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Electrical and electronic installations in ships — Electromagnetic compatibility (EMC) — Ships with a metallic hull

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National foreword

This British Standard is the UK implementation of IEC 60533:2015. It supersedes BS IEC 60533:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee JPEL/18, Electrical installations of ships and of mobile and fixed offshore units.

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
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ELECTRICAL AND ELECTRONIC INSTALLATIONS IN SHIPS – ELECTROMAGNETIC COMPATIBILITY (EMC) – SHIPS WITH A METALLIC HULL

FOREWORD

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International Standard IEC 60533 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

This third edition cancels and replaces the second edition, published in 1999. This edition constitutes a technical revision.

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

– Introduction has been supplemented;
– scope and title have been modified to limit the application of the standard to installations in ships with metallic hulls only;
– the normative references have been updated;
– further explanation for *in-situ* testing has been given in 5.1;
– numbering of CISPR-Standards in Tables 1, 2 and 3 has been updated;

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– title of Annex B has been changed;
– requirements on cable routing in Annex B have been amended;
– new Annex C EMC test report has been added.

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

FDIS	Report on voting
18/1460/FDIS	18/1471/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

A bilingual version of this standard may be issued at a later date.

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INTRODUCTION

Electrical installations of ships with electric and/or electronic systems need to operate under a wide range of environmental conditions.

The control of undesired electromagnetic emission ensures that no other device on board will be unduly influenced by the equipment under consideration. Suitable limits are specified.

On the other hand, the equipment needs to function without degradation in the normal electromagnetic environment. The limit values for immunity, specified in this International Standard, have been chosen under this assumption. Equipment which is tested and installed in accordance with this International Standard meets the relevant IMO requirements. Special risks, for instance lightning strikes, transients from the operation of circuit breakers and electromagnetic radiation from radio transmitters are also covered.

Complex electric and/or electronic systems require EMC planning in all phases of design and installation, considering the electromagnetic environment, any special requirements and the equipment performance.

This third edition of IEC 60533 is applicable to electromagnetic compatibility of all electrical and electronic installations in ships with metallic hull.

It is based on the assumption that the ship is constructed in such a way that metallic hull and structure parts will significantly attenuate electromagnetic disturbance from the outer deck environment to the inner deck environment and vice versa.

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ELECTRICAL AND ELECTRONIC INSTALLATIONS IN SHIPS – ELECTROMAGNETIC COMPATIBILITY (EMC) – SHIPS WITH A METALLIC HULL

1 Scope

This International Standard specifies minimum requirements for emission, immunity and performance criteria regarding electromagnetic compatibility (EMC) of electrical and electronic equipment for ships with metallic hull. Additional or divergent requirements for ships with non-metallic hull will be given in a future International Standard (IEC 62742).

This International Standard assists in meeting the relevant EMC requirements as stated in SOLAS 74, Chapter IV, Regulation 6 and Chapter V, Regulation 17. Reference to this International Standard is made in IMO Resolution A.813(19).

The normative part of this International Standard has been prepared as a product family EMC standard.

This International Standard further gives guidelines and recommendations on the measures to achieve EMC in the electrical and electronic installations of the following equipment groups:

a) group A: maritime navigation and radio communication equipment and systems;
b) group B: power generation and conversion equipment;
c) group C: equipment operating with pulsed power;
d) group D: switchgear and controlgear;
e) group E: intercommunication and signal processing equipment and control systems;
f) group F: non-electrical items and equipment;
g) group G: integrated systems.

The basic EMC standard for groups A and C is IEC 60945. The EMC requirements according to IEC 60945 apply additionally for

- bridge mounted equipment;
- equipment in close proximity to receiving antennas;
- equipment capable of interfering with the safe navigation of the ship and with radio communication.

Effects on humans, like exposure to electromagnetic fields, and basic safety requirements such as protection against electric shock and dielectric strength tests for equipment are not within the scope of this International Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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IEC 60945, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-16, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*

CISPR 16-1-4, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-3, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

IACS E10, *Test specification for type approval*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161 and the following apply.

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3.1
electromagnetic compatibility
EMC
ability of an equipment or system to function satisfactorily in its *electromagnetic environment* without introducing intolerable *electromagnetic disturbances* to anything in that environment

[SOURCE: IEC 60050-161:1990, 161-01-07)

3.2
electromagnetic influence
effect of electromagnetic quantities on electrical and electronic circuits, equipment, systems or humans

3.3
electromagnetic interference
EMI
degradation of the performance of an equipment, transmission channel or system caused by an electromagnetic disturbance

Note 1 to entry: In French, the terms “perturbation électromagnétique” and “brouillage électromagnétique” designate respectively the cause and the effect, and should not be used indiscriminately.

Note 2 to entry: The English words "interference" and "disturbance" are often used indiscriminately.

[SOURCE: IEC 60050-161:1990, 161-01-06)

3.4
degradation
<of performance> undesired departure in the operational performance of any device, equipment or system from its intended performance

Note 1 to entry: The term "degradation" can apply to temporary or permanent failure.

[SOURCE: IEC 60050-161:1990, 161-01-19]

3.5
loss of function
loss of function of a device beyond that permissible and where the function can be restored only by technical measures

Note 1 to entry: A special case of loss of function is destruction.

Note 2 to entry: Loss of function may be permanent or temporary:

– technical measures to correct permanent loss require the use of tools or spare parts;

– technical measures to correct temporary loss require simple operator actions such as resetting a computer or reswitching.

3.6
electromagnetic disturbance
any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

Note 1 to entry: An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

[SOURCE: IEC 60050-161:1990, 161-01-05]

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3.7
emitter
<of electromagnetic disturbance> device, equipment or system which gives rise to voltages, currents or electromagnetic fields that can act as electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-23]

3.8
susceptible device
device, equipment or system whose performance can be degraded by an electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-24]

3.9
emission
electromagnetic emission
phenomenon by which electromagnetic energy emanates from a source

[SOURCE: IEC 60050-161:1990, 161-01-08]

3.10
immunity
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-20]

3.11
coupling
interaction of circuits between which energy can be transferred

3.12
insertion loss
logarithmic ratio of the magnitude of the power which a load picks up when fed directly from the power source, to the magnitude of the power which the load picks up after inserting a two-port network (for example a filter) between source and load

3.13
return loss
a
logarithmic ratio of the reciprocal value of the reflection factor:

$$a = 20 \times \lg \frac{1}{r};$$

where

r is the ratio of return wave to forward wave

Note 1 to entry: $r = 0$, $a = \infty$, if the impedance of the protection circuit is matched to the wave impedance of the connected cable.

3.14
EMC analysis
compilation and interpretation of EMC data to determine the degree of influence with electrical devices

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3.15
electromagnetic interference matrix
EMI matrix
structure where emitters are set against susceptible devices

Note 1 to entry: At the crosspoints of lines and columns the extent of electromagnetic interference is noted.

3.16
system
set of devices and/or components which interact according to a design

EXAMPLE Hardware (controlling system, controlled system), software, human interaction.

Note 1 to entry: The total ship with its equipment may be considered to be a system.

3.17
subsystem
single device and/or component intended to perform a given function, combining a number of sub-units, electrically and mechanically

3.18
integrated system
combination of separate systems intended to perform a given function

EXAMPLE Integrated cargo monitoring system with sensors and equipment in different zones.

3.19
ground
earth
point, plane, or surface designated as the zero potential (nominally) and serving as a common reference potential for electrical or electronic equipment

EXAMPLE Ship's metallic structure and all other metal parts conductively interconnected.

Note 1 to entry: For EMC purposes, interconnections between metal parts equalize the different potentials and require a low impedance in the frequency range considered. The frequency range considered includes the operating as well as the disturbing frequencies. This frequency range and the physical size of the electrical device determine the achievable equalization of potentials and thus the effectiveness of the grounding. The ground (earth) does not in all cases meet the personnel safety requirements of the protective earth.

Note 2 to entry: For ships with a non-metallic structure, all conductively interconnected metal parts (including earth/ground plate if existing) form the common ground (earth).

3.20
grounding
establishing of potential difference minimizing electrical connections

Note 1 to entry: The term "bonding" is normally used for the act of creating a conductive path between two conductive surfaces.

Note 2 to entry: The term "earthing" (US, CA: "grounding") is normally used for measures to prevent the danger of an electric shock by connection to earth. Additionally, "earthing/grounding" are used for the act of creating a return path to the power source.

3.21
type test
test for a sample item of equipment to ascertain that it meets the requirements according to this International Standard

3.22
port
defined interface of an equipment with the external electromagnetic environment through which disturbances may be received or emitted

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Note 1 to entry: Conductive interfaces may also consist of cables, bond straps or mechanical interfaces such as metallic pipes and mounting provisions.

Note 2 to entry: No testing needs to be performed on the ground port.

Note 3 to entry: See Figure 1.

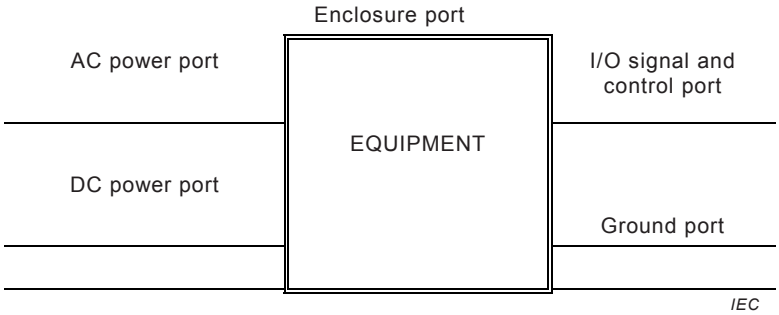

Figure 1 – Examples for ports

3.23
zone
area characterized by sensitive and/or disturbing devices located therein

SEE: Figure 2.

3.24
deck and bridge zone
area in close proximity to receiving and/or transmitting antennas and the wheelhouse as well as the control rooms, characterized by equipment for intercommunication, signal processing, radio communication and navigation, auxiliary equipment and large openings in the metallic structure

SEE: Figure 2.

3.25
general power distribution zone
area characterized by normal consumers

SEE: Figure 2.

3.26
special power distribution zone
area characterized by propulsion systems, bow thrusters, etc.

SEE: Figure 2.

Note 1 to entry: The generated emissions exceed the limits given in Table 3.

3.27
accommodation zone
area characterized by equipment that is non-essential for the ship's purpose

SEE: Figure 2.

EXAMPLE Crew quarters; offices; mess; lounges; passenger cabins.

Note 1 to entry: Precautions should be taken for a sufficient decoupling of the accommodation zone from all other zones.

3.28
normal consumers
equipment for ship's operation

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EXAMPLE Machinery, control equipment, static convertors.

3.29
cable selection
allocation of cables to categories depending on signal type and level

3.30
cable separation
routing of cables of different categories with intermediate free space in order to reduce interference

3.31
***in-situ* testing**
testing at the mounting place

Note 1 to entry: *In-situ* testing cannot be performed with standardized procedures under controlled conditions. That means only test facilities can be standardized, not the test and environmental conditions.

Note 2 to entry: *In-situ* testing can be performed, for example, in case of large and or heavy installations.

3.32
metallic hull
watertight main part or body of a ship made of metal or other equivalent conductive material

Note 1 to entry: It can be assumed that a metallic hull significantly reduces electromagnetic field strengths.

Note 2 to entry: Aside from that, measures are taken to reduce disturbance currents from entering or leaving the inner deck environment.

4 General

Ships' equipment and systems can be exposed to various kinds of electromagnetic disturbances conducted by power or control lines or directly radiated from the environment. The types and levels of disturbances depend on the particular conditions in which the system, the subsystems or the equipment are installed and to be operated.

The individual equipment of a ship can also be a source of electromagnetic disturbances over a wide frequency range, conducted through power and signal lines, or directly radiated, affecting the performance of other equipment or influencing the external electromagnetic environment.

The acceptance criteria for the tests for immunity requirements are related to performance criteria which are defined in terms of operational requirements.

For the emission limits, the objective of these requirements is to ensure that the disturbances generated by the equipment and systems do not exceed a level which could prevent other equipment and systems from operating as intended.

The emission limits of this International Standard may not, however, provide adequate protection against interference to radio receivers when other ship equipment is used closer than 3 m to the receiving antenna, see Annex A.

In special cases, for instance when highly susceptible equipment is being used closer than 3 m to a transmitting antenna, additional mitigation measures may have to be employed to increase the electromagnetic immunity beyond the limits specified in Clause 7.

NOTE The minimum immunity requirements in Clause 7 represent a typical electromagnetic environment and have been selected so as to ensure an adequate level of immunity for ships.

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5 EMC test plan

5.1 Objective

Prior to performing the tests, an EMC test plan shall be established. It shall contain as a minimum the elements given in 5.2 to 5.5.

Tests detailed in this International Standard are normally conducted as type tests and shall be carried out whenever possible at an EMC test laboratory. For test procedures, reference is made to IEC basic standards.

However, in cases where type tests are impracticable (e.g. large mechanical dimensions of equipment, functional control), individual tests may be performed. This can be done *in situ*, if necessary, and in accordance with a tailored test procedure. *In-situ* testing is not as repeatable as testing on a test site. Therefore, care should be taken when using the results of *in-situ* testing on one site to predict compliance for a product from series production.

5.2 Configuration of equipment under test (EUT)

5.2.1 General

Ships' systems are not uniform assemblies. The type, number and installation of equipment, whether installed individually or integrated, may vary from system to system. Hence it is not reasonable to test every possible arrangement; however, it is recommended to carry out type tests.

For a realistic simulation of the EMC situation (related both to emission and immunity), an assembly of EUT with its auxiliary equipment, such as cabling, power supplies, etc. shall be built to represent a realistic installation. This assembly shall be operated as far as possible under normal conditions (including the software).

5.2.2 Assembly of EUT

If the EUT to be type tested is a system, subsystem or equipment likely to be installed at distributed locations, one or more typical configurations with all components of the EUT shall be chosen to reproduce the real installations. A justification for the chosen configurations shall be provided in the EMC test plan.

NOTE The type test certificate issued after the test is valid only for the EUT composition listed in the EMC test plan.

5.2.3 EUT interconnecting cables

A sufficient number of interconnecting cables shall be selected. At least one of each type of interconnecting cable shall be used during testing in a representative configuration.

Interconnecting cables shall be standardized types, see Table B.1. Where special cables are required, the manufacturer of the EUT should provide the specification.

5.2.4 Auxiliary equipment

A list of all auxiliary equipment shall be provided. The auxiliary equipment enumerated shall be sufficient to simulate all realistic operational conditions and to ensure that all feasible types of operation can be performed.

5.2.5 Cabling and grounding

The EUT shall be connected with all necessary cables and connected to ground in accordance with the manufacturer's specifications and the installation requirements. There shall be no additional grounding connections.

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5.3 Test pre-conditioning

5.3.1 Operational conditions

Typical operating modes of the EUT shall be defined by the manufacturer before testing, considering that only the most typical functions of the equipment can be tested, for example analogue signals at 0 %, 50 % and 100 % magnitude, or digital signals with typical impulse trains. Particular attention shall be paid to the choice of critical mode.

5.3.2 Environmental conditions

EMC tests shall be performed under normal environmental conditions. Normal environmental conditions shall consist of any convenient combination of temperature in the range +15 °C to +45 °C and relative humidity in the range 20 % to 75 %.

When it is impractical to perform the tests under the environmental conditions defined above, a note to this effect stating the actual environmental conditions prevailing during the tests shall be appended to the test report.

5.3.3 Test software

The test software used for different modes of operation shall be identified.

5.4 Acceptance criteria

Pass/fail criteria for each port and test shall be specified. The acceptance criteria shall be specified as quantitative values where possible.

For evaluation, the performance criteria are as follows:

Performance criterion A

The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

Performance criterion B

The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed as defined in the relevant equipment standard and in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self-recoverable is however allowed; but no change of actual operating state or stored data is allowed.

Performance criterion C

Temporary degradation or loss of function or performance is allowed during and after the test, provided the function is self-recoverable, or can be restored by the operation of the controls as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

5.5 Scope of EMC testing

Each test to be applied shall be specified in the EMC test plan based on the equipment test matrix in Table 1. The description of tests, the test methods, the characteristics of the tests and the test set-ups are given in the basic standards which are referred to in 6.2 and 7.2. In addition, information needed for the practical implementation of the tests is given in this International Standard. In some cases the EMC test plan should specify the application in detail.

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