

INTERNATIONAL STANDARD



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



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INTERNATIONAL STANDARD



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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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;
- 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- withdrawn,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.

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

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.

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. ~~It assists in meeting the requirements of IMO resolution A.813 (see annex A).~~ Additional or divergent requirements for ships with non-metallic hull will be given in a future International Standard (IEC 62742).

~~Equipment which is tested and installed in accordance with this standard meets the relevant IMO requirements.~~

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).

~~NOTE 1~~ The normative part of this International Standard has been prepared as a product family EMC standard.

~~NOTE 2~~ Effects on human beings are not the subject of this 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 ~~and navigation~~ equipment and systems;
- b) group B: power generation and conversion equipment;
- c) group C: equipment operating with pulsed power;
- d) group D: switchgear and ~~control systems~~ 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.

~~NOTE~~ This standard does not specify unsafe operation. 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 Guide 107: Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications~~

~~IEC 60050(161): International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility~~

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

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

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

~~IEC 60092-504: Electrical installations in ships – Part 504: Special features – Control and instrumentation~~

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

~~IEC 61000-1-1: Electromagnetic compatibility (EMC) – Part 1: General – Section 1: Application and interpretation of fundamental definitions and terms~~

~~IEC 61000-4-1: Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 1: Overview of immunity tests. Basic EMC Publication~~

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

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: Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus~~

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: Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbance and immunity~~

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*

~~SOLAS, International Convention for the Safety of Life at Sea, 1974 (as amended)~~

~~IMO Resolution A.813 (19):1995, General requirements for electromagnetic compatibility (EMC) for all electrical and electronic ship's equipment~~

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. ~~Generic definitions can also be found in IEC 60050(161) and in IEC 61000-1-1.~~

~~Additional definitions, not included in IEC 60050(161) but nevertheless necessary for the application of the different tests, are given in the Basic EMC publications.~~

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" ~~is also used with the meaning of 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]

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 ~~(to a disturbance)~~**

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 ~~from one to another~~

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 ~~four-pole device~~ **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

3.15**electromagnetic interference matrix****EMI matrix**

~~matrix structure~~ where emitters ~~of disturbance~~ are set against susceptible devices ~~of disturbance~~.

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

3.14**~~equipment under test (EUT)~~**

~~equipment (devices, appliances and systems) subjected to EMC (emission and immunity) compliance tests~~

3.16 system

set of devices and/or components which interact according to a design. ~~A device and/or component of a system can be another system (called subsystem).~~

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 ~~equipment or~~ subsystem

~~a technical~~ 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 ~~items of equipment interconnected for the intended performance of 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 For protective ground (protective earth) see 3.19.~~

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).

~~3.19 protective ground (protective earth)~~

~~conductor, necessary as a protective measure against currents dangerous to the human body, which electrically connects the conductive parts of the equipment casing with one or more of the following:~~

- ~~— external conductive parts;~~
- ~~— main grounding (earthing) terminal;~~
- ~~— earth point of power distribution system, if existing;~~
- ~~— metallic casing of other equipment.~~

3.20 reference ground

~~conductor whose potential is that to which the potentials of other conductors refer~~

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

EMC test for a sample item of equipment to ascertain that ~~its design~~ it meets the requirements according to this International Standard

3.22 port

particular defined interface of an equipment with the external electromagnetic environment through which disturbances may be ~~suscepted~~ received or emitted

Note 1 to entry: Conductive interfaces may also consist of cables, ~~grounding bonds~~, 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.

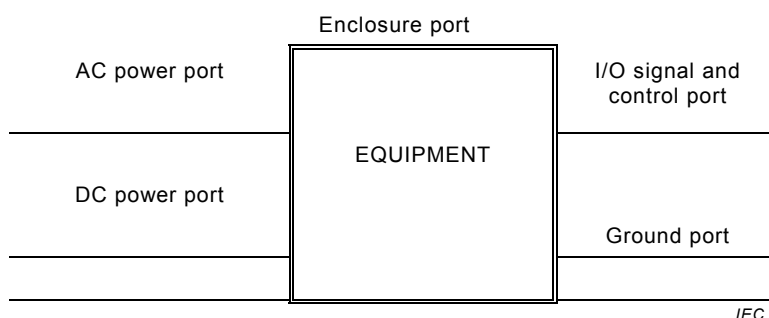


Figure 1 – Examples for ports

3.23 zones

area characterized by sensitive and/or disturbing devices located therein

- ~~— 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;~~
- ~~— general power distribution zone: area characterized by normal consumers;~~
- ~~— special power distribution zone: area characterized by propulsion systems, bow thrusters, etc., producing emissions exceeding the limits given in table 3;~~
- ~~— accommodation zone: area of ships characterized by equipment, carried on board by passengers, crew and other persons to be operated 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

EXAMPLE Machinery, control equipment, ~~small~~ static convertors.

3.29

cable selection

~~cables of similar signal types and levels are selected and assigned to the same category~~
allocation of cables to categories depending on signal type and level

3.30

cable separation

~~routing of~~ cables of different categories ~~routed~~ with intermediate free space in order to reduce interference ~~crosstalk~~

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 ~~subjected~~ **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 ~~have to operate 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.

NOTE 2 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.

NOTE 3 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.

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 ~~EMC~~ test procedures, reference is made to IEC basic standards.

However, in cases where type tests are impracticable (~~dimension of EUT, 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.

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 ~~conducted~~ 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.

Performance criteria for the individual tests are given in Table 1.

NOTE Normally, no additional EMC tests are required beyond those stated in this International Standard.

6 Emission requirements

6.1 Conditions during the emission tests

Measurements shall be made with the EUT in the operating condition that produces the highest emission level in the frequency band being investigated, see Clause 5.

NOTE 1 The conducted emission limits covered here are given on a port-by-port basis.

NOTE 2 The radiated emission requirements within the range of receiving frequencies presume in the deck and bridge zone a minimum distance of 3 m between the emitters and the receiving antennas. For ~~smaller~~ distances **less than 3 m, an extra a special compatibility analysis is necessary shall be carried out.**

Measurements shall be performed in well-defined and reproducible conditions for each type of emission.

The description of the tests, the test methods and the test set-ups are given in the basic standards as stated in Table 2 and Table 3. Measurements shall be performed with a quasi peak detector.

The measuring bandwidth stated in CISPR 16-1-1 is 200 Hz in the frequency range 10 kHz to 150 kHz, 9 kHz in the frequency range 150 kHz to 30 MHz and 120 kHz in the frequency range 30 MHz to 2 000 MHz. According to IEC 60945, the measuring bandwidth shall be 9 kHz in the frequency range 156 MHz to 165 MHz, a peak detector or frequency analyser may be accepted in accordance with the manufacturer of the EUT and the test laboratory.

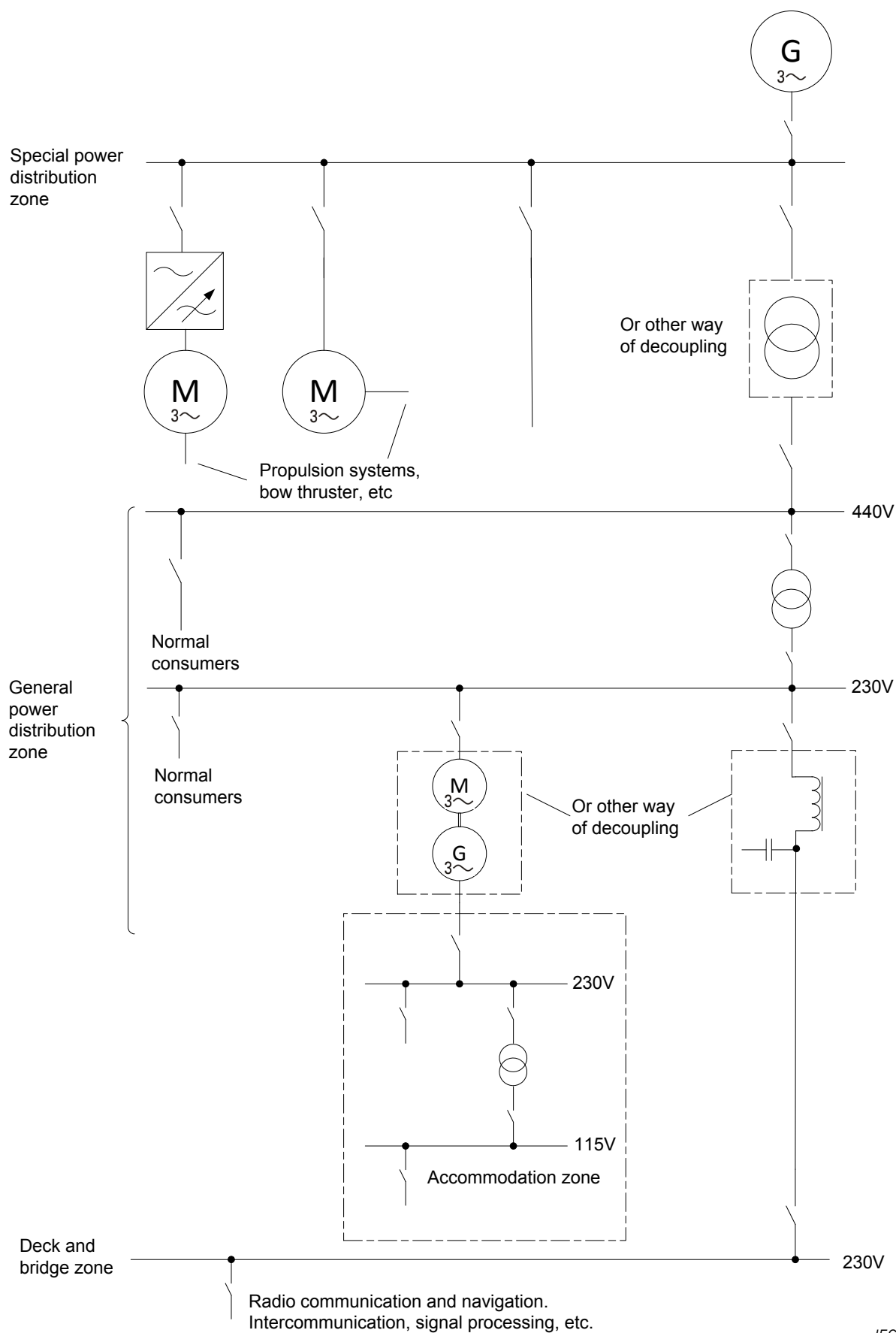
6.2 Emission limits

6.2.1 General

~~NOTE 1~~ Equipment not permanently installed which is intended to be operated in the ~~passenger~~ accommodation zone ~~is not required to comply with any emission limits~~ (non-essential equipment) shall comply with IEC 61000-6-1 and IEC 61000-6-3 or equivalent standards.

~~NOTE 2~~ Precautions should be taken for a sufficient decoupling of the accommodation zone from all other zones.

Figure 2 is an example schematic diagram of zones.



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Figure 2 – Schematic diagram of zones (example)

6.2.2 Emission limits for equipment installed in the deck and bridge zone

Emission limits for equipment installed in the deck and bridge zone are given in Table 2.

Table 2 – Emission limits (deck and bridge zone)

Port	Frequency range	Limits	Basic standard
Enclosure (radiated emission)	150 kHz to 300 kHz	80 dB μ V/m to 52 dB μ V/m ^c	CISPR 16-1-4 ^a
	300 kHz to 30 MHz	52 dB μ V/m to 34 dB μ V/m ^c	CISPR 16-2-3 ^a
	30 MHz to 2 GHz	54 dB μ V/m ^c	
	except: 156 MHz to 165 MHz	24 dB μ V/m ^c 30 dB μ V/m	CISPR 16-2-3 ^a CISPR 16-2-3 ^b
Power, I/O signal and control (conducted emission)	10 kHz to 150 kHz	96 dB μ V to 50 dB μ V	CISPR 16-1-2
	150 kHz to 350 kHz	60 dB μ V to 50 dB μ V	CISPR 16-2-1
	350 kHz to 30 MHz	50 dB μ V	
^a Measured at a distance of 3 m. ^b Measured with a peak detector or a frequency analyser at a distance of 3 m. ^c Values in accordance with IACS E10, applicable for intended operation in ship's environment.			

6.2.3 Emission limits for equipment installed in the general power distribution zone

Emission limits for equipment installed in the general power distribution zone are given in Table 3.

Table 3 – Emission limits (general power distribution zone)

Port	Frequency range	Limits	Basic standard
Enclosure (radiated emission)	150 kHz to 30 MHz	80 dB μ V/m to 50 dB μ V/m	CISPR 16-1-4 ^a
	30 MHz to 100 MHz	60 dB μ V/m to 54 dB μ V/m	CISPR 16-2-3 ^a
	100 MHz to 2 000 MHz	54 dB μ V/m	
	except: 156 MHz to 165 MHz	24 dB μ V/m 30 dB μ V/m	CISPR 16-2-3 ^a CISPR 16-2-3 ^b
Power, I/O signal and control (conducted emission)	10 kHz to 150 kHz	120 dB μ V to 69 dB μ V	CISPR 16-1-2
	150 kHz to 500 kHz	79 dB μ V	CISPR 16-2-1
	500 kHz to 30 MHz	73 dB μ V	
NOTE Between the general power distribution zone and the special power distribution zone, a decoupling device should be installed in the power supply circuit (see Figure 2) capable of achieving a decoupling equivalent to the difference of the limits of the general power distribution zone and the existing emissions of equipment installed in the special power distribution zone. NOTE 1 Between the deck and bridge zone and the general power distribution zone an RFI filter ~~should~~ could be installed in the power supply circuit (see Figure 2) capable of achieving a decoupling of about 30 dB in the frequency range of 10 kHz to 30 MHz.			
^a Measured at a distance of 3 m. ^b Measured with a peak detector or a frequency analyser at a distance of 3 m.			

6.2.4 Emission limits for equipment installed in the special power distribution zone

For the special power distribution zone where semiconductors are connected having a total system rating representing a significant portion of the total system rating, it may not be feasible to suppress the low frequency as well as the high frequency harmonics. Appropriate measures should be taken to attenuate these effects on the distribution system so that safe operation is assured. Care should be taken in selecting consumers supplied from an electric power supply system with a higher harmonic content than specified.

NOTE An agreement should be reached between the manufacturer of the equipment and the user.

Further requirements are not defined for equipment installed in this zone.

7 Immunity requirements

7.1 Conditions during the immunity tests

The measurements shall be made with the EUT operating such that any reaction to the tests allows the required performance criteria to be recognized, see Clause 5.

The configuration and modes of operation during immunity tests shall be precisely noted in the test report.

Tests shall be applied to the relevant ports according to Table 4.

The tests shall be performed in accordance with the basic standards.

7.2 Minimum immunity requirements

The minimum immunity requirements and tests are given in Table 4.

Table 4 – Minimum immunity requirements for ~~ship~~ equipment

Port	Phenomenon	Basic standard	Performance criteria	Test value
AC power	Conducted low frequency interference	IEC 61000-4-16	A	10 % AC supply voltage 50 Hz to 900 Hz; 10 % to 1 % 900 Hz to 6 000 Hz; 1 % 6 kHz to 10 kHz
	Power supply variation	IEC 61000-4-11	A B	voltage: ± 20 % for 1,5 s frequency: ± 10 % for 5 s
	Power supply failure	IEC 61000-4-11	C	60 s interruption
	Electrical fast transient (burst)	IEC 61000-4-4	B	2 kV ^c
	Surge voltage	IEC 61000-4-5	B	0,5 kV ^{a,h} and 1 kV ^{b,h}
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms ^c ; (10 kHz) ^f 150 kHz to 80 MHz sweep rate $\leq 1,5 \times 10^{-3}$ decade/s ^g modulation 80 % AM (1 kHz)
DC power	Conducted low frequency interference	IEC 61000-4-16	A	10 % DC supply voltage 50 Hz to 10 kHz
	Power supply variation	IEC 61000-4-11	A B	Voltage + 20 % / – 25 % equipment non-connected to battery
	Power supply failure	IEC 61000-4-11	C	60 s interruption
	Electrical fast transient (burst)	IEC 61000-4-4	B	2 kV ^c
	Surge voltage	IEC 61000-4-5	B	0,5 kV ^a and 1 kV ^b
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms ^c ; (10 kHz) ^f 150 kHz to 80 MHz sweep rate $\leq 1,5 \times 10^{-3}$ decade/s ^g modulation 80 % AM (1 kHz)
I/O ports, Signal/control	Electrical fast transient (burst)	IEC 61000-4-4	B	1 kV ^d
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms ^c ; (10 kHz) ^f 150 kHz to 80 MHz sweep rate $\leq 1,5 \times 10^{-3}$ decade/s modulation 80 % AM (1kHz)
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	B	6 kV contact and 8 kV air
	Electromagnetic field	IEC 61000-4-3	A	10 V/m ^e 80 MHz to 2 GHz sweep rate $\leq 1,5 \times 10^{-3}$ decade/s modulation 80 % AM (1 kHz)

NOTE 1 Equipment not permanently installed which is intended to operate in the passenger accommodation zone is not required to comply with any immunity requirements.

NOTE 2 Precautions should be taken for a sufficient decoupling of the passenger accommodation zone from all other zones.

^a Line to line.

^b Line to ground.

^c Capacitive coupling.

^d Coupling clamp.

^e Special situations to be analysed.

^f Test procedure to be described in the test report.

^g For equipment installed in the deck and bridge zone, the test levels shall be increased to 10 V r.m.s. for spot frequencies in accordance with IEC 60945 at 2 MHz / 3 MHz / 4 MHz / 6,2 MHz / 8,2 MHz / 12,6 MHz / 16,5 MHz / 18,8 MHz / 22 MHz / 25 MHz. For ~~screened~~ shielded cables a special test set-up shall be used enabling the coupling into the cable ~~screen~~ shield.

^h Values in accordance with IACS E10, applicable for intended use in ship's environment.

7.3 System aspects

If higher levels or tests of other phenomena under special system aspects are necessary (for example, equipment very close to transmitting antenna) the immunity shall be increased or mitigation measures in the installation shall be applied.

8 Test results and test report

The test results shall be recorded in a comprehensive test report. The test report shall accurately, clearly, unambiguously and objectively present the objective, the results and all relevant information of the tests. The test report shall clearly define the EUT, including the cable layout, cable types and the auxiliary equipment used. Any deviation from the EMC test plan shall be mentioned, [see Annex C](#).

Annex A
(informative)

IMO Resolution A.813 (19): 1995

INTERNATIONAL MARITIME
ORGANIZATION



A 19/Res.813
18 December 1995
Original: ENGLISH

ASSEMBLY
19th session
Agenda item 10

RESOLUTION A.813(19)
adopted on 23 November 1995

**GENERAL REQUIREMENTS FOR ELECTROMAGNETIC COMPATIBILITY (EMC)
FOR ALL ELECTRICAL AND ELECTRONIC SHIP'S EQUIPMENT**

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO resolution A.694(17), which requires that all reasonable and practical steps should be taken to ensure electromagnetic compatibility between the equipment concerned and other radiocommunication and navigational equipment carried on board in accordance with the relevant requirements of chapters IV and V of the International Convention for the Safety of Life at Sea (SOLAS), 1974,*

NOTING the growing number of problems experienced with equipment that is susceptible to electromagnetic interference, which can result in dangerous situations,

NOTING ALSO that some standards on electromagnetic compatibility have been developed,

RECOGNIZING the need to prepare standards on electromagnetic compatibility for all electrical and electronic ship's equipment to ensure the operational reliability and suitability of such equipment,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-fifth session,

INVITES Governments to ensure that all ship's electrical and electronic equipment is tested to the relevant electromagnetic compatibility standards.

* IEC Publications 533 and 945.

Annex A (informative)

General EMC planning procedures

A.1 Introduction Overview

Annex B contains guidelines for achieving EMC for ships and their equipment. The general procedures for achieving EMC are described.

By using this International Standard, an adequate consideration of EMC matters in the planning, construction and operation stages can be reached. This allows EMC measures to be realized in timely fashion during the course of the project, whilst respecting the necessary coordination.

During the lifetime of the ship, it is important that the EMC is not impaired by maintenance procedures and that, for modifications and extensions, maintenance is achieved by the application of minimum requirements.

A.2 General procedures

The aim of Annex A is to support the manufacturer responsible for the overall performance of the ship in achieving the EMC of the system. Since EMC is a quality related feature, it is necessary to treat it in the same way as general quality assurance.

Depending on the complexity of the system, EMC management needs to control and monitor the following activities for achieving EMC:

- EMC analysis;
- planning and performing EMC measures;
- checking EMC measures on equipment;
- checking implementation and effectiveness of EMC measures in the system;
- ensuring EMC measures remain effective during the system's lifetime.

A.3 EMC management

A.3.1 General

For most merchant ships, EMC management is a general management task, normally assigned to one responsible person. Appropriate skills are expected to be found in the electrical and electronic department of the shipyard.

For more complex ships more extensive skills and knowledge might be necessary. In this case, an EMC advisory group should be established to support the management in making the appropriate decisions in EMC matters.

A.3.2 EMC advisory group

The EMC advisory group should be established during the planning phase of the system. The group is chaired by the person responsible for EMC matters.

In the group, experts from different disciplines work together to define the EMC requirements of the system, sufficiently and economically justified by the occurrence of potential EMC problems, technology know-how and assessment of EMC measures.

Members of the EMC advisory group should include:

- representative of the contractor;
- representative of the customer;
- representatives of the suppliers of EMC-related equipment;
- representative of the classification society;
- independent EMC experts.

Not all members of the group are necessarily permanent members. The contractor has the authority to invite temporary members, depending on the subject treated.

A.3.3 EMC management tasks

The basic sequence of management tasks to achieve EMC is as follows:

- carry out a rough EMC analysis;
- establish EMC requirements for the equipment;
- define required operational conditions;
- define installation recommendations;
- define quality assurance measures;
- discuss results of preceding steps;
- perform additional EMC measures.

A.3.4 Rough analysis

The initial analysis of the EMC situation shall answer the following questions.

- a) Which equipment could be influenced by transmitting antennas?

The primary influence mode is radiation. Consequently all above-deck equipment may be influenced. Below-deck equipment may profit from the shielding properties of the metal hull. However, electronic equipment installed in the deck and bridge zone should be considered.

- b) Which equipment could interfere with receiving antennas?

Influence also comes from radiation. Only strong radiating equipment in the deck and bridge zone should be considered. It is difficult to prevent system interference due to the number of transmitting and receiving antenna systems on the top deck. Systems that radiate/receive in-band and near-band with other systems require spectrum planning and precise antenna location and design. A compatibility matrix should be made to prevent inter system EMI from intentional emitters to all receivers. During the design phase the locating and relocating of the different antennas and sensors on the top deck will use the results of this matrix.

The strict emission requirement in the VHF-range between 156 and 165 MHz is based on the requirement by the telecommunication authority.

- c) Which electronic equipment could be disturbed by radiating electric power lines and equipment?

Radiation coming from electric power lines and equipment normally decays with distance. Therefore, only equipment in close proximity to the radiating electric power lines and equipment need be considered.

- d) Which electronic equipment could suffer interference from inadequate network quality?

Standard ship's ~~network quality is~~ power supply system characteristics are defined in IEC 60092-101. Disturbance may occur when susceptible electronics and emitting power electronics are connected to the same busbar.

A.3.5 EMC requirements for equipment

The primary requirement of equipment before installation on board the ship is compliance with the applicable EMC standards. This should be certified in the manufacturer's specifications. Every case of non-compliance shall result in additional analysis work, and, in many cases, ~~necessitate design constraints consideration during designing~~ or additional EMC measures.

A practical requirement is reliable and interference-free operation in the environment where the equipment is installed. For this, suppliers of equipment need to be informed about the EMC-features of the environment.

A.3.6 EMC interface agreements

When simultaneous operation of equipment combinations is subject to the risk of mutual EM-interference, the contractor should require the suppliers of the equipment to come to an agreement about measures necessary for undisturbed operation. Such an agreement should describe measures, responsibilities and quality assurance procedures.

A.3.7 Installation recommendations

Installation recommendations with special consideration of EMC are contained in Annex B.

Special installation requirements may result from the rough analysis, for example when spacing between devices is mandatory.

A.3.8 Assessment of conformity with EMC regulations

A.3.8.1 General

Assessment of conformity with the EMC regulations is a subtask of general quality assurance. Appropriate measures may be assigned to one of the following levels:

- equipment level;
- production supervision level;
- system level.

Similar to the general quality assurance, EMC assurance shall be performed in agreed cooperation between the appropriate bodies¹ and the quality assurance staff of the manufacturer.

A.3.8.2 Equipment level of conformity with EMC regulations

For equipment conformity, presentation of appropriate certificates is satisfactory. If such certificates cannot be presented for individual systems, agreed tests should be carried out in cooperation with the appropriate bodies.

A.3.8.3 Production supervision for EMC

During the ship's construction the applicable measures of Annex B should be observed. Special attention should be given to the performance of "decoupling by design", i.e. spacing between radiating and susceptible equipment—~~must~~ **should** not be reduced, unintended disturbance connection to susceptible equipment via the same busbar—~~must~~ **should** be avoided, etc.

¹ Government authorities, notified bodies, classification societies, etc.

A.3.8.4 System level of conformity with EMC regulations

The standard procedure to prove EMC of the system is the "switch-on/switch-off test". During this test combinations of electrical and electronic devices are operated and observed to detect effects possibly caused by electromagnetic influence. If such effects occur, the source should be identified by sequentially switching off and on those devices that are likely to produce interference.

The evaluation of electromagnetic influence effects should conform to the performance criteria defined in this International Standard, unless otherwise specified.

A.3.9 Additional measures

If, due to the complexity of the ship, additional measures beyond the basic tasks described in A.3.3 are required by the appropriate bodies, an analysis as described in Clause A.4 should be carried out.

If this analysis reveals the need for additional EMC measures, planning and realization should be performed as described in Clause A.5.

The verification of the efficiency of the above-mentioned EMC measures is carried out by testing and inspection as described in Clause A.6.

A.4 Full EMC analysis

A.4.1 General

EMC analysis can be used to specify limits for equipment and units within systems. A flow chart for the analysis of equipment is given in Figure A.1. A similar procedure applies to subsystems.

A full EMC analysis can be performed and in the case of complex systems this is often necessary. In some cases it is sufficient to perform only parts of an analysis: for example, preparing frequency or level surveys or specifying compatibility levels.

A.4.2 Electromagnetic interference matrix (EMI matrix)

In the case of a full EMC analysis, an EMI matrix is drawn up. EMI relevant data on the ship's equipment is collected and recorded on EMI sheets. This equipment, potential emitters as well as susceptible devices ~~of disturbance~~ are entered into the matrix. At each of the crosspoints an analysis is performed to ascertain whether the pieces of equipment interfere with one another. The result is noted by means of symbols at the crosspoints and then the matrix is analysed. Conclusions can be drawn from the analysis concerning the EMI levels of the equipment and EMC measures to be taken for the system.

Figure A.2 shows an example of an electromagnetic interference matrix (EMI matrix). Emitters of disturbance are recorded in the columns, and susceptible devices ~~of disturbance~~ are recorded in the rows. Equipment will normally appear in both the columns and the rows. Each piece of equipment is ~~assigned~~ **designated** by a matrix number. In addition, data from the electromagnetic environment is recorded in the matrix.

A.4.3 Collection of data

To conduct an EMC analysis, various data have to be obtained. These include:

- a) emission and immunity levels;
- b) dimensions of equipment;
- c) distances between the units;

- d) data concerning cables, both power and signal cables;
- e) electric and electronic data of the equipment, such as:
 - 1) power;
 - 2) frequencies / frequency ranges;
 - 3) the sensitivity level of receivers;
 - 4) the transmitting power of transmitters, etc.

Also necessary are:

- f) data concerning the details of the installation;
- g) levels in the electromagnetic environment.

Preferably data from test reports have to be used. If these are not available, it may be necessary to estimate levels on the basis of the operation of equipment. These levels can then be employed until more accurate ones become available.

The way in which the equipment is installed and cables are connected needs to be known. This applies to the equipment configuration, the cable laying and the distances between these items. The EMC measures already planned for the system need to be known.

A questionnaire may be helpful to obtain this data from the equipment suppliers.

A.4.4 Data processing

A.4.4.1 EMI sheet

For each equipment the data are collected in a data base or on a separate "EMI sheet". This document is given a number, which is recorded in the EMI matrix for the fast retrieval of data. The sheet can be replaced if there are any changes of the data on the document.

A.4.4.2 Frequency surveys

On the basis of the data collected, a frequency survey is produced for the operating frequencies and their harmonic components. This applies especially to all frequency ranges in which equipment has frequencies either above the emission limit or below the immunity limit. An example is given in Figure A.3.

It is practical to carry out two types of survey, one for conducted interference and one for radiated interference.

The survey is especially important for the several transmitting and receiving pieces of equipment of the system. The frequency survey can be used to find out whether transmitting and receiving equipment are operating in the same frequency bands.

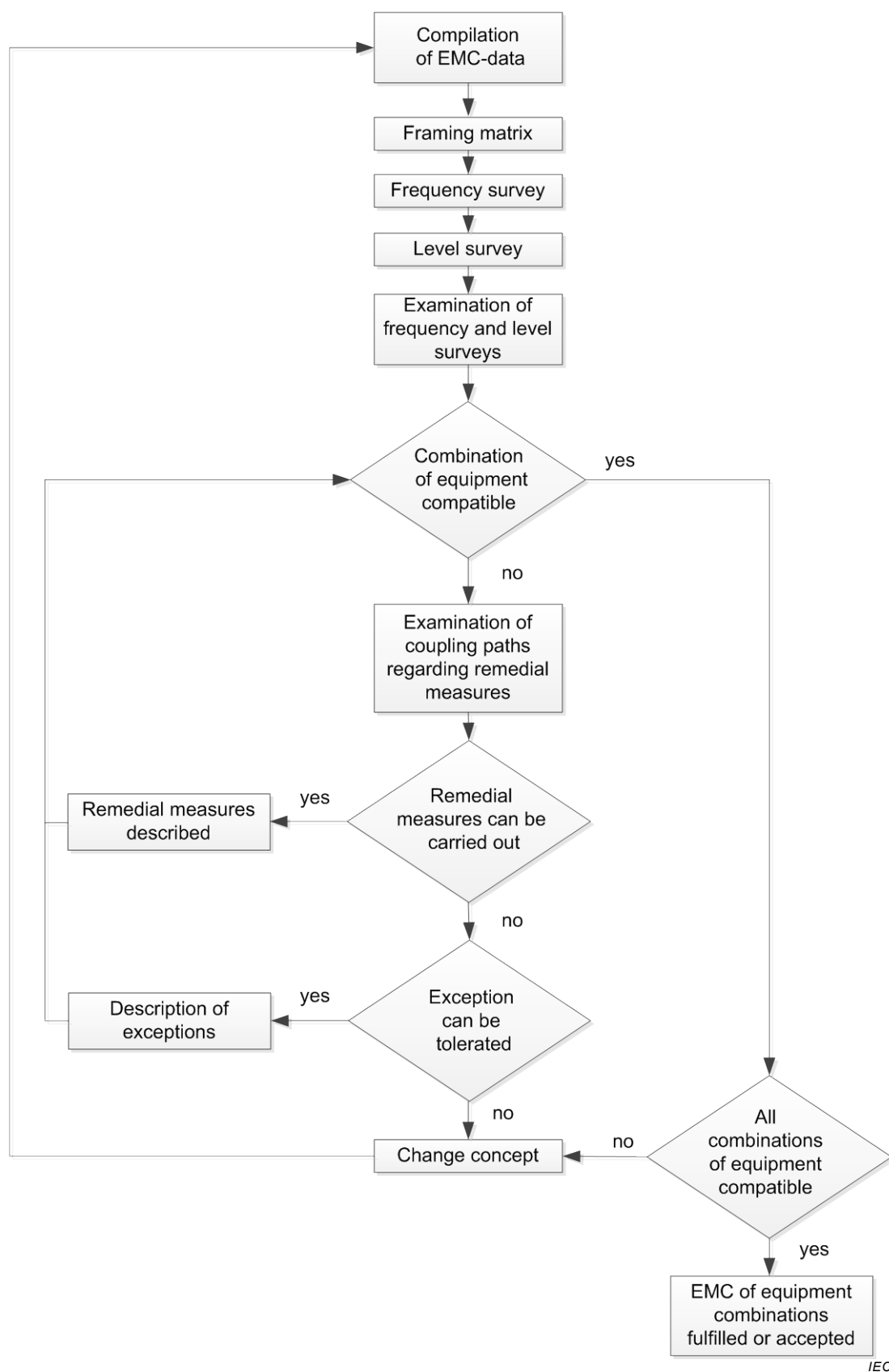
A.4.4.3 Level surveys

Level surveys indicate the emission and immunity levels in the frequency ranges. Figure A.4 gives an example of this. Surveys often only record levels that deviate from standard limits: for example, the emission level of a transmitter or the immunity level of a receiver. By including the limits contained in the relevant EMC-specification, it is also possible to see how far these levels either exceed the emission limits or fall below the immunity limits.

For conducted interference, the level survey will show whether the pieces of equipment will interfere with each other. In the case of conducted interference, not much damping usually occurs in wires or cables.

For interference resulting from crosstalk, the coupling impedance ~~must~~ needs to be known, and no conclusions can be drawn before a calculation has been performed.

A similar situation applies in the case of level surveys for interference. Before any conclusions can be drawn, distances and shielding objects (such as other equipment, metal components, etc.) need to be taken into account by calculating levels at the location of the equipment susceptible to disturbance.



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Figure A.1 – EMC analysis, flow chart