.3 High voltage transformer

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

Suitable means shall be provided or installed on the transformer for local earthing and short-circuiting devices according to IEC 60092-509:2011, Clause 6.

NOTE More information can be found in IACS UR E11.

8.4 Documentation requirements

All transformers shall be delivered with documentation that contain schematic and wiring diagrams. Instruction/operating manuals including trouble shooting guidance shall be provided.

9 Tests

Equipment shall be tested according to IEC 60076-1.

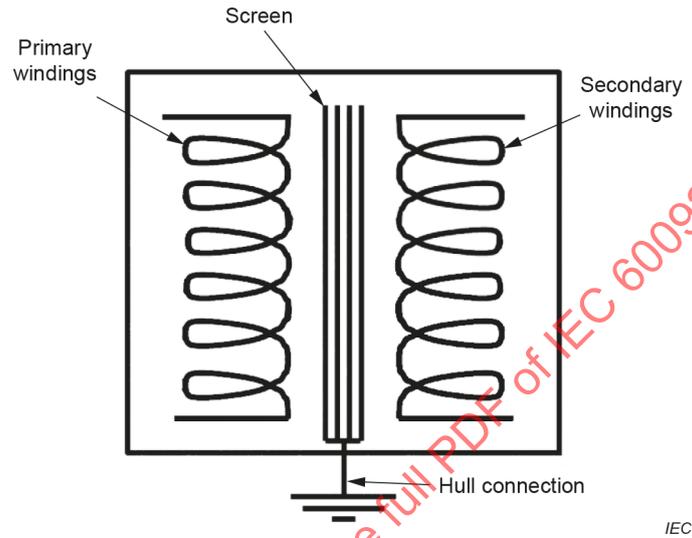
The lowest levels of test voltages for a particular value of U_m as found in IEC 60076-3:2013 and IEC 60076-3:2013/AMD1:2018, 7.2.2, apply.

Annex A (informative)

Method for reducing harmonics disturbances

Methods to reduce common mode disturbance are shown in Figure A.1 and Figure A.2.

A screen is placed between primary and secondary windings and connected in the shortest way to the hull possibly through the transformer frame.



NOTE Figure A.1 shows a screen placed between primary and secondary windings and connected in the shortest way to the hull, possibly through the transformer frame.

Figure A.1 – Screen between primary and secondary winding

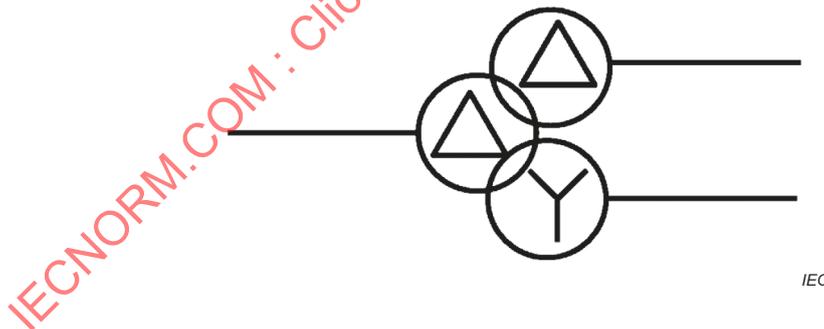


Figure A.2 – Phase shifting in transformers with multiple windings