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TECHNICAL REPORT

Electrical installations in ships – Electromagnetic compatibility – Optimising of cable installations on ships – Testing method of routing distance

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL INSTALLATIONS IN SHIPS – ELECTROMAGNETIC COMPATIBILITY – OPTIMISING OF CABLE INSTALLATIONS ON SHIPS – TESTING METHOD OF ROUTING DISTANCE

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IEC 62482/TR, which is a technical report, has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
18/1030/DTR	18/1041A/RVC

Full information on the voting for the approval of this technical report 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 maintenance result 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- withdrawn,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 publication may be issued at a later date.

INTRODUCTION

In accordance with IMO-Resolution A.694/6.1: "*All reasonable and practicable steps shall be taken to ensure electromagnetic compatibility between the equipment concerned and other radio communication and navigational equipment carried on board in compliance with the relevant requirements of chapters III, IV and V of the SOLAS Convention*."

To fulfil this requirement it is necessary to survey the chosen cables and cable installation with regard to EMC.

Basic rules for cabling in international shipbuilding are presently specified in the series of standards given in IEC 60092 [1][1], requirements on dimensions of routing distances in cable systems are given in IEC 60533 and basic requirements on cable routing in IEC 60092-352. As the requirements differ between the relevant documents, the question of validity has been discussed internationally. This applies particularly in regard to parallel routing of power electronics cables on the one hand and measuring and control equipment cables on the other hand.

General Information about routing distances is mainly based on the German standard VG 95375-3 [4]. This standard is based on tests performed in 1982 [2].

In those days tests were performed mainly with sinusoidal signals in the frequency range of 0.1 MHz up to > 40 MHz and even today there is no reason to doubt these test results. However, the question has often been raised whether these results are also adequate for unacceptable crosstalk into cables for integrated digital circuits. In no case fast transients may affect the function inadmissibly where interference thresholds should be a maximum. The measurements were accomplished to investigate this issue.

1 Numbers in square brackets refer to the Bibliography.

ELECTRICAL INSTALLATIONS IN SHIPS – ELECTROMAGNETIC COMPATIBILITY – OPTIMISING OF CABLE INSTALLATIONS ON SHIPS – TESTING METHOD OF ROUTING DISTANCE

1 Scope

This Technical Report describes tests methods carried out to determine minimum routing distances in order to avoid crosstalk of fast transients (bursts). The test results may be applied to cable installations according to IEC 60092-352.

2 Normative references

The following referenced documents are indispensable for the application 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 60092-352, *Electrical installations in ships – Part 352: Choice and installation of electrical cables*

IEC 60092-353, *Electrical installations in ships – Part 353: Single and multicore non-radial field power cables with extruded solid insulation for rated voltages 1kV and 3 kV*

IEC 60092-374, *Electrical installations in ships – Part 374: Shipboard telecommunication cables and radio-frequency cables – Telephone cables for non-essential communication services*

IEC 60092-375, *Electrical installations in ships – Part 375: Shipboard telecommunication cables and radio-frequency cables – General instrumentation, control and communication cables*

IEC 60092-376, *Electrical installations in ships – Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)*

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

IEC 60533:1999, *Electrical and electronic installations in ships – Electromagnetic compatibility*

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

IEC 61196-1, *Coaxial communication cables – Part 1: Generic specification – General, definitions and requirements*

3 Terms and definitions

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

3.1
cable category
classification of a cable depending on the purpose or the kind of voltage (power supply, signal transmission) the cable is intended for

NOTE Cable categories are shown in IEC 60533:1999, Table C.1 (categories 2 and 4) or in VG 5375-3:2006, Table 2, categories 2 and 5 [4].

3.2
routing distance
intermediate free space between cables or bundle of cables of different, i. e. interfering and susceptible, cable categories

3.3
routing height
distance of cable or bundle of cables from reference ground (earth)

3.4
signal detector (SD)
electronic equipment used for detection and indication of disturbance

4 Principle

4.1 General

Electromagnetic compatibility (EMC) of electrical equipment or installations can be optimised by providing a defined distance between interfering and susceptible cable categories on cable routing. On the other hand the special situation aboard may call for such a distance to be as low as possible.

With the test described in this technical report, the sufficient separation distance between cables of different categories can be quantified. Definition numbers of the cable categories used in this technical report are stated in Table 1.

Table 1 – Cable categories

Cable for transmission of	Voltage level *V*	Emission/ immunity rating	Number of cable category[a]	Cable type[b]	Applicable standard
Analogue signals (Low frequency): telephone, loudspeaker and similar	0,1-115	Not disturbing / susceptible	2	Twisted; single screened; screened twisted pairs	IEC 60092-374, IEC 60092-375, IEC 60092-376
Digital signals: control, automation, alarm					
High-power signals, pulsed high-power signals[c]	10-1 000	Extremely disturbing / non-susceptible	4	Coaxial; screened power	– (Special cable)
High powered semi-conductor converter output				1 kV power cable	IEC 60092-353

a In accordance with IEC 60533.

b The transfer impedance should be specified and should not exceed 30 mΩ/m at 10 MHz as determined by IEC 61196-1.

c Cables for radar, sonar equipment and echo sounders should be double screen cables or coaxial cables inside protective piping.

4.2 Reference ground

Precondition to correct and reproducible measurement results is the simulation of the properties of the metallic ship's structure as reference ground. This can be achieved by use of a metallic ground plane of an extensive area. The minimum area should be 10 m × 10 m.

4.3 Signal detector (SD)

The signal detector serves as detecting device by signal processing and displaying the malfunction caused by the disturbance voltage. It is connected with the susceptible cable. Such a detecting device should simulate industrial manufactured digital electrical equipment, e. g. a storage-programmable logic controller, which has been chosen to be used for controlling and automation tasks in ships (see IEC 60092-504).

4.4 Susceptible (drain) cable

The susceptible cable serves as a receiver for the signal detector. The cable length should match to the side length of the test area. The following two types of cable should be used in this test.

- Type 1: two-wire unshielded cable, or
- Type 2: four-wire shielded cable, e. g. in accordance with VG 95218-24 [3].

4.5 Interfering (source) cable

The interfering cable is required to be of the same length as the susceptible cable and is fed by fast transient pulses relative to ground (earth). For interfering purposes the unshielded (type 1) cable should be used.

4.6 Burst generator

The fast transients pulses will be generated by a burst generator in accordance with IEC 61000-4-4.

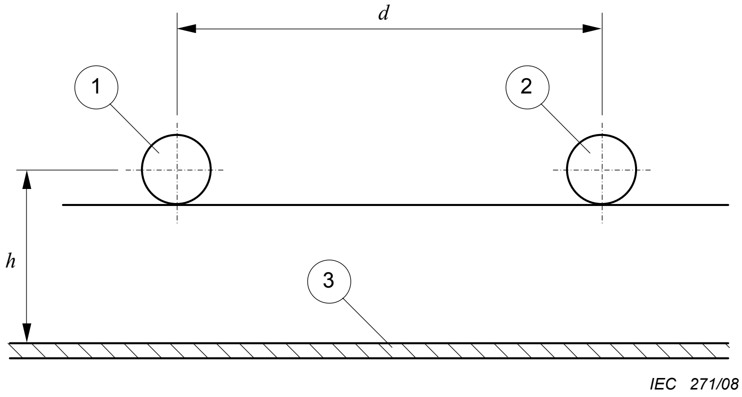
5 Test set-up

5.1 Susceptible interference threshold

To determine the positive and negative susceptible interference threshold values of the type of signal detector used, pulses of the burst generator output should be fed directly (short connection) to the power supply input of the signal detector during the tests.

5.2 Cable routing and distances

The susceptible cable and the interfering cable are routed in parallel to each other with a routing distance, *d,* in accordance with the cable category and a fixed distance, *h,* above reference ground (earth), see Figure 1.



Key

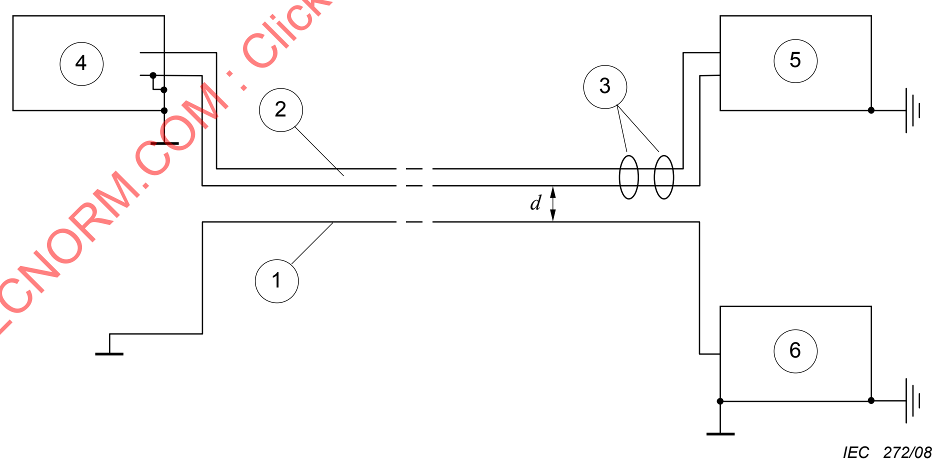
1 Interfering cable
2 Susceptible cable
3 Reference ground
d Routing distance
h Routing height

Figure 1 – Routing distance and routing height

6 Test

6.1 General

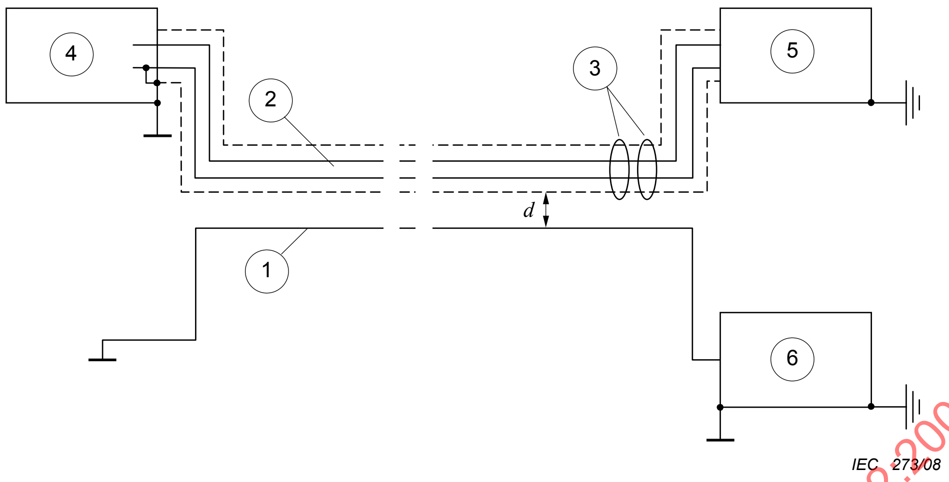
The tests are performed with the cables stated in 4.3 and 4.4. The two different test-set ups are shown in the Figures 2 and 3.



Key

1 Interfering cable: one wire to ground
2 Susceptible cable
3 Ferrite rings
4 Signal detector (SD)
5 Power supply for SD
6 Burst generator
d Routing distance

Figure 2 – Test set-up 1: Unshielded susceptible cable



Key

See Figure 2

Figure 3 – Test set-up 2: Shielded susceptible cable

6.2 Test performance

Increase the interference voltage at the output of the burst generator starting from 500 V until the signal detector responds to the detected pulses or until the maximum interference output voltage (4 kV) is reached. The height, h, should be selected according to the special conditions decided upon. For surface vessels a value of e. g. h = 100 mm applies (see Figure 1).

The cable-cable coupling is varied by changing

- the routing distance, d (fixed h), or
- the routing height, h, above ground (fixed d).

Example values for distances, d and h, are given in Table A.1.

6.3 Test result

The optimum value, d or h, is reached if no disturbances on the susceptible cable can be detected by the SD,

- either for a given height, h, above ground at the acquired routing distance, d, or
- for a given cable distance d, at the acquired routing height, h, above ground.

Annex A
(informative)

Test Report: Performance of a routing optimising test

A.1 Test facilities

A.1.1 General

The tests were performed at the EMC-Laboratory of the Technical University in Dresden, Germany, in 2002 and 2003.

Examples of the test facilities used are given in Table A1. For other facilities and equipment and for the general test set-up, see Figures A.3 and A.4.

Table A.1 – Examples for test facilities

Facility	Manufacturer	Type	Remarks
Burst generator	EM-TEST, 59174 Kamen, Lünener Straße 211	UCS 500	In accordance with IEC 61000-4-4
Signal detector (SD)	LANGER EMV-Technik, 01728 Bannewitz, Nöthnitzer Hang 31	VM 102	Not in accordance with 4.3
Power supply	Hewlett Packard	E 3615 A	–
Ferrite rings	Würth Elektronik	7427/5	–
Two-wire cable, unshielded	Commercial	2 $mm^2 \times 0{,}75\ mm^2$	–
Four-wire cable, shielded	Navy standard	VG 95218 part 24	German naval type
Paving stones	Commercial	10 cm × 10 cm × 8 cm	Concrete

A.1.2 Reference ground

The reference ground used is designed as a zinc-coated wire gauze with a mesh width of 25 mm x 25 mm and a wire diameter of 3 mm arranged on a plane including an area of 22 m x 22 m. Each cross-over point is welded. The wire gauze covers the area of the test site as shown in Figure A.1. A solution with equivalent properties may be used.

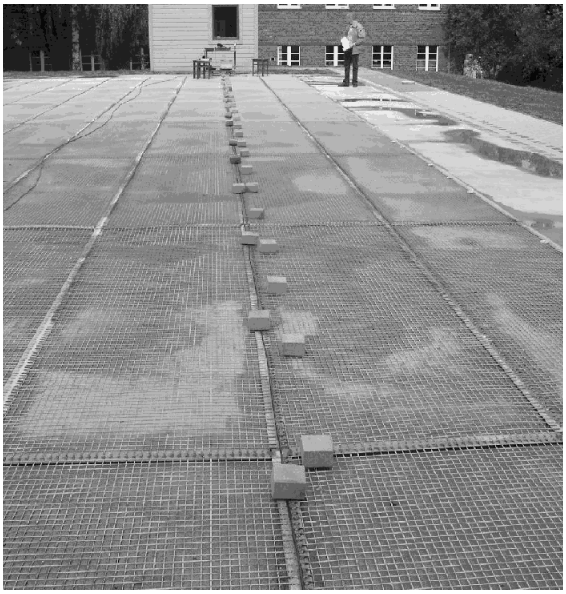


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Figure A.1 – Test site with reference ground

A.1.3 Signal detector

The signal detector (SD) used was designed originally to demonstrate the influence of electrical fast transients (bursts), according to IEC 61000-4-4, on integrated circuits. It operates with integrated circuits of the H-CMOS family such as program memory, processor unit with interface. For indicating purposes, a running light chain of LEDs, a piezoelectric transducer or a relay could be connected with the interface outputs (see Figure A.4). The supply voltage input serves also as a susceptible input and was connected with the susceptible cable at one end. The other end of the susceptible cable was protected by two ferrite rings and connected with a standard 12 V d.c. power supply (see Figure A.2).

A.1.4 Susceptible (drain) cable

A cable length, l = 25 m, was used. Firstly, a type 1 cable (2 mm^2 × 0,75 mm^2 unshielded) was used. For the second test run, a type 2 cable in accordance with VG 95218-24 [3], two from four wires were used.

A.1.5 Interfering (source) cable

Type 1 cable was used for both test runs, length l, given in A.1.4.

A.1.6 Burst generator

The generator was able to produce pulse peak voltages of ± 4 kV.

A.1.7 Susceptible inherence threshold values

The measured susceptible interference threshold values in accordance with the requirements stated in 5.1 were +700 V and –500 V (see Table A.2, No. 5 and No. 6).

Table A.2 – Measured interference threshold values versus separation, height and type of susceptible cable

No	Routing distance *d* mm	Routing height *h* mm: interfering	Routing height *h* mm: susceptible	Interference threshold voltage V	Type of susceptible cable	Remark
1	100	0		1 720 to 1 780	1 (unshielded two-wire cable)	–
2	200			2 040 to 2 180		
3		0	50	1 820 to 1 900		
4	600	50	0	2 600 to 2 980		
5	not applicable	not applicable		+700		susceptible interference threshold voltage
6				-500		
7	50	0		> +4 000 < -4 000	2 (shielded four-wire cable) [a]	maximum generator output voltage
8						
9	100					
10						
11		50		+1 500		–
12				-1 300		
13	200			+2 700		
14				-2 100		
15		100		+1 400		
16				-1 200		
17	400	50		> +4 000		maximum generator output voltage
18				< -4 000		

[a] Two wires used.

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Figure A.2 – Burst injection into interfering cable

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Figure A.3 – Signal detector (SD)