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INTERNATIONAL STANDARD

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

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

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

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

FOREWORD

International Standard IEC 62742 has been prepared by Technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

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

FDIS	Report on voting
18/1725/FDIS	18/1733/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/standardsdev/publications.

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- withdrawn,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.

INTRODUCTION

It is important that electrical installations of ships with electric and/or electronic systems 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. On the other hand, the equipment is expected to function without degradation in the normal electromagnetic environment. It is also important to take into account special risks, for instance lightning strikes, transients from the operation of circuit breakers and electromagnetic radiation from radio transmitters.

Experience related to the EMC of non-metallic ships can be expected in the area of defence technology. But most of this information including the documents is classified and therefore not publicly available. This document was derived from the NATO document ANEP 45 (unclassified), MIL-STD-1310H (NAVY) and VG 95375 (all parts) due to lack of information from other sources, for example from yards which had already built such kind of ships.

This document can assist to achieve electromagnetic compatibility of all electrical and electronic installations in ships with non-metallic hull, for example manufactured from wood or composite.

Composite structures typically comprise of resin and fibre laminate layers combined with a core material (colloquially referred to as a "sandwich"). The most widely used being glass fibre reinforced plastic (GRP or FRP). Many composites are non-conductive and offer no inherent electromagnetic shielding. Carbon fibre technology has the important characteristic of a conductive material that can provide electromagnetic shielding.

This document should be used during the ship design process and not as a problem solving procedure. The intent is to decrease the number of special EMI/EMC problems which could occur as a consequence of the use of non-metallic constructions.

Originally, this document had been designed as a "stand-alone-document" which covers the complete field of EMC similar to IEC 60533. But with progressing work, it became more and more clear that many repetitions of requirements already contained in IEC 60533 would have been necessary to fulfil the stand-alone demand: most of the requirements are identical, no matter whether composite or metal is used.

Finally, the project team came to the conclusion that it would be better to avoid repetitions. Therefore, this document was further prepared to align with, and refer to IEC 60533.

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

1 Scope

This document specifies minimum requirements for emission, immunity and performance criteria regarding electromagnetic compatibility (EMC) of electrical and electronic equipment for ships with non-metallic hull.

NOTE Requirements for metallic hull are given by IEC 60533. This document acts an extension of IEC 60533 to cater for EMC effects on non-metallic hull.

This document further gives guidance on how to achieve electromagnetic compatibility (EMC) on ships whose hull (surface) is made from non-metallic material and can also be useful for ships with hull comprising of a metallic hull, but with non-metallic superstructure or components.

This document assists in meeting the requirements of IMO resolution A.813(19).

It does not specify basic safety requirements such as protection against electric shock and dielectric tests for equipment. Electromagnetic effects on human beings are not the subject of this document.

NOTE More information on 'Basic safety' can be found in IEC guide 104.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

IEC 60092-507, *Electrical installations in ships – Part 507: Small vessels*

IEC 60533:2015, *Electrical and electronic installations in ships – Electromagnetic compatibility (EMC) – Ships with a metallic hull*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60533 and the following apply.

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

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

3.1
hull
watertight main part or body of a ship

3.2
compartment
subdivision of the hull formed by bulkheads

3.3
room
subdivision of a compartment or deck space

3.4
non-metallic
material which is non-conductive or has a high-impedance

EXAMPLE Carbon fibre, epoxy-glass resin, wood.

Note 1 to entry: The property under consideration is strictly seen not "metallic", but "conductive". "Conductive" is technically more correct, but because of the title of IEC 60533 and the fact that "metallic" is a synonym for "conductive", the term "metallic" has been applied. This also avoids the difficulty of having to specify measurement values for "conductive" and/or "non-conductive".

3.5
composite
composition of several materials, usually consisting of a core with several layers

EXAMPLE Glass reinforced plastic (GRP).

3.6
shield
<EMC> electrically conductive or magnetic material barrier or enclosure

EXAMPLE Metal plate, wire mesh, metal foil.

Note 1 to entry: Conductive ship structures can act as a shield.

3.7
shielding
<EMC> construction method to protect against disturbing electromagnetic emissions and/or to prevent unintended electromagnetic emissions

EXAMPLE Use of a conductive layer or enclosure.

3.8
screen
screening
<EMC> property of conductive or magnetic material to reduce (damp, filter) electromagnetic emissions

EXAMPLE A braided shield can be used for screening a cable from EMI.

Note 1 to entry: Shielding can be carried out by use of screening materials.

3.9
bond
electrically conductive path between two or more conductors

Note 1 to entry: A bond can be established by welding, bolting/clamping or with a special strap.

3.10
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

[SOURCE: IEC 60050-195:1998, 195-01-10]

3.11
reference earth
reference earth potential
ground, US, CA
point, plane, or surface designated as the zero potential (nominally) common reference point for electrical or electronic equipment

3.12
reference earthing
reference grounding, US, CA
method of establishing an electrical connection between a metallic item to earth potential

3.13
protective earthing
protective grounding, US, CA
earthing a point or points in a system or in an installation or in equipment, for purposes of electrical safety

[SOURCE: IEC 60050-195:2001, 195-01-11]

3.14
earth plate
ground plate, US, CA
earth electrode consisting of a metal plate below water level for common use as protective earth and reference earth

3.15
antenna ground plane
flat conductive surface that is at the same electric potential as reference earth

4 General

Installations shall comply with relevant requirements of IEC 60533, except those that are only relevant for metallic hull.

NOTE 1 The requirements of IEC 60533 are not fully applicable for non-metallic hull.

NOTE 2 Basic requirements on the design of a ship's electrical system are specified in IEC 60092-201 and IEC 60092-202. The ship specific climatic and mechanic environment is reflected by the condition limits and design parameters given in IEC 60092-101.

Two detailed comparative tables about the connection of this document with IEC 60533:2015 are given in Annex A and Annex B.

5 Electromagnetic environment (EME)

5.1 General

The specified electromagnetic environment needed in the early design phase should be based on prediction and experiences.

NOTE The electromagnetic environment describes those interferences which act on a system or equipment from outside. Because there is generally a lack of information in the early design phase, it is difficult to accurately define the real electromagnetic environment. Scale-modelling or test mock-ups or numerical simulation can help to build up the design information base. The field strengths are mainly influenced by the topside design and the maximum transmitting power combined with the antenna type.

5.2 Susceptibility study

A study shall be made, on the susceptibility of the equipment to be placed in a certain room compared with the expected electromagnetic environment, to decide if additional room-shielding is required.

NOTE 1 The result of a study can be:

a) no susceptibility problem expected; additional room shielding is not needed;

b) susceptibility problem expected; change arrangement of equipment, additional room-shielding is not needed;

c) susceptibility problem expected; decrease equipment susceptibility, additional room-shielding is not needed;

d) susceptibility problem expected; replace the equipment by less susceptible ones, additional room-shielding is not needed;

e) susceptibility problem expected; specify an overall shielded room if decreasing of equipment susceptibility is more burdensome than creating an additional room-shielding;

f) susceptibility problem expected; the problem can be controlled by operational regulations.

Which rooms to be shielded shall be identified during the design phase.

NOTE 2 Required equipment, relevant standards, specifications and rules normally influence the decisions on which rooms to be shielded, for example for the radiocommunication room.

NOTE 3 See the information about EMC plan in IEC 60533.

5.3 Unintentional radiators installed near VHF antennas

Lighting systems using light emitting diode (LED) technology (navigation lights, deck lighting, rigging lighting) and other electronic devices capable of unintentional radiated emission can cause interference to VHF marine radio and shipboard automatic identification system (AIS) equipment when installed near antennas. LED lighting certified to IEC 60945 should be separated from antennas by a distance greater than 15 m. If 15 m separation is not possible, devices should be separated by as much as possible, placed above or below the antenna plane, and should be tested after installation to verify the absence of interference.

NOTE Requirements to unintentional radiators are under consideration for IEC 60533.

6 Shielding

6.1 General

A significant reduction or elimination of radiated fields from the outside electromagnetic environment can be achieved by shielding of sensitive equipment. This also applies vice-versa against unintended radiation of electronic equipment which is mounted inside the shield.

A ship mainly constructed with non-metallic materials has a low hull conductivity. This is synonymous with decreased or absence of shielding, normally provided by the metallic structure of a conventional ship. Therefore, additional problems can be expected for electric and electronic equipment operated on board.

6.2 Function of shielding

Shielding should be used to solve the following problem areas:

– interference to electrical/electronic systems and equipment by (intentional and unintentional) emissions from sources outside of the ship;
– interference to electrical/electronic equipment by unintentional emissions of the ship's own electrical and electronic installations, for example of an electric propulsion system;
– strong interference to electrical and electronic devices and systems by the intentional emissions from the ship's on board transmitters.

Additional measures to achieve electromagnetic compatibility (EMC):

a) shielding critical rooms such as radio rooms;
b) fibre optic cables for the transfer of signals;
c) screened cables; the connection of the cable shields to earth should be preferably on both ends of the cable. In special cases, it can be useful to earth one end only to avoid loops or to ensure proper functionality of the system.
d) use of filters on unscreened cables entering or exiting a shielded room;
e) use of EMC standards for the equipment and subsystems;
f) measurement of relevant EMC parameters;
g) to implement EMC maintenance routines;
h) using radiation-absorbent material for rooms and equipment to reduce electromagnetic emissions.

6.3 Ship layout

When identifying which rooms to be shielded, the following aspects shall be considered:

NOTE From an EMC point of view, two types of rooms normally exist on board a non-conductive ship: shielded room and non-shielded room.

a) the electromagnetic environment, mostly caused by the radiation of RF antennas;
b) availability of information on the electromagnetic behaviour of the chosen systems (sensitive or immune);
c) cost and complexity of additional shielding of systems compared with the total cost of the shielding;
d) risk of hazard of electromagnetic radiation to personnel (HERP);
e) antenna ground plane;
f) keeping electromagnetic fields low inside shielded spaces in order that susceptible equipment will not exhibit electromagnetic interference problems when high power transmitters are being used;
g) the electromagnetic environment mostly caused by the radiation of RF antennas and variable frequency drives (VFD).

6.4 Room layout

The shielding may be carried out by using the single protection layer approach as shown in Figure 1, or the multiple protection layer approach as illustrated in Figure 2.

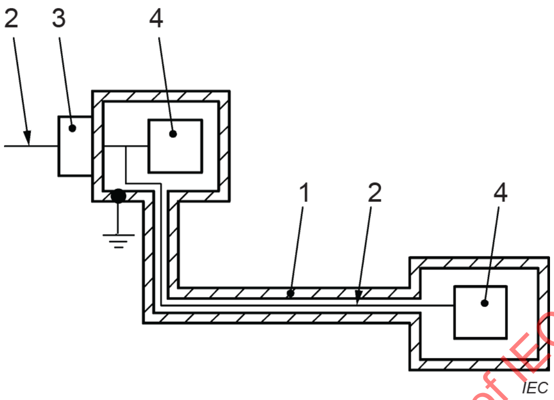
When the susceptibility study according to 5.2 is performed, the required attenuation and frequency range should be defined.

NOTE 1 The principle of single protection layer is a method of protecting sensitive items of equipment by means of a single overall shield.

NOTE 2 The principle of multiple protection layer is a method of protecting sensitive items of equipment by means of a number of concentric shields.

NOTE 3 When many sensitive systems or devices are located in one room, it can be more cost effective to keep the susceptibility requirement for each individual system low compared to the external electromagnetic environment by providing additional shielding for the room.

NOTE 4 The required attenuation for the shielded room can be defined by the electromagnetic environment and the anticipated susceptibility level of each system



Key

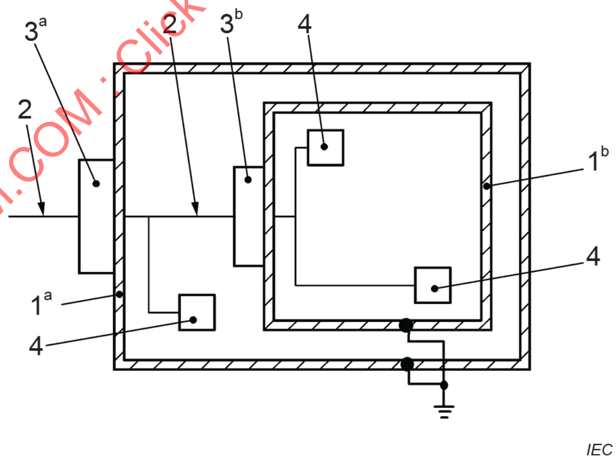
1 shielding enclosure

2 electric cable

3 filter (for unshielded cable), connected with enclosure or EMC cable penetration

4 equipment

Figure 1 – Principle of single protection layer



Key

1 shielding enclosure

2 electric cable

3 filter (for unshielded cable) or EMC cable penetration

4 equipment

a primary protection

b secondary protection

Figure 2 – Principle of multiple protection layers

7 Antenna layout

7.1 General

A non-metallic structure does not attenuate the RF radiation from the transmitting antennas as much as a structure of metallic material. Due to less shielding, the field strengths below deck can be greater than on a metallic ship. This leads to the following implications which shall be taken into account:

- radiation hazard (RADHAZ) for crew and passengers;
- coupling of high frequency electromagnetic energy into the electrical installation.

Therefore, RF antennas and their associated feeders should be positioned away from unshielded electronic equipment and cabling.

For certain areas and countries, limited values for transmitting are mandatory and stated by the appropriate authority.

7.2 Whip antenna

7.2.1 General

A suitable antenna ground plane shall be used to provide the RF currents a defined path back to their feeding point (base of antenna).

NOTE 1 If a suitable ground plane is not used, the current will flow back over other metallic structures, for example, equipment, cables etc. This could cause worse functionality of the antenna and electromagnetic interference. Therefore, the lack of conductive surfaces is not only an EMC problem, but also a problem with respect to RF radiation efficiency, where the largest possible ground plane for RF whip antennas is essential.

NOTE 2 The RF whip antenna layout for the ship can be verified by use of scale models, test mock-ups or numerical simulation. Communication efficiency, RADHAZ and EMC can be checked.

NOTE 3 IEC 60945:2002, Annex C, indicates that the radiated emission limits are based upon a typical separation of 15 m between the bridge and the VHF antenna, in the band 156 MHz to 165 MHz.

7.2.2 Transmitter location

The transmitter should be housed in a dedicated shielded compartment. This shielded compartment should be positioned directly below or near the RF antenna. Positioning the antennas on the roof of a shielded room has the advantage that the shielding of the room also serves as an antenna ground plane.

7.2.3 Antenna ground plane

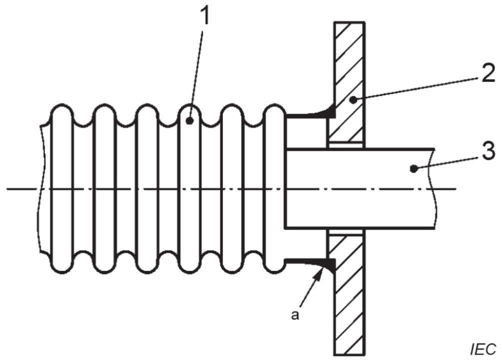
To determine the size of the antenna ground plane for a RF transmitting whip antenna, the following aspects shall be considered:

- for acceptable communication characteristics, it could be relatively small but of high conductivity;
- for EMC reasons, this ground plane should be extended as large as possible.

NOTE On non-metallic ships, the ship's own RF transmissions using whip antennas can cause major electromagnetic interference problems if the antenna ground plane is of insufficient size.

It is not necessary that the whole ground plane consists of the same material. The extension can also be made of metallic wire mesh or other shielding material like metal spray. However, a continuous metallic sheet is better for EMC purposes.

Screened cables etc. which penetrate the antenna ground plane shall be circumferentially bonded to the antenna ground plane, to avoid RF currents on metal pipes. Unshielded cables should be filtered at the entry point (see Figure 1 and Figure 2). Alternatively, they could be routed inside conductive pipes in the radiation zone. These pipes end at the entry point of the antenna ground plane (see Figure 3). There, they shall be circumferentially bonded.



Key

1 conduit (shielding pipe)

2 antenna ground plane

3 unscreened cable

a circumferential connection

Figure 3 – Unshielded cable penetrating the antenna ground plane

7.3 Loop antenna

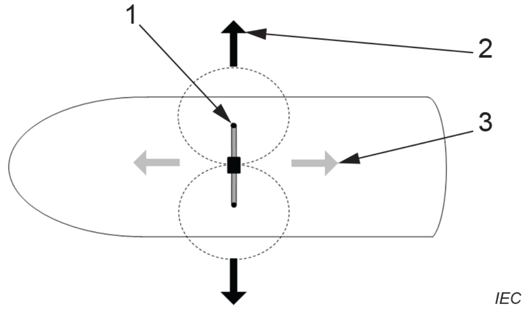
The use of loop antennas reduces the ship's own EMI problems in comparison with whip antennas.

A loop antenna does not require any external return current path and so electromagnetic interference is not produced by the above means. It also does not require an antenna ground plane and hence it needs not to be mounted in the middle of a conducting deck. This in turn means that it can be sited further away from susceptible equipment.

Also the "figure of eight" radiation pattern of the loop antenna for its electromagnetic field can be used to advantage by siting the antenna so as to place potentially susceptible equipment in the zero radiation area of the antenna. Typically, the axis of the loop should lie fore-aft (longitudinal) – see Figure 4.

However, in using a loop rather than a whip, there may be a substantial degradation in performance of the RF communication systems and ship manoeuvrability. Therefore, the RF communication system used on ships should be generally omni-directional.

NOTE Loop antennas are not omni-directional.



Key

1 loop antenna

2 high field strength direction

3 low field strength direction

Figure 4 – Radiation pattern of a vertically installed loop antenna (seen from above), showing the main direction of radiation

8 Earthing and equipotential bonding system

8.1 General

When selecting the earthing and equipotential bonding system, the following shall be considered:

a) protective earthing

- to protect personnel from shock hazards by keeping all exposed equipment cabinets, etc. at the same potential;
- to provide a safe conducting path for a lightning strike;

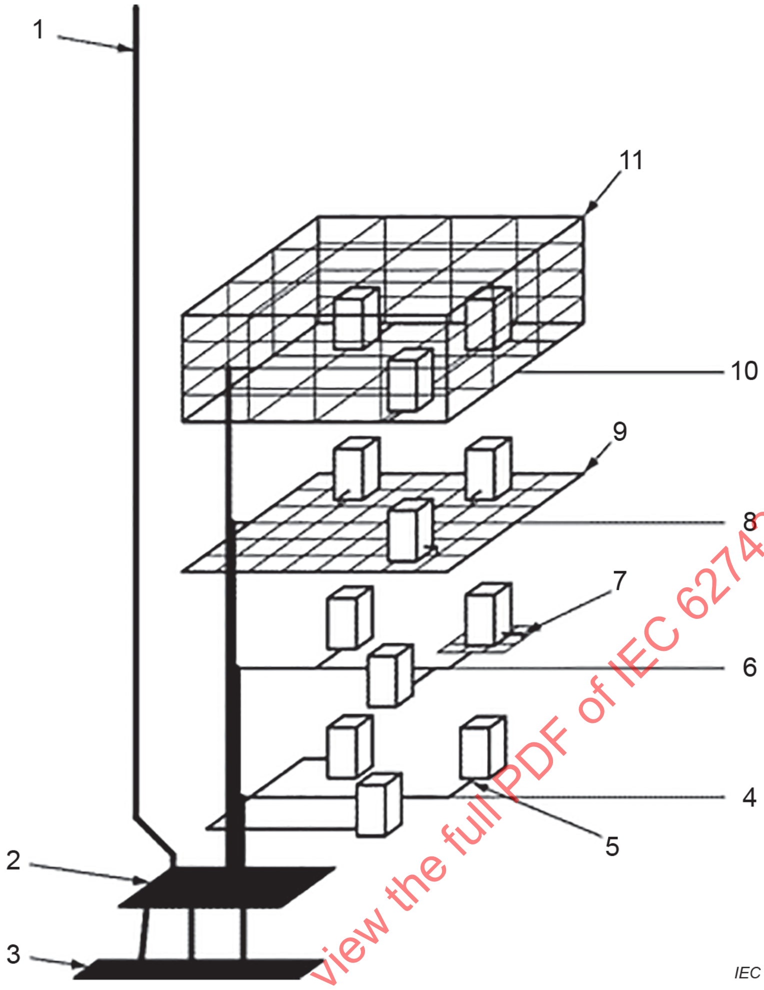
b) reference earthing

- to provide a connection between communication systems, sea and antenna ground planes;
- to provide an electronic or digital reference earth;
- to provide a conducting path for the bonding of cable shields;
- to improve EMC.

In a metallic hulled ship of conventional construction, electrical equipment is normally bonded to the nearest point on the ship's hull. In non-metallic ships, there are no inherent conducting paths and so they shall be provided in the form of an earthing system.

In general, only one earthing system is sufficient. In certain situations, it can be useful to have more than one, for example due to functional reasons. To avoid loops, all systems shall be connected at one point to the common earth plate. Any additional interconnection of branches of different earthing systems would destroy this concept. A possible solution is shown in Figure 5. The impedance of the tree shaped earthing conductor(s) should be decreased in direction to the earth plate.

NOTE The mesh size depends on the frequencies which occur at the cage/floor location on the ship. An approximate value would be $\lambda/10$ for the local frequencies.



Key

1 lightning rod
2 main earth connection point
3 earth plate/s
4 deck D
5 star (can be located at each deck)
6 deck C
7 tree with local mesh floor (can be located at each deck)
8 deck B
9 mesh floor (can be located at each deck)
10 deck A
11 mesh cage (can be located at each deck)

Figure 5 – Double-tree earthing system

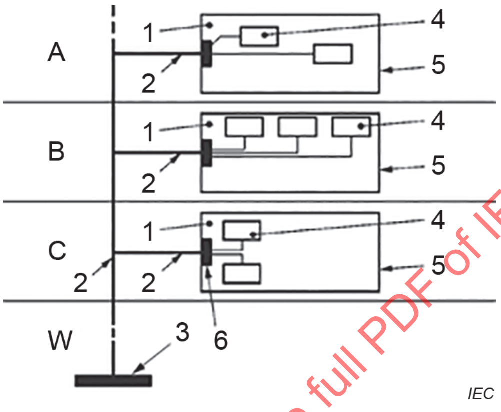
8.2 Earthing systems

A basic system should include an earth plate, a primary earth system and several secondary earth systems. Figure 5 shows a typical primary earth system connected to the earth plate. The earth plate shall be mounted on the outer surface at the lowest practical point of the structural hull and shall have direct electrical contact with sea water in all seakeeping conditions. The primary earth system branches out from the earth plate to every compartment in the ship in which equipment is installed.

The actual arrangement of branches should be determined by the layout of the ship, which is normally accomplished so that one branch only serves one deck level.

Large earth loops can easily develop when equipment located on different decks is interconnected with screened cables from which the screen is connected to the equipment at both sides as can be derived from Figure 6. If a shielded cable, from which the shield is connected at both ends, is connected to device 4 on deck A and to device 4 on deck C and it is routed along the right side of Figure 6, a large loops arises. Therefore, shielded cables from which the shield is connected to the reference earth at different decks shall run

a) from the equipment to the vertical reference earth conductor very close to the reference earth conductor to which the equipment is connected,
b) very close alongside the vertical reference earth conductor, minimizing the loop area, to the desired deck, and
c) from the vertical reference earth conductor very close to the reference earth conductor to which the equipment is connected.



Key

1 shielded compartments ("screen rooms") on for example the deck levels A, B and C

2 earth conductors ("main earth cables")

3 earth plate below water level W

4 equipment enclosures, located in a shielded space connected to local earth connection plate

5 shield (metal barrier)

6 local earth connection plate

Figure 6 – Example of an earthing system with shielded spaces

NOTE Within the shielded compartments, the influence of earth loops is less significant since this is a protected environment. For that reason, equipment can be interconnected with, if necessary, shielded cables without placing them very close to the reference earth system.

8.3 Protective earth

Electrical and electronic equipment shall be connected to the earth system to prevent electric shock hazards to personnel, except for equipment with supplementary or reinforced insulation, or equipment supplied with safety voltage according to IEC 60092-101.

Earth connections should be as short as possible. Special attention shall be paid to the protective earth connection of conductive parts and equipment in the vicinity of transmitting antennas to prevent sparking, electrical shock, RF burns and re-radiation.

All protective earth connections shall be selected with respect to the risk of corrosion.

The protective earthing cable and the supply cables shall be fixed as close together as practicable to reduce magnetic fields by reducing the radiating loop area.

Equipment that is very sensitive to EM disturbances (e.g. equipment according to IEC 61000-6-1) or generates a significant amount of these disturbances (e.g. equipment according to IEC 61000-6-4) and is located within a screened compartment should be RF bonded to the shield (material) of the compartment. In addition, the equipment shall also be provided with a full short-circuit current carrying earth connection to the ships earthing system for personnel safety.

The short circuit protective earthing path shall be traced from the equipment to the ships cables, intermediate earth plates and other connection devices and be able to handle the full current load associated with the equipment.

Care should be taken to avoid utilising the compartment shielding material as part of the protective earth path from the equipment to the ships earth plates although the shielding material itself as well as the protective earth connections shall be able to withstand such a current.

8.4 Earth plate

8.4.1 Material

The earth plates may be constructed out of any conducting metal compatible with sea water which does not form an electrochemical corrosion cell with any other immersed metallic components, for example propeller. Earth plates shall be left in their bare metallic state and not isolated by paint or coating in any way. The earth plate material shall be the best corrosion protected galvanic part in contact with seawater.

NOTE Typical materials are Cu Sn 8 (CW 453 K) or special stainless steel.

8.4.2 Location

The earth plate shall be located on the outside of the hull in a position that is permanently immersed during operational conditions and which, in the case where it is connected to a lightning conductor, allows the shortest practicable route for the down conductor. The plate shall be shaped so as to conform with the hull profile.

8.4.3 Dimensioning and construction

The earth plate shall be at least 10 mm thick, 250 mm wide and, to avoid dielectric breakdown of the water at the plate surface when carrying the lightning currents, it shall have a minimum contact area with the sea of 5 m^2. The length of the earth plate depends on the length of the ship and the number and location of connection points (see Figure 7).

To provide an electrical connection, a connecting pillar shall be made from the same material as the earth plate and shall have a minimum diameter of 50 mm. To withstand the severe magnetic forces produced during the passage of a lightning strike, the connecting pillar shall be solidly connected to the earth plate by brazing or welding.

Means shall be provided to allow connection of a conductor size of minimum 75 mm^2, directly to the earth plate to enable it to be connected to a suitable earth on shore when the ship is in dry dock or on a slipway. It is recommended to install this connection in the vicinity of the shore power supply connection.

8.4.4 Number

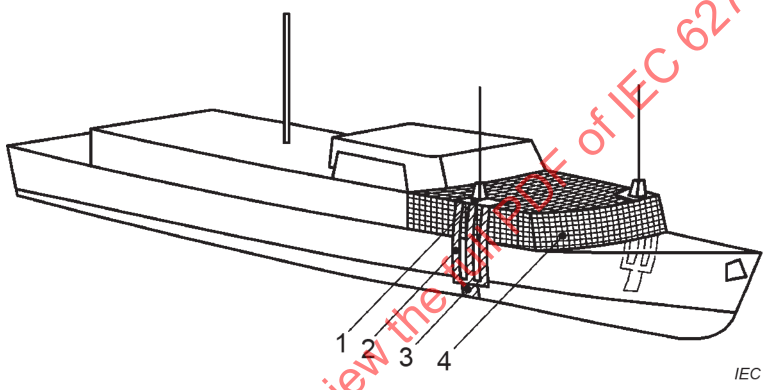
The number of earth plates required depends on the layout of the ship. There should be one main earth plate which would serve most of the ship. This could be sufficient.

However, if possible, for each lightning conductor, there should be a separate earth plate so that the down conductors are as short as possible. Also, it may be advantageous to provide earth plates and dedicated conductors for the RF transmitters and antenna ground planes to prevent RF currents flowing in the main system.

8.5 Communication transmitter system

The antenna ground planes of the RF antennas shall be connected with the earth plate. The impedance of these conductors shall be as low as possible. The reason for this is that the sea water area also acts as an extension to the antenna ground plane and the return currents from the sea need to take some path back to the base of the antenna (key 1 in Figure 4). The lower the impedance of these connections, the less current will flow in the circuit made up of the ships internal cabling etc. and also its capacitance both to the sea and to the antenna.

Different methods of achieving low impedance are possible. One method is to connect the antenna ground plane (key 4) to the earth plates (key 3) using wide conducting straps (key 2) routed down the side of the ship as shown in Figure 7.



Key

1 antenna base

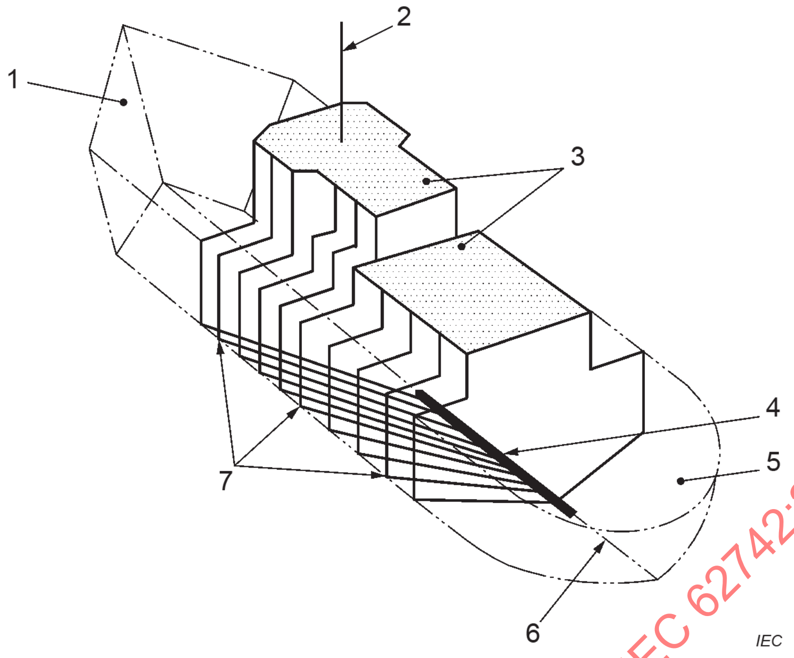
2 strap connection to the earth plate

3 earth plate

4 wire mesh

Figure 7 – Antenna ground plane, strap connection of base plate with earth plate

Another possible design (see Figure 8) is to use a large number of stainless steel tapes which enclose the centre section of the ship and can give a low level of shielding.



Key

1 bow

2 antenna

3 base plate (ship's superstructure with conductive coating)

4 earth plate

5 stern

6 fore-and-aft line

7 reference earth connections along the ship's contour

Figure 8 – Antenna ground plane, tape connection of base plate with earth plate

The stainless-steel tapes will also serve to provide lightning protection (via spark gaps to the antennas) and shall also be used to connect the transmitters and associated shielded enclosures with reference earth. Potentially susceptible or electrically noisy equipment should not be connected to the same connecting strap or tape.

8.6 Dimensions of earth conductors

If earth conductors are used for safety earthing and RF reference earthing simultaneously, the cross section shall comply with the requirements stated in IEC 60092-401 and IEC 60092-507. For RF reference earthing, the impedance of the connection with the reference earthing system shall be as low as possible.

8.7 Lightning conductor

The lightning conductor down lead may not be used for the purposes of protective or reference earthing other equipment. The lightning conductor is connected to the lightning arrestor and shall be routed directly to the earth plate by the shortest possible path.

Care shall be taken to prevent the lightning conductor down lead from running parallel with other cables and connectors to avoid magnetic field coupling. Careful planning in the routing of this connection is required.

The lightning earth connection shall be routed in such a way that hard bends or sharp transitions are avoided.

NOTE 1 If the lightning current can be kept within the conductor leading to the earth plate, a minimum amount of damage will be the most likely outcome. The greatest damage would occur when the lightning current leaves the conductor and arcs through the air or tracks across non-conductive material in order to reach the earth potential along the shortest way and/or way with the lowest impedance.

NOTE 2 Detailed requirements for lightning protection are not in the scope of this document. Requirements on lightning protection can be found in IEC 60092-401. Further information can also be found in IEC 62305 (all parts) and ISO 10134.

NOTE 3 Although IEC 62305 (all parts) is not specifically intended for ships, especially IEC 62305-1 and IEC 62305-2 contain useful background information.

8.8 Unbalanced systems

Unbalanced electric and electronic systems need a common reference potential for their signals. This reference potential shall be considered as part of the electronic system and neither as part of the protective earth system nor as part of the reference earth system. This will make it necessary to specify the internal and external bonding of the equipment and of the signal cable's shielding to be installed in the ship.

9 Cable installation

9.1 Cable routing

The planning of an optimal cable routing in a defined electromagnetic environment requires to assign each cable to a specific category, which again can be assigned to defined routing separations. The various differing categories of cables shall be separated from each other, for example disturbing power cables from sensitive signal cables according to IEC 60533:2015, Table B.1. The routing distances given in IEC 60533:2015, B.2.5, shall be observed. Cables shall be routed with metallic cable trays or along the metallic branch structure (see 8.2). Cable trays, if used, shall be earthed. Pieces of cable trays and protective cable piping should have electrical connections to each other and to the metallic branch structure at as many points as possible.

In general, screened cables shall be used. This requirement is also valid for power supply cables. Special measures shall be taken when routing signal cables in the vicinity of transmitting antennas. Such measures could be choosing of special cables, routing in larger distances or in trunkings or metallic conduits.

9.2 Electrical connection (bonding) of cable shields

Cable shields should be connected with low-impedance bonding at those points where cables penetrate conductive materials like antenna ground planes or the boundary between shielded areas. In general, the cable screen shall be connected to reference earth at least at both ends. To ensure durable low-impedance connections, suitable measures shall be taken to maintain the proper condition of the bonding surfaces in the given system environment (e.g. vibration, shock, temperature, corrosion).

9.3 Protection against RF fields

Cable shields which are used to protect the signal cables against RF fields should be bonded to the shielded enclosures (either equipment cabinet or screened room) at least at both ends. The shield should be circumferentially (360°) bonded to the enclosure. So-called "pig tail connections" are not sufficient. This method is valid for cable glands, (EMC) penetrations (fixed connections) and connectors.

Shielded cables penetrating screened rooms should have their shields circumferentially bonded at the point of penetration.

In cases where a shield is only connected at one end for functional reasons, an additional overall shield bonded at both ends of the cable or equivalent measures shall be considered.

9.4 Protection against induced currents

In case the frequency of the signal is low, it may be necessary to avoid loops for the following reason. Where the loops are formed by the shields of cables connecting two cabinets, there may be currents induced in the loop from HF or lower frequency radiation. These currents can be large due to the resonance effects and low resistance of the conductors. This may cause interference to the signals carried by the cables. The level of interference will depend on the transfer impedance and the length of the cable. The transfer impedance of the cable should be as low as possible for good EMC performance. This effect can be further reduced by placing shielded cables very close to conductive surfaces. This will reduce the loop area and with it the induced current.

9.5 Filtering

Electrical equipment for ships is usually developed for onshore or metallic ship's installation. Due to the transparency of the hull below deck, equipment could be exposed to higher levels of field strengths in comparison with the situation on metallic ships. Therefore, appropriate filters for equipment power, control and signal cables should be considered. Those filters shall be placed as close as possible to the equipment (primary protection), when they are placed in a non-shielded environment or at the entrance of the screened compartment that protects the equipment when such a compartment is available.

Filters intended for use on metallic ships may not perform adequately when installed in composite ships due to different reference earth conditions.

The definition of the filter characteristics should be carried out by an analysis.

10 Overvoltage protection

The requirements of IEC 60533:2015, B.2.6 and B.3.5, apply.

11 Maintenance test and inspection

After modification of the electrical installation onboard, the earthing system shall be evaluated and adapted. After revision of the earthing system, the relevant documentation shall be modified accordingly and shall be available onboard.

A maintenance plan for the testing of the earthing connections shall be provided.

All earthing connections shall be easily accessible for inspection.

During the precommissioning of the ship, the effectiveness of the shielding shall be tested in relation to the EMC plan according to 5.2.

Annex A
(normative)

Comparison of IEC 60533:2015, Clause 4 to Clause 8, with this document

The requirements of IEC 60533:2015 shall apply for non-metallic hull according to the comparison given by Table A.1.

Table A.1 – Connection of this document with IEC 60533:2015 – Allocation, additions or modifications

IEC 60533:2015		IEC 62742:2021		
Reference	**Heading**	**Remark with respect to IEC 60533:2015**	**Corresponding reference**	**Heading**
4	General	Applicable with	4	General
5	EMC test plan	Applicable without modification	-	-
5.1	Objective	Applicable without modification	-	-
5.2	Configuration of equipment under test (EUT)	Applicable without modification	-	-
5.2.1	General	Applicable without modification	-	-
5.2.2	Assembly of EUT	Applicable without modification	-	-
5.2.3	EUT interconnecting cables	Applicable without modification	-	-
5.2.4	Auxiliary equipment	Applicable without modification	-	-
5.2.5	Cabling and grounding	Applicable without modification	-	-
5.3	Test pre-conditioning	Applicable without modification	-	-
5.3.1	Operational conditions	Applicable without modification	-	-
5.3.2	Environmental conditions	Applicable without modification	-	-
5.3.3	Test software	Applicable without modification	-	-
5.4	Acceptance criteria	Applicable without modification	-	-
5.5	Scope of EMC testing	Applicable without modification	-	-
6	Emission requirements	Applicable without modification	-	-
6.1	Conditions during the emission tests	Applicable without modification	-	-