BRITISH STANDARD

BS EN
60945:2002

Maritime navigation and radiocommunication equipment and systems — General requirements — Methods of testing and required test results

The European Standard EN 60945:2002 has the status of a British Standard

ICS 47.020.70

National foreword

This British Standard is the official English language version of EN 60945:2002. It is identical with IEC 60945:2002. It supersedes BS EN 60945:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/80, Maritime navigation and radiocommunication equipment and systems, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results

(IEC 60945:2002)

Matériels et systèmes de navigation et de radiocommunication maritimes - Spécifications générales - Méthodes d'essai et résultats exigibles (CEI 60945:2002)

Navigations- und Funkkommunikationsgeräte und -systeme für die Seeschifffahrt - Allgemeine Anforderungen - Prüfverfahren und geforderte Prüfergebnisse (IEC 60945:2002)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 80/345/FDIS, future edition 4 of IEC 60945, prepared by IEC TC 80, Maritime navigation and radiocommunication equipment and systems, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60945 on 2002-10-01.

This European Standard supersedes EN 60945:1997.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2003-07-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2005-10-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annexes A and ZA are normative and annexes B to G are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60945:2002 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-2-32	NOTE	Harmonized as EN 60068-2-32:1993 (not modified).
IEC 60068-3-4	NOTE	Harmonized as EN 60068-3-4:2002 (not modified).
IEC 60073	NOTE	Harmonized as EN 60073:1996 (not modified).
IEC 60300-1	NOTE	Harmonized as EN 60300-1:1993 (not modified).
IEC 60721-2-1	NOTE	Harmonized as HD 478.2.1 S1:1989 (not modified).
IEC 60721-2-4	NOTE	Harmonized as HD 478.2.4 S1:1989 (not modified).
IEC 60721-3-6	NOTE	Harmonized as EN 60721-3-6:1993 + A2:1997 (not modified).
IEC 61162 (Series)	NOTE	Harmonized as EN 61162 (Series) (not modified).
IEC 61209	NOTE	Harmonized as EN 61209:1999 (not modified).
IEC 61508-1	NOTE	Harmonized as EN 61508-1:2001 (not modified).

CONTENTS

INTRODUCTION

IEC 945 was originally produced to give test methods and, where appropriate, limit values to the IMO Resolution A.574(14) which was a recommendation on general requirements for electronic navigational aids. (It has subsequently been replaced, see below.) The tests dealing with electromagnetic immunity could not be produced in time for the publication of the original standard, and these were added later in 1992 as amendment 1.

In 1991 the IMO, when discussing the changes that would arise with the introduction of the global maritime distress and safety system (GMDSS), noted that in future, radio equipment would be installed on the bridge of a vessel alongside the navigation equipment instead of in a special radio room as hitherto. The IMO consequently withdrew Resolution A.574(14), and a corresponding Resolution A.569(14) dealing with the general requirements of radio equipment, and replaced them with IMO Resolution A.694(17). A second edition of IEC 945 was rapidly prepared to reflect this change.

The third edition of IEC 945 in 1996 was a complete revision which aligned the test methods with appropriate other IEC standards and introduced, wherever possible, the requirements of the classification societies. The scope was extended to make the standard applicable additionally to other equipment installed on and around the bridge of a ship with regard to EMC. A new class of equipment – “portable” – was added, together with better definitions of operational tests which involve subjective judgement and descriptions of operational and durability aspects of software.

This fourth edition (now IEC 60945) extends the detail of operational tests particularly for equipment which is operated through software menus. This has been derived from an exhaustive investigation of appropriate references as described in the Bibliography. The layout of clause 4 (Minimum performance requirements) has been changed to give a better grouping of ergonomics, hardware and software requirements.

The EMC tests have been revised with the frequency range having been extended from 1 GHz to 2 GHz.

Clarifications to the text of the third edition have been added where experience has shown a need and the references have been updated.

A comparison of the test requirements in the third and fourth editions is given in annex G to assist manufacturers and test houses in the use of the new edition.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS –

General requirements – Methods of testing and required test results

1 Scope

This International Standard assists in meeting a requirement of the International Convention for Safety of Life at Sea (SOLAS), adopted by the International Maritime Organization (IMO), that the radio equipment defined in chapters III and IV, and the navigation equipment defined in chapter V of the Convention, be type-approved by administrations to conform with performance standards not inferior to those adopted by the IMO. (Administrations are defined by the IMO as governments of the states whose flags the ships are entitled to fly.)

The performance standard for general requirements for shipborne radio equipment and electronic navigation aids that has been adopted by the IMO is given in IMO Resolution A.694 and is reproduced in this standard as annex A, which forms the basis for this standard. Reference is made, where appropriate, to IMO Resolutions A.694 and A.813 and all subclauses whose wording is identical to that in the resolutions are printed in italics.

This standard specifies minimum performance requirements, methods of testing and required test results for general requirements which can be applied to those characteristics common to all equipment described hereunder:

a) shipborne radio equipment forming part of the global maritime distress and safety system required by the International Convention for Safety of Life at Sea (SOLAS) as amended, and by the Torremolinos International Convention for the Safety of Fishing Vessels as amended;

b) shipborne navigational equipment required by the International Convention for Safety of Life at Sea (SOLAS) as amended, and by the Torremolinos International Convention for the Safety of Fishing Vessels as amended, and to other navigational aids, where appropriate; and

c) for EMC only, all other bridge-mounted equipment, equipment in close proximity to receiving antennas, and equipment capable of interfering with safe navigation of the ship and with radio-communications (see IMO Resolution A.813).

NOTE For EMC, this standard is in the IEC category “product family”.

The requirements of this standard are not intended to prevent the use of new techniques in equipment and systems, provided the facilities offered are not inferior to those stated.

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 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*
Amendment 1 (1997)
Amendment 2 (1998)

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests – Tests A: Cold*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*
Amendment 1 (1993)
Amendment 2 (1994)

IEC 60068-2-5:1975, *Environmental testing – Part 2: Test Sa: Simulated solar radiation at ground level*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Test Fc: Vibration (sinusoidal)*
Corrigendum 1 (1995)

EC 60068-2-9:1975, *Environmental testing – Part 2: Guidance for solar radiation testing*
Amendment 1 (1984) Corrigendum 1 (1989)

IEC 60068-2-30:1980, *Environmental testing – Part 2: Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)*
Amendment 1 (1985)

IEC 60068-2-48:1982, *Environmental testing – Part 2: Guidance on the application of the tests of IEC 60068 to simulate the effects of storage*

IEC 60068-2-52:1996, *Environmental testing – Part 2: Test Kb: Salt mist, cyclic (sodium chloride solution)*
Corrigendum 1 (1996)

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

IEC 60092-101:1994, *Electrical installations in ships – Part 101: Definitions and general requirements*
Amendment 1 (1995)
Corrigendum 1 (1996)

IEC 60417(all parts), *Graphical symbols for use on equipment*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*
Amendment 1 (1999)

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

IEC 60651:1979, *Sound level meters*
Amendment 1 (1993)

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test* – Basic EMC publication

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test* – Basic EMC publication

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test* – Basic EMC publication

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests*

CISPR 16-1:1999, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

ISO 694:2000, *Ships and marine technology – Positioning of magnetic compasses in ships*

ISO 3791:1976, *Office machines and data processing equipment – Keyboard layouts for numeric applications*

IMO Convention for Safety of Life at Sea (SOLAS):1997

IMO Torremolinos Convention for the Safety of Fishing Vessels, 1977, as modified by the Torremolinos Protocol of 1993

IMO MSC/Circ.794 IMO Standard Marine Communication Phrases (SMCPs):1997

IMO Resolution A.694:1991, *General requirements for shipborne radio equipment forming part of the global maritime distress and safety system and for electronic navigational aids*

IMO Resolution A.803:1995, *Performance standards for shipborne VHF radio installations capable of voice communication and digital selective calling*

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

ITU-T Recommendation E.161:1993, *Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network*

NOTE A bibliography of informative references is given at the end of this standard.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this International Standard, the following definitions apply:

3.1.1
electronic navigational aid
an electronic item, for example instrument, device or chart, carried on board and intended to assist the navigation of a craft

3.1.2
maintenance
repair or replacement of defective parts or corresponding corrections to software. Minor changes and improvements to existing functionality are considered to be maintenance but not the addition of new functionality

3.1.3
operational check
a check by a suitably qualified person to confirm that the equipment complies with the operational requirements in this standard or in the equipment standard

3.1.4
performance check
a short functional test carried out during or after a technical test to confirm that the equipment operates

3.1.5
performance check (EMC)
a short functional test carried out during or after an EMC test to confirm that the equipment complies with the required immunity performance criteria

3.1.6
performance test
a measurement or a group of measurements carried out during or after a technical test to confirm that the equipment complies with selected parameters as defined in the equipment standard

3.1.7
pre-conditioning
the treatment of a specimen with the object of removing or partly counteracting the effects of its previous history

NOTE 1 Where pre-conditioning is called for, it is the first process in the test procedure.

NOTE 2 It may be effected by subjecting the specimen to climatic, electrical, or any other conditions required by the relevant specification in order that the properties of the specimen may be stabilised before measurements and test.

3.1.8
product family EMC standard
definition of specific EM requirements and test procedures dedicated to particular product families. It applies the IEC basic standards, is co-ordinated with IEC generic standards, and has precedence over IEC generic standards.

3.1.9
technical test
each test for which a repeatable method of measurement is defined in this standard or in the equipment standard

3.2 Abbreviations used in this standard

a.c.	Alternating current
AE	Auxiliary equipment
ASTM	American Society for Testing and Materials
CDN	Coupling and decoupling network
CISPR	International special committee on radio interference
d.c.	Direct current
EFT/B	Electrical fast transients/bursts
EMC	Electromagnetic compatibility
e.m.f.	Electromotive force
ESD	Electrostatic discharge
EUT	Equipment under test
HMI	Human machine interface
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITU	International Telecommunications Union
PC	Performance check
PT	Performance test
r.m.s.	Root mean square
SOLAS	International Convention for Safety of Life at Sea
SMCPs	Standard Marine Communication Phrases
VCP	Vertical coupling plane
VDU	Visual display unit

3.3 IMO performance standards

For the purpose of interpreting IMO performance standards the following definitions apply:

3.3.1
accessible; readily; easily
affording unrestricted access appropriate to the function served. Access for the operation shall not require the use of tools, and shall be gained comfortably from the operator's assigned work station. Access for maintenance is not subject to these restrictions, but should not require the removal of other fixtures or the use of special aids to reach the point of access

3.3.2
adjustments; normal
adjustments made by an operator in the course of equipment usage to maintain its operational efficiency

3.3.3
atmosphere; satisfactory
an atmosphere suitable for the preservation, safety and comfort of occupying material and/or personnel

3.3.4
audible; clearly
of sufficient amplitude and characteristics relative to the ambient noise environment to alert a person with normal hearing within a prescribed area

3.3.5
conspicuous/prominent/clearly visible
of good visibility by virtue of position, size or contrast with surroundings

3.3.6
marked; clearly
marked in a conspicuous place with information which can be easily seen and understood by qualified personnel

3.3.7
means; all practicable
means within accepted practice, or of a similar implementation standard, for the equipment or function concerned

3.3.8
observable; readily
affording unrestricted visibility of legible information to an operator at his assigned (not necessarily fixed) work station

3.3.9
operable; readily
operable without difficulty regarding access to controls, action required and indication of response

3.3.10
qualified; suitably
trained and experienced in the operation of specified equipment

3.3.11
removable/renewable/replaceable; easily
capable of removal, etc. by qualified personnel on board ship with the use of tools, if necessary, but without the need to disturb other equipment

3.3.12
time; adequate
sufficient time for the execution of a function by equipment with a qualified operator

3.3.13
time; limited
the maximum permitted time for the execution of a function. (must be compatible with adequate time)

3.3.14
ventilated; adequately
maintaining a satisfactory atmosphere (as previously defined) or environment within a compartment or equipment

4 Minimum performance requirements

4.1 General

4.1.1 Introduction

All equipment shall be subjected to all the appropriate tests in this standard unless otherwise specified in the relevant equipment standard, with the following exceptions:

a) the solar radiation test, the oil test and the corrosion test shall be waived where the manufacturer is able to produce evidence that the components, materials and finishes employed in the equipment would satisfy the test;

b) the safety test for visual display units (VDU) shall be waived where the manufacturer is able to produce evidence that the VDU would satisfy the tests;

c) the X-radiation test shall be waived where the manufacturer is able to produce evidence that the equipment would satisfy the test.

The relevant equipment standard referred to above shall contain the following information which is required for the conduct of tests in this standard:

– equipment category (see 4.4);

– performance test (see 5.1);

– performance check (see 5.1);

– pre-conditioning for environmental tests (see 8.1).

In order to assist administrations in granting type approval as required by SOLAS, the laboratory or test facility conducting technical tests shall be approved for this purpose, and shall conform to appropriate international standards concerning calibration and quality control.

Operational checks, particularly those involving subjective judgement, shall be conducted by personnel having appropriate qualifications and nautical knowledge.

Requirements and the related tests are cross-referenced in annex F.

4.1.2 General requirements

(A.694/1.2) *Where an equipment provides a facility which is additional to the minimum requirements of* both this standard and the relevant equipment standard, *the operation and, as far as is reasonably practicable, the malfunction of such additional facility* shall *not degrade the performance of the equipment*.

(A.694/2) *Equipment* shall *be installed in such a manner that it is capable of meeting the requirements of* applicable performance standards adopted by IMO.

There are no tests given in this standard to support this IMO requirement as this standard applies solely to equipment. Guidance on installation of equipment can be found in IEC 60092 and IEC 60533 and by reference to equipment manuals.

4.2 Design and operation

4.2.1 Ergonomics and HMI

4.2.1.1 General

Equipment shall be so constructed that it is capable of being operated readily and in accordance with the requirements of the relevant standard by a suitably qualified person.

The user shall be easily able to develop and maintain an understanding of the HMI state at any time.

The HMI shall not increase workload in a way that causes risk to safety related operational requirements.

4.2.1.2 Arrangement

(See 6.1.2)

(A.694/3.1) *The number of operational controls, their design and manner of function, location, arrangement and size* shall *provide for simple, quick and effective operation.* Controls shall be arranged in functional groups.

The layout of function keys shall be compatible with their importance, for example keys for emergency functions should have a prominent position, distinctive appearance and be dedicated to their function.

4.2.1.3 Operation

(See 6.1.3)

(A.694/3.1/3.2) *All operational controls* shall *permit normal adjustments to be easily performed and* shall *be arranged in a manner which minimises the chance of inadvertent operation. Controls not required for normal operation* shall *not be readily accessible.*

The operation of a control shall not cause obscuration of its related indicator where observation of the indicator is necessary for making the adjustment.

In all operations, there shall be a clearly marked or consistent simple action to recover from a mistaken choice or to leave an unwanted state. It shall be possible for the user to start, interrupt, resume and end an operation**.** Incomplete or interrupted manual inputs shall not inhibit the operation of the equipment.

4.2.1.4 Identification

(See 6.1.4)

(A.694/3.2) *All operational controls* and indicators *shall be easy to identify* and to read *from the position at which the equipment is normally operated.*

The controls and indicators shall be identified in English, and the identifications provided in the equipment standard shall be used. Symbols as specified in IEC 60417 or in the relevant equipment standard may be used in addition to the identification in English.

4.2.1.5 Screen displays and indications

(See 6.1.5)

Displays shall present the simplest information consistent with their function, information irrelevant to the task shall not be displayed, and extraneous text and graphics shall not be present. As a minimum English language shall be used.

Menus shall be grouped according to the task. Items of any kind which appear the same shall behave consistently. The user shall not have to remember information when moving from one part of a menu to another.

In all operations, the system state shall be observable with essential data displayed. All information required by the user to perform an operation shall be available on the current display**.** Any mode in use shall be distinctively identified by the display(s). It shall be possible at any step of a screen supported operation to return with one action to the original status before the operation was started.

Feedback timing shall be consistent with the task requirements. There shall be a clear feedback from any action within a short time. Where a perceptible delay in response occurs, visible indication shall be given.

Displayed text shall be clearly legible to the user and easy to understand. Simple natural language shall be used wherever possible. The equipment shall employ marine terminology.

Where additional on-line help is available it shall be in task dependent form, easy to search and list the steps to be carried out.

All information shall be presented on a background of high contrast, emitting as little light as possible at night, so that it does not degrade the night vision of the officer of the watch.

4.2.1.6 Voice announcement

(See 6.1.6)

Voice announcement, if provided, shall be supplementary to other indications and alarms. Failure of the voice announcement system shall not degrade the operation of the provided indicators and alarms.

As a minimum English language shall be available. Announcements shall be in plain language using marine terminology but such that they will not be confused with commands usually given by persons.

Methods shall be provided to check the functionality of the voice output and to adjust the necessary volume. It shall be possible to adjust the volume to extinction.

Announcements shall be clearly understandable at all possible places where the operator may be situated and under the prevailing environmental conditions.

Loudness of announcements shall not exceed that defined for alarms (see 4.2.2.2). Sudden changes of loudness shall not be permitted.

Announcements shall be stopped when their associated indication or alarm is acknowledged.

4.2.1.7 Safety of operation

(See 6.1.7)

The system shall attempt to prevent ascertainable user-action error from occurring.

All actions that may cause irreversible errors shall require a confirmation before proceeding.

When an action causes a detectable error, the system shall give clear feedback such as by including UNDO and/or REDO options where possible.

Equipment shall make use of any quality indication contained in the input from other systems or sources.

The user is to have available means to return to a known safe state with a single action.

4.2.1.8 Distress alert (if provided)

(See 6.1.8)

(A.803/2.6) *A distress alert* shall *be activated only by means of a dedicated distress button. This button* shall *not be any key of an ITU-T digital input panel or an ISO keyboard provided on the equipment,* shall be red in colour and marked “DISTRESS”.

(A.803/2.7) *The dedicated distress button* shall:

1) *be clearly identified*; *and*
2) *be protected against inadvertent operation* by means of a spring loaded lid or cover.

(A.803/2.8) *The distress alert initiation* shall *require at least two independent actions.*

(A.803/2.9) *The equipment* intended to transmit a distress alert shall *indicate the status of the distress alert transmission.* There shall be a time delay of at least 3 s between initial operation of the button and the alert being activated.

(A.803/2.10) *It shall be possible to interrupt the repetition of distress alerts and initiate distress alerts at any time.*

4.2.2 Hardware

4.2.2.1 General

(See 6.2.1)

Equipment with a safety-related function shall be simple in design.

(A.694/3.4*) The design of the equipment* shall *be such that misuse of the controls* shall *not cause damage to the equipment or injury to personnel.*

Operational controls, the inadvertent exercise of which could switch off the equipment, lead to its performance degradation, or to false indications not obvious to the operator, shall be protected against unintentional operation.

Provision shall be made for the removal of, or for blocking off, the position of controls of any optional facilities which are not fitted.

(A.694/3.6) *Where a digital input panel with the digits "0" to "9" is provided, the digits shall* preferably *be arranged to conform with* ITU-T recommendation E.161/Q.11 (4x3 array). *However, where an alpha-numeric keyboard layout, as used on office machinery and data processing equipment, is provided, the digits "0" to "9" may, alternatively, be arranged to conform with* ISO 3791*.*

4.2.2.2 Alarms and indicators

(See 6.2.2)

The equipment shall be provided with facilities, which permit the testing of all operational indicators (alarm, warning and routine), displays and audible devices required by the relevant equipment standard.

Warning and alarm indicators shall show no light in normal condition (indication of a safe situation). Alarm indications shall be red, or if on displays, red or otherwise highlighted.

If alarm messages are displayed on colour VDUs, the alarm status shall remain visible in the event of a failure of one colour of the display system.

The sound pressure level of an audible alarm 1 m from the source shall be at least 75 dB(A) but not greater than 85 dB(A).

4.2.2.3 Illumination

(See 6.2.3)

(A.694/3.3) Where equipment is likely to be fitted in places which need to have low levels of ambient lighting, *adequate* adjustable *illumination* shall *be provided in the equipment or in the ship to enable identification of controls and facilitate reading of indicators at all times. Means* shall *be provided for dimming the output of any equipment light source which is capable of interfering with navigation.*

Any external illumination required shall be clearly identified in the equipment manual.

The illumination shall be dazzle-free and adjustable to extinction, except that those warning and alarm indicators which are illuminated in the warning/alarm condition, and indicators required for switching on/off or resetting the equipment, or for initiation of distress alerting, shall be clearly visible in all appropriate conditions of ambient illumination.

Transparent covers to instruments shall not cause reflections which reduce readability.

4.2.3 Software

4.2.3.1 General

(See 6.3.1)

The code of practice employed in the design and testing of the software integral to the operation of the equipment under test shall be specified and conform to a quality control system audited by a competent authority. The code of practice shall define the methodology used in the development of the software and the standards applied. It shall, amongst others, include the following criteria:

– complex software shall be structured to support separate testing of single modules or of groups of associated modules. Functions of safety protection linked with control functions shall always give priority to safety.
– the structure shall support maintenance and up-dates of software by minimizing the risk of undetected problems and failures.

The manufacturer shall supply documentation demonstrating that the software of the EUT is developed and tested according to the code of practice and the requirements of 4.2.3 e.g. by block, data flow or status diagram.

4.2.3.2 Safety of operation

(See 6.3.2)

Facilities shall be provided to protect all operational software incorporated in the equipment.

Any software required in an equipment to facilitate operation in accordance with its equipment standard, including that for its initial activation/reactivation, shall be permanently installed with the equipment, in such a way that it is not possible for the user to have access to this software.

It shall not be possible for the operator to augment, amend or erase, during normal use, any program software in the equipment required for operation in accordance with the equipment standard. Data used during operation and stored in the system shall be protected in such a way, that necessary modifications and amendments by the user cannot endanger its integrity and correctness.

Default values shall be inserted whenever relevant to facilitate the required operation of the equipment.

Display and update of essential information available in the equipment as well as safety related functions shall not be inhibited due to operation of the equipment in any particular mode, for example dialogue mode.

When presented information is uncertain or derived from conflicting sources, the equipment shall indicate this.

4.2.3.3 Monitoring

(See 6.3.3)

Means shall be provided to monitor the operational software and stored data of the equipment automatically. The check should be carried out during system start-up and at regular intervals, as indicated in the manufacturer's documentation. In the case of a non-automatically recoverable error or failure, the system shall release an independent alarm observable to the user on the workstation.

4.2.3.4 Operation

(See 6.3.4)

The system may allow function keys to speed up selection of common sequences.

4.2.4 Inter-unit connection

(See 6.4)

For external communication equipment shall comply with standard communication protocols and data formats in accordance with IEC 61162 series as applicable.

(A.694/3.5) *If a unit of equipment is connected to one or more other units of equipment the performance of each* shall *be maintained*, in such a manner that the performance of one element does not affect the required performance of the others.

Equipment shall be capable of working if data exchange fails as far as its functions do not depend on the data.

4.3 Power supply

4.3.1 Extreme power supply

(See 7.1)

(A.694/4.1) *Equipment* shall *continue to operate in accordance with the requirements of* the relevant standard *in the presence of variations of* the *power supply normally to be expected in a ship.*

4.3.2 Excessive conditions

(See 7.2)

(A.694/4.2) *Means* shall *be incorporated for the protection of equipment from the effects of excessive current and voltage, transients and accidental reversal of the power supply polarity* or phase sequence.

4.3.3 Power supply short-term variation and power supply failure

(See 7.3, 7.4)

(A.694/4.3) *If provision is made for operating equipment from more than one source of electrical energy, arrangements for rapidly changing from one source to the other* shall *be provided but not necessarily incorporated in the equipment.*

4.4 Durability and resistance to environmental conditions

(See clause 8)

(A.694/5) *Equipment* shall *be capable of continuous operation under the conditions of various sea states, ships' motion, vibration, humidity and temperature likely to be experienced in ships.*

For the purposes of this standard, equipment or units shall be divided into four categories, as follows:

a) portable;

b) protected from the weather (formerly class B);

c) exposed to the weather (formerly class X);

d) submerged or in continuous contact with sea water (formerly class S).

Examples of equipment in each category are given in annex D.

The equipment manual shall identify the category of the equipment.

A description of the environmental conditions for ships is given in annex B.

4.5 Interference

4.5.1 Electromagnetic compatibility

(See clauses 9, 10)

(A.694/6.1) *All reasonable and practicable steps* shall *be taken to ensure electromagnetic compatibility between the equipment concerned and other radiocommunication and navigational equipment carried on board in compliance with the relevant requirements of chapters III, IV and V of the SOLAS Convention.*

Equipment earthing requirements shall be incorporated in the equipment installation instructions and shall, as a minimum, comply with IEC 60533.

A description of the electromagnetic compatibility (see IEC 60050-161) requirements for ships is in annex C.

4.5.2 Acoustic noise

(See 11.1)

(A.694/6.2) *Mechanical noise from all units* shall *be limited so as not to prejudice the hearing of sounds on which the safety of the ship might depend*.

4.5.3 Compass safe distance

(See 11.2)

(A.694/6.3) *Each unit of equipment normally to be installed in the vicinity of a standard or a steering magnetic compass* shall *be clearly marked with the minimum safe distance at which it may be mounted from such compasses.*

Alternatively, the minimum safe distance for fixed equipment may be given in the equipment manual, but portable equipment shall always be marked.

ISO 694 defines “vicinity”, relative to the compass, as within 5 m separation. For equipment not marked with compass safe distance, the equipment manual shall contain an instruction that the equipment shall be positioned outside the vicinity thus defined.

4.6 Safety precautions

4.6.1 Protection against accidental access to dangerous voltages

(See 12.1)

(A.694/7.1) *As far as is practicable, accidental access to dangerous voltages* shall *be prevented. All parts and wiring in which the direct or alternating voltages or both (other than radio frequency voltages) combine to give a peak voltage greater than* 50 V shall *be protected against accidental access and* shall *be isolated automatically from all sources of electrical energy when the protective covers are removed. Alternatively, the equipment* shall *be so constructed that access to such voltages may only be gained after having used a tool for this purpose, such as a spanner or screwdriver, and warning labels* shall *be prominently displayed both within the equipment and on protective covers.*

(A.694/7.2) *Means* shall *be provided for earthing exposed metallic parts of the equipment, but this* shall *not cause any terminal of the source of electrical energy to be earthed.*

4.6.2 Electromagnetic radio frequency radiation

(See 12.2, 12.3)

(A.694/7.3) *All* practicable *steps* shall *be taken to ensure that electromagnetic radio frequency energy, radiated from the equipment* shall *not be a hazard to personnel.*

4.6.3 X-radiation

(See 12.4)

(A.694/7.4) *Equipment containing elements such as vacuum tubes,* for example cathode ray tubes, magnetrons and TR cells, *which are likely to cause X-radiation shall comply with the following requirements.*

1) External X-radiation from the equipment in its normal working condition shall *not exceed the limits laid down by the Administration concerned.*

2) When X-radiation can be generated inside the equipment above the level specified *by the Administration, a prominent warning* shall *be fixed inside* and outside *the equipment and the precautions to be taken when working on the equipment* shall *be included in the equipment manual.*

3) If malfunction of any part of the equipment can cause an increase in X-radiation, adequate advice shall *be included in the* equipment manual, *warning of the circumstances which could cause the increase and stating the precautions which should be taken.*

4.7 Maintenance

(See clause 13)

4.7.1 Maintenance of hardware

(A.694/8.1) *The equipment* shall *be so designed that the main units can be replaced readily,* for on-board repair, *without elaborate recalibration or readjustment.*

(A.694/8.2) *Equipment* shall *be so constructed and installed that it is readily accessible for inspection and maintenance purposes.*

4.7.2 Maintenance of software

Equipment shall be so designed that maintenance of software can be readily carried out on board. Maintenance shall be supported by labelling in accordance with 4.9 (Marking and identification). No user retraining shall be necessary after maintenance.

On board documentation shall be updated with the software maintenance to reflect any changes introduced.

4.8 Equipment manuals

(See clause 14)

(A.694/8.3) *Adequate information* shall *be provided to enable the equipment to be properly operated and maintained* by suitably qualified members of a ship's crew.

Operating and servicing manuals shall:

a) be written in English;

b) identify the category of the equipment or units to which they refer (4.4);

c) (A.694/8.3.1) *in the case of equipment so designed that fault diagnosis and repair down to component level are practicable, provide full circuit diagrams, component layouts and a component parts list;*

d) (A.694/8.3.2) *in the case of equipment containing complex modules in which fault diagnosis and repair down to component level are not practicable, contain sufficient information to enable a defective complex module to be located, identified and replaced. Other modules and those discrete components which do not form part of modules* shall *also meet the requirements of 4.8 c) above.*

Moreover adequate information shall be provided to allow equipment to be installed so that it operates in accordance with the requirements of the relevant equipment standard, taking into account limitations imposed by the operation of other equipment also required to be installed on the bridge.

4.9 Marking and identification

(See clause 15)

(A.694/9) *Each unit of the equipment* shall *be marked externally with the following information which,* where practicable, shall *be clearly visible in the normal installed position:*

1) identification of the manufacturer;

2) equipment type number or model identification under which it was type tested; and

3) serial number of the unit.

Alternatively, the marking may be presented on a display at equipment start-up.

The equipment shall be marked either before delivery to the ship, or on the ship at the time of installation.

The title and version of each software element included in the installed software system shall be either marked or displayed on command on the equipment.

When the marking and the title and version of the software are displayed only on the display, such information shall also be included in the equipment manual.

Marking requirements for compass safe distance are given in 4.5.3.

5 Methods of testing and required test results

5.1 General

There are two categories of tests and associated test methods, technical tests and operational checks. Technical tests for performance, durability and electromagnetic compatibility (EMC) are carried out at a laboratory or test facility. Operational checks, to check that facilities provided for operational use of equipment are adequate, may be carried out in a laboratory or on a ship.

Confirmation of technical performance is required at two or more levels. The level required to confirm compliance with selective parameters of the equipment standard is a performance test. The levels required only to confirm that the equipment operates are performance checks. Performance checks are generally less comprehensive and less time-consuming than the performance test. For some equipment, a single performance check definition will suffice, but for others it may be preferable for technical reasons to define different checks for the various types of test defined in this standard.

Performance tests and checks, and the appropriate check for each test shall be fully defined in the equipment standard. If no equipment standard exists or if the performance test is not specified in the equipment standard, the performance test shall be as defined in the test plan and described in the test report.

Durability tests are designed to test equipment resistance to mechanical deterioration due to exposure to the shipboard environment, or to the rigours of mishandling, such as dropping, where appropriate, or transportation and installation.

EMC tests either check that equipment can operate as intended in the expected shipborne electromagnetic environment, or that it does not contribute unduly to that environment.

Except where otherwise stated, electric power shall be supplied to the equipment under test (EUT) only during the periods specified for EMC tests, for performance tests, and checks and operational checks.

Unless a deviation is specifically stated in the relevant equipment standard, all tests and checks shall be carried out as called for, and under the conditions prescribed in this standard. Tests may be conducted in any convenient order, unless a sequence is specified in the relevant equipment standard, and may be combined.

Adequate information shall be provided to enable the EUT to be properly set up, maintained and operated during testing.

Cross-references between the IMO Resolution A.694 and the tests in this standard are in annex F.

5.2 Test conditions

Normal and extreme test conditions are defined in terms of environmental conditions and power supply parameters. The term “normal” shall be read in context, particularly noting that normal and extreme test conditions together cover the broad range of conditions which may normally be found on ships.

The test power supply shall be capable of providing the normal and extreme test voltages and, for a.c. supplies, frequencies, for all variations of load imposed by the EUT, that is its internal impedance shall be low enough to have only negligible effect on the test results. The power supply voltage and frequency shall be measured at the input terminals of the EUT.

For equipment powered from integral batteries, the use of a test power supply is for convenience only, and shall be agreed with the manufacturer. In the event of any discrepancy, results obtained using the batteries shall take precedence over results obtained using a test power source.

5.2.1 Normal test conditions

Normal environmental conditions shall be a convenient combination of +15 °C to +35 °C temperature and 20 % to 75 % relative humidity.

When it is impractical to carry out 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.

The normal test power supply voltage shall be within a tolerance of ±3 % relative to the nominal voltage of one (or any) of the ship's power supplies for which the equipment is designed. For a.c. supplies, the test power supply frequency shall be within ±1 Hz of the nominal frequency.

5.2.2 Extreme test conditions

Extreme environmental conditions are defined in clause 8.

The extreme variations in the power supplies in ships are described in IEC 60092-101. To test for these, the combinations of power supply variations given in table 1 shall be used as appropriate to the EUT.

Table 1 – Extreme power supply variation

Power supply	Voltage variation %	Frequency variation %
a.c.	±10	±5
d.c.	+30 −10	Not applicable

The lower extreme test voltage for equipment using integral batteries shall be in accordance with the type of batteries used, that is for:

– primary: alkaline or lithium cells: 0,8 times the nominal voltage of the battery;
– mercury cells: 0,9 times the nominal voltage of the battery;
– secondary: cadmium cells: 1,2 and 0,9 times the nominal voltage of the battery;
– other types of battery: the end point voltage declared by the manufacturer.

The upper extreme test voltage for all types of primary integral battery shall be the nominal voltage of the battery.

The extreme test voltages for equipment using other power sources, or capable of being operated from a variety of power sources, shall be agreed with the equipment manufacturer, and shall be recorded in the test report.

The schedule of performance tests and checks to be carried out on the EUT are defined in table 2.

5.2.3 Excessive conditions

These conditions exceed the extreme test conditions in which the EUT is required to operate, with or without performance degradation, as indicated in the equipment standard. Excessive current is defined as greater than normal working current.

Excessive voltage is greater than that specified in 5.2.2. Protection shall be provided against such excesses at an appropriate level chosen by the manufacturer and, when activated, may require the EUT to be reset, for example by fuse replacement. The power supply shall be adjusted to cause activation of the protection and after EUT reset, a performance check under normal test conditions shall be carried out.

Power supply misconnections are also regarded as excessive conditions. Where appropriate, the EUT shall be subjected to an input from a power supply of reversed polarity or improper phase sequence for a period of 5 min. After completion of the test, and reset of the protection of the EUT, if required, the power supply shall be connected normally and a performance check shall be carried out.

5.3 Test results

A test report shall be prepared to record the results of all appropriate tests.

The measured test results shall be compared with the corresponding acceptable performance limits, and the EUT shall pass the test only if the measured performance margin is favourable and greater than the test measurement uncertainty. The test report shall show, for each test measurement, the test result, its associated measurement uncertainty, the acceptable performance limits, and the performance margin, as applicable.

Any requirement stated in clause 4 for which no method of testing is specified shall be checked by inspection of the equipment, its manufacturing drawings or other relevant documents. The check carried out shall be described and the result noted in the test report.

Guidance on the information required in the test report is given in Annex E.

6 Operational checks (all equipment categories)

6.1 Ergonomics and HMI

The EUT shall be checked to ensure compliance with the specific requirements as detailed below. The checks carried out shall be described and the results noted in the test report.

6.1.1 General

A check shall be made that all modes of operation required by the equipment standard are available, and that they may be controlled over the required range. Use shall be made of every position of every control provided to ensure that it performs the function for which it is identified and that it operates in the expected manner.

6.1.2 Arrangement

(See 4.2.1.2)

a) Check that the number of operational controls, their design and manner of function, location, arrangement and size provide for simple, quick and effective operation of the EUT. Check that the controls are logically grouped according to their function.

b) Check that the shape and size of each control is appropriate to its mode of operation. In the case of trackballs, joysticks and mice check that the controller can produce any combination of x and y axis output values and that the controller does not drive the follower off the edge of the screen. In the case of joysticks, check that there is a “home position” with a capability for a return to that point.

c) In the case of touch screens check that the dimension of the response area for a push to activate operation is a minimum of 15 mm height and width and the force required for operation is a maximum of 1,5 N where applicable.

d) Check that information presentation is suited to the maximum expected rate of change of information, for example analogue presentation is sometimes more suited to rapid change than digital.

e) Check that rotating controls and indicators turn clockwise for increased value or effect.

f) Check that linear controls and indicators move upwards or to the right for increased value or effect.

g) Check that where users must rapidly discern directional change, digital displays are provided with indications of directions of change.

h) Check that equipment elements relating to control, and indicators associated with control, are readily distinguishable from elements provided for other functions, such as equipment set-up.

6.1.3 Operation

(See 4.2.1.3)

a) Check that all operational controls permit normal adjustments to be easily performed, and are arranged in a manner which minimizes the chance of inadvertent operation. Check that controls not required for normal operation and which may affect performance are not readily accessible.

b) Check all operational controls and indications for ease of use and correctness, and for general suitability related to their function and environment, for example expected ambient illumination and sound.

c) Check that the operation of a control does not cause obscuration of its related indicator where observation of the indicator is necessary for making the adjustment.

d) Check that in all operations there is a clearly marked or consistent simple action to recover from a mistaken choice or to leave an unwanted state. Check that it is always possible for a user to start, interrupt, resume and end an operation.

6.1.4 Identification

(See 4.2.1.4)

a) Check that all operational controls and indicators are easy to identify and read from the position where the equipment is normally operated.

b) Check that instrument and indicator character type is simple and clear. The character height (mm) shall be not less than 3,5 times the reading distance in metres, and the nominal character width shall be 0,7 times the character height. Check that instruments meant to be operated, or fitted in connection with controls are readable from a distance of at least 1 m, and that other instruments are readable from a distance of at least 2 m.

c) Check that the controls and indicators are identified in English, and that the identifications provided in the equipment standard are used.

d) Check that indicators are satisfactorily positioned relative to the operator's line of sight, and are not obscured when operating associated controls under normal operating conditions.

6.1.5 Screen display and indicators

(see 4.2.1.5)

a) Check that menus are grouped according to the task environment. Check that hierarchical menu structures have been designed to minimize the number of steps required and that the user has an indication of current position in the menu.

b) If menu selections are made of keyed codes, check that each code is the first letter or letters of the displayed option label rather than an arbitrary letter.

c) Check that a menu displays only those options currently available in the current context to the user. Check that menu items are highlighted when the cursor passes over them.

d) Check that for menu items that can be in an “On” or “Off” state the “On” state should be indicated by making the item perceptually distinct and that selection of menu items with “On” and “Off” states change their state.

e) Check that items which appear the same behave consistently by, for instance,

   – checking for consistent display format and selection logic in hierarchical menus,

   – checking that menus used in different displays are consistent,

   – checking that menus are displayed in consistent screen locations,

   – checking for consistent input prompts and checking that labels are consistent.

f) Check that the user does not have to remember information from one part of a dialogue to another

g) Check that the system employs marine terminology conforming with the SMCPs where appropriate.

h) Check that displayed text is easy to understand wherever possible.

i) Check that where additional on-line help is available it is in task dependent form, easy to search and list the steps to be carried out.

j) Check that in all operations the system state is observable with essential data displayed.

k) Check that all information required by the user to perform an operation is available on the current display.

l) Check that feedback timing is consistent with the task requirements. Check that there is a clear feedback from any action within a short time. Check that where a perceptible delay in response occurs, a visible indication is given.

m) Check that it is possible at any step of a screen supported operation to return with one action to the original status before the operation was started.

n) Check that any mode in use is distinctively identified by the display.

o) Check that displays present the simplest information consistent with their function, information irrelevant to the task is not displayed, and extraneous text and graphics are not present.

p) Check that displayed text is clearly legible to the user. Check that the font and size of alphanumeric characters are consistent. For any font used, check that it is possible to clearly distinguish between the characters: X and K, T and Y, I and L, I and 1, 0, O and Q, S and 5 and U and V.

q) Check that the unit of measure is indicated for any data.

r) Check that all information is presented on a background of high contrast.

s) Check that highlighting is easily recognizable and is disabled when it is no longer applicable.

t) Check that flashing is only used to signal an alarm and that only a small percentage of the screen is flashing at any one time. Check that if a user is required to read alarm text a marker symbol shall flash rather than the text. Check that no more than two flash rates are used and that they are then time synchronized.

6.1.6 Voice announcement

(See 4.2.1.6)

a) Check that voice announcements are in plain language, using marine terminology conforming with the SMCPs where appropriate, and in the English language.

b) Check that it is possible to adjust the volume to extinction and that sudden changes in loudness do not occur.

c) Check that voice announcements stop when their associated indication or alarm is acknowledged.

d) Check that failure of the voice announcement system by disabling the loudspeaker, does not degrade the operation of the provided indicators and alarms.

6.1.7 Safety of operation

(See 4.2.1.7)

a) Check that the system attempts to prevent ascertainable user-action error from occurring.

b) Check that all actions that may be irreversible, require a confirmation before proceeding.

c) Check that when an action causes a detectable error the system gives clear feedback such as by including UNDO and/or REDO options where possible.

d) Check that the EUT makes use of any quality indication contained in the input from other systems or sources.

e) Check that the user has available means to return to a known safe state with a single action.

6.1.8 Distress alert

(See 4.2.1.8)

a) Check that a distress alert is only activated by means of a dedicated distress button, and that it is not a key of an ITU-T digital input panel, or of an ISO keyboard on the equipment. Check that the button is physically separated from functional buttons/keys used for normal operation. Check that the button is a single button used for no other purpose than to initiate a distress alert.

b) Check that the dedicated distress button is clearly identified by being red in colour and marked “DISTRESS”. Where a non-transparent protective lid or cover is used check that this is also marked “DISTRESS”.

c) Check that the dedicated distress button is protected against inadvertent operation by means of a spring loaded lid or cover permanently attached to the equipment, for example by hinges. Check that it is not necessary for a user to remove additional seals or to break the lid or cover in order to operate the distress button.

d) Check that the distress alert initiation requires at least two independent actions. Lifting the protective lid or cover is considered as the first action. Pressing the distress button is considered as the second independent action.

e) Check that the equipment indicates the status of a distress alert transmission by checking that the distress button generates a visible and audible indication. Check that when the distress button is pressed a flashing light and intermittent acoustic signal start immediately. Check that after the distress button has been pressed for at least 3 s, the transmission of the distress alert is initiated and the indication becomes steady.

f) Check that it is not possible to interrupt the transmission of a distress alert or distress message which is in progress, but that it is possible to interrupt repetitive transmissions of a distress message.

6.2 Hardware

The EUT shall be checked to ensure compliance with the specific requirements as detailed below. The checks carried out shall be described and the results noted in the test report.

6.2.1 General

(See 4.2.2.1)

a) Check that provision has been made for the removal of, or for blocking off, the position of controls of any optional facilities which are not fitted.

b) Check that operational controls, the inadvertent exercise of which could switch off the equipment, lead to performance degradation, or to false indications not obvious to the operator, are specially protected against unintentional operation.

c) Check that the design of the EUT is such that misuse of the controls required for normal operation, and which are accessible to the operator, shall not cause damage to the equipment or injury to personnel.

d) Check that where a digital input panel with the digits “0” to “9” is provided, the digits are arranged to conform with ITU-T Recommendation E.161 (4x3 array) or, alternatively, where an alpha-numeric keyboard layout, as used on office machinery and data processing equipment, is provided, the digits “0” to “9” are arranged to conform with ISO 3791.

6.2.2 Alarms and indicators

(See 4.2.2.2)

a) Check that the EUT is provided with facilities which permit the testing of all operational indicators (alarm, warning and routine), displays and audible devices. Check audible alarms as described in 11.1.

b) Check that alarm indications are red, or if on displays, red or otherwise highlighted.

c) Check that warning and alarm indications show no self-illumination, except to outline the alarm area on CRT or LCD displays, in the “safe” condition, and that any indirect illumination is low enough to avoid false indications.

6.2.3 Illumination

(See 4.2.2.3)

a) Check that any illumination provided in the EUT is adequate for operation of the equipment under all expected conditions of ambient illumination. Check that it can be adjusted for night use so that the night vision of the officer of the watch is not harmed by it.

b) Check that means are provided for dimming the output of any light source of the equipment which is capable of interfering with navigation.

c) Check that any external illumination required is clearly identified in the equipment manual.

d) Check that warning and alarm indicator lamps cannot be dimmed below reading intensity.

e) Check that the illumination is dazzle-free and adjustable to extinction, except for those warning and alarm indicators which are illuminated in the warning/alarm condition, and indicators required for equipment reactivation or distress alerting, which are to be clearly visible in all appropriate conditions of ambient illumination.

f) Check that controls which are not illuminated, such as tracker balls, are locatable easily and unambiguously by tactile means.

g) Check that all information is presented with high contrast on a low-reflectance background which emits negligible light at night.

h) Check that transparent covers to instruments cannot cause reflections which reduce readability to an unacceptable level.

i) Check that adjustable dimming from full brightness is provided for all lamps which are to be used in conditions of varying ambient illumination.

6.3 Software

The EUT shall be checked to ensure compliance with the specific requirements as detailed below. The checks carried out shall be described and the results noted in the test report.

6.3.1 General

(See 4.2.3.1)

Check documentation for compliance with 4.2.3.1.

6.3.2 Safety of operation

(See 4.2.3.2)

a) Check documentation for compliance with 4.2.3.2.

b) Check that software defaults, where applicable, are inserted in all modes of operation and that the default value:

- facilitates the preferred or expected operation of the equipment in accordance with the applicable equipment standards
- does not lead to an unexpected or invalid operation, and
- has the effect of minimising the number of inputs or transmissions into the system under which it operates.

c) Check that the software prevents an operation or warns an operator when attempting an input that leads to an invalid operation of the equipment.

d) Check that the operator has the possibility to choose a value other than the default value.

e) Check that operations not required for normal operation, or which may adversley affect system performance, are not readily accessible.

6.3.3 Monitoring

(See 4.2.3.3)

Check documentation for compliance with 4.2.3.3. The manufacturer shall provide information on how to produce a non-recoverable error.

Carry out the non-automatically recoverable error according to the above information. Check that the alarm can be recognized as noted in the manufacturers documentation.

NOTE This test can be waived if the manufacturer gives a written explanation of how the equipment watchdog operates and a written declaration is given to the test-house of how this function works and that the behaviour of the watchdog complies with the noted requirements.

6.3.4 Operation

(See 4.2.3.4)

Check documentation for compliance with 4.2.3.4.

6.4 Inter-unit connection

(See 4.2.4)

Check with the manufacturer of the EUT, using equipment documentation if necessary, that when it is connected to, and operating with, other units of equipment, arrangements have been provided to maintain the performance of the EUT and of the other units. In particular:

a) check that the software interfaces between the EUT and other equipment are tested, and that special test software is provided for this purpose if necessary;

b) ensure that arrangements have been made to achieve electrical separation and isolation between the EUT and the equipment to which it may be connected, if appropriate, such as by checking that:

   1) an exchange of any signals between units is carried out with minimum effect on the signal source;

   2) there is no loading of circuits or mismatch of transmission lines, particularly on high-frequency or fast-rise time signals;

   3) a capability exists of sustaining a 1 kV isolation between units of equipment.

7 Power supply – Methods of testing and required test results

7.1 Extreme power supply

(See 4.3.1)

Tests and performance checks at extreme power supply conditions shall be performed under the environmental conditions indicated in table 2.

Table 2 – Schedule of performance tests and checks

Environment	Normal power supply	Extreme power supply
Dry heat	Performance test	Performance check
Damp heat	Performance check	–
Low temperature	Performance test	Performance check
Normal temperature	Performance test	Performance test

NOTE These tests may be carried out together with those of clause 8.

7.2 Excessive conditions

(See 4.3.2)

For the relevant requirements to be met, see 5.2.3.

7.3 Power supply short-term variation

(See 4.3.3)

For the relevant test, see 10.7.

7.4 Power supply failure

(See 4.3.3)

For the relevant test, see 10.8.

8 Durability and resistance to environmental conditions – Methods of testing and required test results

(See 4.4)

8.1 General

Prior to testing, the EUT shall be visually inspected, and shall then be preconditioned and mechanically and electrically checked as required by the equipment standard.

All tests shall be carried out with the EUT in its normal operational configuration, including mounting and supports, and with all mechanical arrangements secure.

The test chamber shall simulate free air conditions as closely as possible, either by virtue of its large size relative to the EUT, or by forced air circulation. The inside of the chamber shall be treated to avoid re-radiation of the heat dissipated by the EUT. The maximum rate of raising or reducing the temperature of the chamber in which the EUT is being tested shall be 1 °C/min and, except where otherwise stated, the humidity in the test chamber shall be controlled so that excessive condensation does not occur.

The EUT shall be subjected to performance tests (PT) and performance checks (PC) under normal and extreme test conditions in the combinations indicated in table 2.

A performance check shall be carried out under normal test conditions, following each durability test.

The EUT shall operate correctly in accordance with its equipment standard during each test or check.

The environmental conditions for tests to be carried out on each unit of an EUT in each of the categories given in 4.4 are summarized in table 3 below, and examples of equipment in each category are given in annex D.

Table 3 – Durability and resistance to environmental conditions

	Portable	Protected	Exposed	Submerged
Dry heat	+55 °C (storage +70 °C)	+55 °C	+55 °C (storage +70 °C)	(storage +70 °C)
Damp heat	+40 °C 93 % relative humidity 1 cycle			*
Low temperature	–20 °C (storage –30 °C)	–15 °C	–25 °C	*
Thermal shock	45 K into water	*		
Drop onto hard surface	6 drops from 1 m	*		
Drop into water	3 drops from 20 m	*		
Vibration	Sweep 2 Hz – 13,2 Hz at ± 1 mm, 13,2 Hz – 100 Hz at 7 m/s^2 and for 2 h on each resonance, otherwise 2 h at 30 Hz in all three axes			
Rain and spray	*		12,5 mm nozzle 100 l/min at 3 m	*
Water immersion	100 kPa (1 bar) for 5 min 10 kPa (0,1 bar) for two-way VHF	*		600 kPa (6 bar) for 12 h
Solar radiation	1120 W/m^2 80 h	*	*	*
Oil resistance	ISO Oil No. 1 24 h, 19 °C	*	*	*
Corrosion	Four periods of seven days at 40 °C with 90 % – 95 % relative humidity after 2 h salt spray			
* Not applicable				

At the end of each test under extreme environmental conditions, the EUT shall be exposed to normal environmental conditions (5.2.1) for not less than 3 h, or until moisture has dispersed, whichever is the longer, before the next test is carried out. Moisture dispersal may be assisted by agitating the EUT, or by subjecting it to a blast of air at normal temperature.

8.2 Dry heat

8.2.1 Storage test (portable, exposed and submerged equipment)

8.2.1.1 Purpose

To simulate the effects of temperature stress on equipment in the non-operating (un-powered) mode. A temperature of +70 °C is the maximum likely to be encountered in enclosed spaces on ships and in equipment exposed to the full effects of solar radiation in ports.

8.2.1.2 Method of test

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be raised to and maintained at +70 °C ± 3 °C, for a period of 10 h to 16 h.

At the end of the test, the EUT shall be returned to normal environmental conditions and then subjected to a performance check as specified in the relevant equipment standard (see 7.1).

Further information is given in IEC 60068-2-2 and IEC 60068-2-48.

8.2.1.3 Required result

The requirements of the performance check shall be met.

8.2.2 Functional test (portable, protected and exposed equipment)

8.2.2.1 Purpose

This test determines the ability of equipment to be operated at high ambient temperatures and to operate through temperature changes. The reasonable maximum air temperature likely to be encountered over the sea is +32 °C and the maximum solar gain at sea is +23 °C giving +55 °C as the maximum temperature likely to be encountered by ships at sea.

8.2.2.2 Method of test

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The EUT and, if appropriate, any climatic control devices with which it is provided shall then be switched on. The temperature shall then be raised to and maintained at +55 °C ± 3 °C.

At the end of a soak period of 10 h to 16 h at +55 °C ± 3 °C, the EUT shall be subjected to a performance test and check as specified in the relevant equipment standard (see 7.1).

The temperature of the chamber shall be maintained at +55 °C ± 3 °C during the whole performance test period.

At the end of the test, the EUT shall be returned to normal environmental conditions.

Further information is given in IEC 60068-2-2.

8.2.2.3 Required results

The requirements of the performance test and check shall be met.

8.3 Damp heat

8.3.1 Functional test (portable, protected and exposed equipment)

8.3.1.1 Purpose

This test determines the ability of equipment to be operated under conditions of high humidity. A single cycle is used with an upper temperature limit of +40 °C which is the maximum that occurs in the earth's surface atmosphere with a relative humidity of 95 %.

8.3.1.2 Method of test

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be raised to +40 °C ± 2 °C, and the relative humidity raised to 93 % ± 3 % over a period of 3 h ± 0,5 h. These conditions shall be maintained for a period of 10 h to 16 h. Any climatic control devices provided in the EUT may be switched on at the conclusion of this period.

The EUT shall be switched on 30 min later, or after such period as agreed by the manufacturer, and shall be kept operational for at least 2 h during which period the EUT shall be subjected to a performance check as specified in the relevant equipment standard.

The temperature and relative humidity of the chamber shall be maintained as specified during the whole test period.

At the end of the test period and with the EUT still in the chamber, the chamber shall be brought to room temperature in not less than 1 h.

At the end of the test the EUT shall be returned to normal environmental conditions.

Further information is given in IEC 60068-2-30.

8.3.1.3 Required result

The requirements of the performance check shall be met.

8.4 Low temperature

8.4.1 Storage test (portable equipment)

8.4.1.1 Purpose

This test simulates the effects of temperature stress on equipment in the non-operating (un-powered**)** mode. It is applied to the portable equipment because of the importance that emergency equipment functions correctly after prolonged non-operation.

8.4.1.2 Method of test

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be lowered to and maintained at –30 °C ± 3 °C, for a period of 10 h to 16 h.

At the end of the test period, the EUT shall be returned to normal environmental conditions and then subjected to a performance check as specified in the relevant equipment standard (see 7.1).

Further information is given in IEC 60068-2-48.

8.4.1.3 Required result

The requirements of the performance check shall be met.

8.4.2 Functional tests

8.4.2.1 Purpose

These tests determine the ability of equipment to be operated at low temperatures and also to demonstrate the ability of equipment to start up at low ambient temperatures.

8.4.2.2 Method of test (portable equipment)

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be reduced to, and maintained at –20 °C ± 3 °C, for a period of 10 h to 16 h. Any climatic control devices provided in the EUT may be switched on at the conclusion of this period.

The EUT shall be switched on 30 min later, or after such period as agreed by the manufacturer, and shall be kept operational for at least 2 h during which period the EUT shall be subjected to a performance check test and check as specified in the relevant equipment standard (see 7.1).

The temperature of the chamber shall be maintained at –20 °C ± 3 °C during the whole test period.

At the end of the test the EUT shall be returned to normal environmental conditions.

Further information is given in IEC 60068-2-1.

8.4.2.3 Required result

The requirements of the performance test and check shall be met.

8.4.2.4 Method of test (protected equipment)

The EUT shall be subject to the conditions specified for portable equipment except that the temperature of the chamber shall be reduced to, and maintained at –15 °C ± 3 °C.

8.4.2.5 Required result

The requirements of the performance test and check shall be met.

8.4.2.6 Method of test (exposed equipment)

The EUT shall be subject to the conditions specified for portable equipment except that the temperature of the chamber shall be reduced to, and maintained at –25 °C ± 3 °C.

8.4.2.7 Required result

The requirements of the performance test and check shall be met.

8.5 Thermal shock (portable equipment)

8.5.1 Purpose

To determines the ability of portable equipment to function correctly after sudden immersion in water from storage at high temperature.

8.5.2 Method of test

The EUT shall be placed in an atmosphere of +70 °C ± 3 °C for 1 h. It shall then be immersed in water at +25 °C ± 3 °C to a depth of 100 mm ± 5 mm, measured from the highest point of the EUT to the surface of the water, for a period of 1 h.

At the end of the test the EUT shall be subjected to a performance check, and shall then be examined for damage and for unwanted ingress of water. Following examination, the EUT shall be resealed in accordance with the manufacturer's instructions. Alternatively, if there are no external signs of unwanted ingress of water, an internal examination of the EUT, which involves disturbance to seals, may be carried out after all environmental tests have been completed.

8.5.3 Required result

The requirements of the performance check shall be met. There shall be no damage to the EUT or ingress of water**.** The findings shall be noted in the test report.

8.6 Drop (portable equipment)

8.6.1 Drop on hard surface

8.6.1.1 Purpose

This test simulates the effects of a free fall of an equipment onto the deck of a ship resulting from mishandling. It is applicable only to portable VHF radios, that are most likely to suffer mishandling.

8.6.1.2 Method of test

A series of six drops shall be carried out; one on each face of the EUT.

The test surface shall consist of a piece of solid hard wood with a thickness of at least 150 mm and a mass of 30 kg or more.

The height of the lowest part of the EUT relative to the test surface at the moment of release shall be 1000 mm ± 10 mm.

The EUT shall be subjected to this test configured for use as in operational circumstances.

At the end of the test the EUT shall be subjected to a performance check, and shall then be examined for external indications of damage.

8.6.1.3 Required result

The requirements of the performance check shall be met. There shall be no visible external indications of damage that could affect the functionality of the EUT. The findings shall be noted in the test report.

8.6.2 Drop into water

8.6.2.1 Purpose

This test simulates the effects of a free fall of an equipment into the sea from the deck of a ship 20 m above. It is applicable only to portable equipment, which has an operational requirement to be deployed in this way. It is not applicable to portable VHF radios, as there is no requirement for this equipment to float.

8.6.2.2 Method of test

A series of three drops shall be carried out. Each drop shall be performed with the initial position of the EUT different from the preceding one. The height of the lowest part of the EUT under test relative to the water surface at the moment of release shall be 20 m ± 1 m.

At the end of the test the EUT shall be subjected to a performance check, and shall then be examined for damage and for unwanted ingress of water. Following examination, the EUT shall be resealed in accordance with the manufacturer's instructions. Alternatively, if there are no external signs of unwanted ingress of water, an internal examination which involves disturbance to seals may be carried out after all environmental tests have been completed.

8.6.2.3 Required result

The requirements of the performance check shall be met. There shall be no damage to the EUT or ingress of water. The findings shall be noted in the test report.

8.7 Vibration (all equipment categories)

8.7.1 Purpose

This test determines the ability of equipment to withstand vibration without resulting in mechanical weakness or degradation in performance. The test simulates the effect of vibration induced in a ship's hull by its propeller and machinery. This is generally at frequencies of up to 13 Hz and predominantly vertical. The tests at higher frequencies simulate the effect of slamming which occurs in irregular stormy seas, and is predominantly horizontal. The test does not simulate the effect of regular seas giving the translational components of surging, swaying and heaving, and the corresponding rotational components of rolling, pitching and yawing which generally produce accelerations too small to be of consequence to electronic equipment.

8.7.2 Method of test

The EUT, complete with any shock and vibration absorbers with which it is provided, shall be fastened to the vibration table by its normal means of support and in its normal attitude. The EUT may be resiliently suspended to compensate for weight not capable of being withstood by the vibration table. Provision may be made to reduce or nullify any adverse effect on EUT performance which might be caused by the presence of an electromagnetic field due to the vibration unit.

The EUT shall be subjected to sinusoidal vertical vibration at all frequencies between:

– 2 Hz to 5 Hz and up to 13,2 Hz with an excursion of ±1 mm ± 10 %
(7 m/s^2 maximum acceleration at 13,2 Hz);
– above 13,2 Hz and up to 100 Hz with a constant maximum acceleration of 7 m/s^2.

The frequency sweep rate shall be 0,5 octaves/min in order to allow the detection of resonances in any part of the EUT as mounted.

A resonance search shall be carried out throughout the test. During the resonance search the EUT shall be externally observed, by unaided visual and aural means, for obvious signs of any resonances of components or sub-assemblies, that may affect the integrity of the EUT. Such observations shall be recorded in the test report. If any resonance, as measured by a sensor fixed to the outside of the EUT at the location where obvious signs of resonance have been observed, has a magnitude ratio ≥5 measured relative to the surface where the EUT is fastened, the EUT shall be subjected to a vibration endurance test at each resonant frequency at the vibration level specified in the test with a duration of 2 h. When resonant frequencies with magnitude ratios ≥5 are harmonically related, only the fundamental frequency shall be tested. If no resonance with a magnitude ratio ≥5 occurs, the endurance test shall be carried out at one single observed frequency. If no resonance occurred, the endurance test shall be carried out at a frequency of 30 Hz.

Performance check(s) shall be carried out at least once during each endurance test period, and once before the end of each endurance test period.

The procedure shall be repeated with vibration in each of two mutually perpendicular directions in the horizontal plane.

Further information is given in IEC 60068-2-6.

8.7.3 Required result

The requirements of the performance check shall be met.

8.8 Rain and spray (exposed equipment)

8.8.1 Purpose

This test simulates the effects of rain, sea spray and light breaking seas on equipment. It is applicable to exposed equipment mounted above deck level such as antennas. It is not applicable to portable equipment, as these are required to meet a more stringent immersion test.

8.8.2 Method of test

The test shall be carried out by spraying the EUT from all practicable directions with a stream of water from a standard test nozzle (hose) as shown in figure 6 of IEC 60529. The EUT shall operate throughout the test.

The conditions to be observed are as follows:

– internal diameter of nozzle: 12,5 mm;
– delivery rate: 100 l/min ± 5 % ;
– water pressure: to be adjusted to achieve the specified delivery rate;
– core of substantial stream: circle of approximately 120 mm diameter at distance 2,5 m from nozzle;
– test duration: approximately 30 min;
– distance from nozzle to the equipment surface: approximately 3 m.

At the end of the test the EUT shall be subjected to a performance check, and shall then be examined for damage and for unwanted ingress of water. Following examination, the EUT shall be resealed in accordance with the manufacturer's instructions.

Alternatively, if there are no external signs of unwanted ingress of water, an internal examination which involves disturbance to seals may be carried out after all environmental tests have been completed.

Further guidance is given in IEC 60529, table 3, second characteristic numeral 6: protected against powerful water jets.

8.8.3 Required results

The requirements of the performance check shall be met. There shall be no visible external indications of damage or of unwanted ingress of water. The findings shall be noted in the test report.

8.9 Immersion

8.9.1 Submerged equipment

8.9.1.1 Purpose

This test simulates the effects of water pressure on equipment intended to be mounted permanently under water.

8.9.1.2 Method of test

A hydraulic pressure of 600 kPa (6 bar) shall be applied for a period of 12 h to that part of the EUT that is normally in contact with the water. The remainder of the EUT shall be exposed to the atmosphere.

At the end of the test, the EUT shall be subjected to a performance check, and shall then be examined for damage and for unwanted ingress of water. Following examination, the EUT shall be resealed in accordance with the manufacturer's instructions. Alternatively, if there are no external signs of unwanted ingress of water, an internal examination which involves disturbance to seals may be carried out after all environmental tests have been completed.

8.9.1.3 Required result

The requirements of the performance check shall be met. There shall be no visible external indications of damage or of unwanted ingress of water. The findings shall be noted in the test report.

8.9.2 Portable equipment

8.9.2.1 Purpose

To simulate the effects of water pressure on equipment which may be required to float free from a sinking ship.

8.9.2.2 Method of test

A hydraulic pressure of 100 kPa (1 bar) shall be applied to the EUT for a period of 5 min.

At the end of the test the EUT shall be subjected to a performance check, and shall then be examined for damage and for unwanted ingress of water. Following examination, the EUT shall be resealed in accordance with the manufacturer's instructions. Alternatively, if there are no external signs of unwanted ingress of water, an internal examination which involves disturbance to seals may be carried out after all environmental tests have been completed.

8.9.2.3 Required result

The requirements of the performance check shall be met. There shall be no visible external indications of damage or of unwanted ingress of water. The findings shall be noted in the test report.

8.9.3 Portable equipment (temporary immersion)

8.9.3.1 Purpose

This test simulates the effects of water pressure on VHF portable radio equipment which although not designed to float may experience a temporary immersion whilst attached to a survivor.

8.9.3.2 Method of test

The EUT shall be subject to the test corresponding to IEC 60529, table 3, second characteristic numeral 7: protected against the effects of temporary immersion in water.

The test shall be carried out by completely immersing the EUT in water so that the following conditions are satisfied:

– the highest point of the EUT is located 1 m below the surface of the water;

– the duration of the test is 5 min;

– the water temperature does not differ from that of the equipment by more than 5 K.

At the end of the test the EUT shall be subjected to a performance check, and shall then be examined for damage and for unwanted ingress of water. Following examination, the EUT shall be resealed in accordance with the manufacturer's instructions. Alternatively, if there are no external signs of unwanted ingress of water, an internal examination which involves disturbance to seals may be carried out after all environmental tests have been completed.

8.9.3.3 Required result

The requirements of the performance check shall be met. There shall be no visible external indications of damage or of unwanted ingress of water. The findings shall be noted in the test report.

8.10 Solar radiation (portable equipment)

8.10.1 Waiver

The solar radiation test shall be waived where the manufacturer is able to produce evidence that the components, materials and finishes employed in the equipment would satisfy the test.

8.10.2 Purpose

This test simulates the effects of continuous solar radiation on equipment which are intended to be mounted above deck levels and exposed to the weather.

8.10.3 Method of test

The EUT shall be placed on a suitable support and exposed continuously to a simulated solar radiation source as specified in table 4 for 80 h. The intensity at the test point, which shall also include any radiation reflected from the test enclosure, shall be 1120 W/m^2 ± 10 % with a spectral distribution as given in table 4.

At the end of the test, the EUT shall be subjected to a performance check and an examination with the naked eye.

Further information is given in IEC 60068-2-5 and IEC 60068-2-9.

8.10.4 Required result

The requirements of the performance check shall be met. There shall be no signs of harmful deterioration of the equipment, including labelling.

Table 4 – Spectral energy distribution and permitted tolerances

Spectral region	Ultraviolet B*	Ultraviolet A	Visible			Infrared
Bandwidth µm	0,28 – 0,32	0,32 – 0,40	0,40 – 0,52	0,52 – 0,64	0,64 – 0,78	0,78 – 3,00
Irradiation W/m^2	5	63	200	186	174	492
Tolerance %	±35	±25	±10	±10	±10	±20
* Radiation shorter than 0,30 µm reaching the earth's surface is insignificant.						

8.11 Oil resistance (portable equipment)

8.11.1 Waiver

The oil test shall be waived where the manufacturer is able to produce evidence that the components, materials and finishes employed in the equipment would satisfy the test.

8.11.2 Purpose

This test simulates the effects of mineral oil on equipment.

8.11.3 Method of test

The EUT shall be immersed at a temperature of 19 °C ± 5 °C for 3 h in a mineral oil of the following specification:

– aniline point: 120 °C ± 5 °C;
– flashpoint: minimum 240 °C;
– viscosity: (10 – 25) cST at 99 °C.

The following oils may be used:

– ASTM oil No. 1;
– ASTM oil No. 5;
– ISO oil No. 1.

After the test, the EUT shall be cleaned in accordance with the manufacturer's instructions. The EUT shall then be subjected to a performance check and an examination with the naked eye.

8.11.4 Required result

The requirements of the performance check shall be met. The EUT shall show no signs of damage such as shrinking, cracking, swelling, dissolution or change of mechanical characteristics.

8.12 Corrosion (salt mist) (all equipment categories)

8.12.1 Waiver

The corrosion test shall be waived where the manufacturer is able to produce evidence that the components, materials and finishes employed in the equipment would satisfy the test.

8.12.2 Purpose

This test determines the ability of an equipment to be exposed to a salt laden atmosphere without physical degradation. The cyclic nature of the test produces an acceleration of effects compared with service conditions.

8.12.3 Method of test

The EUT shall be placed in a chamber and sprayed with a salt solution for 2 h at normal temperature. The salt solution shall be prepared by dissolving (5 ± 1) parts by weight of sodium chloride (NaCl) in 95 parts by weight of distilled or demineralized water.

At the end of the spraying period, the EUT shall be placed in a chamber which shall be maintained at a temperature of 40 °C ± 2 °C, and a relative humidity between 90 % and 95 % for a period of seven days.

The EUT shall be subjected to a test comprising four spraying periods, each of duration 2 h, with a storage period of seven days after each.

At the conclusion of the test the EUT shall be inspected with the naked eye without magnification. The EUT shall then be subjected to a performance check.

Further information is given in IEC 60068-2-52.

8.12.4 Required result

The requirements of the performance check shall be met. There shall be no undue deterioration or corrosion of metal parts.

9 Electromagnetic emission – Methods of testing and required test results

(See 4.5.1)

9.1 General

During the measurements for electromagnetic emission, the EUT shall operate under normal test conditions, and the setting of controls which may affect the level of conducted or radiated emission shall be varied in order to ascertain the maximum emission level. If the EUT has more than one energized state, for example operate, stand-by, etc., the state which produces the maximum emission level shall be ascertained, and full measurements for that state shall be made. The antenna connection of the EUT, if any, shall be terminated in a non-radiating artificial antenna.

For radiated emission tests, equipment including a radio transmitter operating within the measurement bands shall be in the operational state but not the transmitting state.

For conducted emission tests with equipment including a radio transmitter, there shall be an exclusion band of 200 kHz centred at the fundamental and any harmonics within the measurement band.

Particular interfaces of the EUT with the external electromagnetic environment are referred to as ports. The physical boundary of the EUT through which electromagnetic fields may radiate or impinge is the enclosure port (figure 1).

Conditions and tests are summarized in table 5 below. Examples of equipment in each category are given in annex D.

Table 5 – Electromagnetic emission

	Portable	Protected	Exposed	Submerged
Conducted emissions (9.2)		10 kHz – 150 kHz 150 kHz – 350 kHz 350 kHz – 30 MHz	63 mV – 0,3 mV (96 dBμV – 50 dBμV) 1 mV – 0,3 mV (60 dBμV – 50 dBμV) 0,3 mV (50 dBμV)	
Radiated emissions (9.3)	150 kHz – 300 kHz 300 kHz – 30 MHz 30 MHz – 2 GHz 156 MHz – 165 MHz	10 mV/m – 316 μV/m (80 dBμV/m – 52 dBμV/m) 316 μV/m – 50μV/m (52 dBμV/m – 34 dBμV/m) 500 μV/m (54 dBμV/m) except for 16 μV/m (24 dBμV/m) quasi-peak or 32 μV/m (30 dBμV/m) peak		

9.2 Conducted emissions (all equipment categories except portable)

9.2.1 Purpose

This test measures any signals generated by equipment, which appear on its power supply port and which can, therefore, be conducted into the ship's power supply, and potentially disturb other equipment.

9.2.2 Method of test

The emission shall be measured by means of the quasi-peak measuring receivers specified in CISPR 16-1. An artificial mains V-network (figure 3) in accordance with CISPR 16-1 shall be used to provide a defined impedance at high frequencies across the terminals of the EUT, and to isolate the test circuit from unwanted radio frequency signals on the supply mains. The measuring bandwidth in the frequency range 10 kHz to 150 kHz shall be 200 Hz, and in the frequency range 150 kHz to 30 MHz shall be 9 kHz.

The power input cables between the a.c. and the d.c. power ports of the EUT and the artificial mains network shall be screened and not exceed 0,8 m in length. If the EUT consists of more than one unit with individual a.c. and/or d.c. power ports, power ports of identical nominal supply voltage may be connected in parallel to the artificial mains supply network.

Measurements shall be made with all measuring equipment and the EUT mounted on, and bonded to, an earth plane. Where provision of an earth plane is not practicable, equivalent arrangements shall be made using the metallic frame or mass of the EUT as the earth reference.

9.2.3 Required result

In the frequency range 10 kHz to 30 MHz, the radio frequency voltage of the power supply terminals of the EUT shall not exceed the limits shown in figure 2.

9.3 Radiated emissions from enclosure port (all equipment categories except submerged)

9.3.1 Purpose

This test measures any signals radiated by an equipment other than through an antenna which can potentially disturb other equipment on the ship, such as radio receivers.

9.3.2 Method of test

a) The quasi-peak measuring receivers specified in CISPR 16-1 shall be used. The receiver bandwidth in the frequency ranges 150 kHz to 30 MHz shall be 9 kHz and in the frequency ranges 30 MHz to 2 GHz shall be 120 kHz.

For frequencies from 150 kHz to 30 MHz measurements shall be made of the magnetic H field. The measuring antenna shall be an electrically screened loop antenna of dimension so that the antenna can be completely enclosed by a square having sides of 60 cm in length, or an appropriate ferrite rod as described in CISPR 16-1.

The correction factor for the antenna shall include the factor +51,5 dB to convert the magnetic field strength to equivalent electric field strength.

For frequencies above 30 MHz measurements shall be made of the electric E field. The measuring antenna shall be a balanced dipole of resonant length, or alternate shortened dipole or higher gain antenna as described in CISPR 16-1. The dimension of the measuring antenna in the direction of the EUT shall not exceed 20 % of its distance from the EUT. At frequencies above 80 MHz it shall be possible to vary the height of the centre of the measuring antenna above the ground over a range of 1 m to 4 m.

The test site shall be compliant with CISPR 16-1, using a metal ground plane and of dimensions to allow a measurement distance of 3 m.

The EUT shall be fully assembled, complete with its associated interconnecting cables and mounted in its normal plane of operation.

When the EUT consists of more than one unit, the interconnecting cables (other than antenna feeders) between the main unit and all other units shall be the maximum length as specified by the manufacturer or 20 m whichever is shorter. Available input and output ports shall be connected to the maximum length of cable as specified by the manufacturer or 20 m whichever is shorter, and terminated to simulate the impedance of the ancillary equipment to which they are normally connected.

The excess length of these cables shall be bundled at the approximate centre of the cable with bundles 30 cm to 40 cm in length running in the horizontal plane from the port to which they are connected. If it is impractical to do so because of cable bulk or stiffness, the disposition of the excess cable shall be as close as possible to that required, and shall be precisely described in the test report.

The test antenna shall be placed at a distance of 3 m from the EUT. The centre of the antenna shall be at least 1,5 m above the ground plane. The E-field antenna only shall be adjusted in height and rotated to give horizontal and vertical polarization, one being parallel to the ground, in order to determine the maximum emission level. Finally the antenna shall either be moved around the EUT, again in order to determine the maximum emission level, or alternatively, the EUT may be placed on a plane orthogonal to the test antenna at its mid-point and rotated to achieve the same effect.

b) In addition, for the frequency band 156 MHz to 165 MHz, the measurement shall be repeated with a receiver bandwidth of 9 kHz, all other conditions of a) hereinbefore remaining unchanged.

c) Alternatively, for the frequency band 156 MHz to165 MHz, a peak receiver or a frequency analyzer may be used, in accordance with the agreement between the manufacturer and the test house.

9.3.3 Required result

a) The radiation limit at a distance of 3 m from the enclosure port over the frequency range 150 kHz to 2 GHz shall be as shown in figure 4.

b) The radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz shall be 24 dBµV/m.

c) Alternatively the radiation limit at a distance of 3 m from the enclosure port over the frequency 156 MHz to 165 MHz shall be 30 dBµV/m.

10 Immunity to electromagnetic environment – Methods of testing and required test results

(See 4.5.1)

10.1 General

For these tests the EUT shall conform to its normal operational configuration, mounting and earthing arrangements, unless otherwise stated, and shall operate under normal test conditions.

Particular interfaces of the EUT with the external electromagnetic environment are referred to as ports. The physical boundary of the EUT through which electromagnetic fields may radiate or impinge is the enclosure port (figure 1).

Differential tests are those applied between electrical power, signal and control lines. Common mode tests are those applied between groups of lines and a common reference, normally earth.

For the tests in this subclause, the results are evaluated against performance criteria relating to the operating conditions and functional specifications of the EUT, and defined 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 the test, provided the function is self-recoverable, or can be restored at the end of the test by the operation of the controls, as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

Conditions and tests are summarized in table 6 below, which also gives the performance criteria required for the radio equipment and navigational equipment covered by 1a) and 1b) of the scope of this standard. For other equipment, the performance criteria will be given in the relevant equipment standard or the technical specification published by the manufacturer, but as a minimum the EUT shall comply with performance criterion C. Examples of equipment in each category are given in annex D.

Table 6 – Electromagnetic immunity

	Portable	Protected	Exposed	Submerged
Conducted radio frequency disturbance (10.3)	*	3 V r.m.s. e.m.f. 150 kHz – 80 MHz, 10 V r.m.s. e.m.f. at specified spot frequencies. a.c. and d.c. power ports, signal and control ports, common mode. Performance criterion A.		
Radiated disturbance (10.4)	10 V/m 80 MHz – 2 GHz Enclosure port Performance criterion A			*
Fast transients (bursts) (10.5)	*	2 kV differential on a.c. power ports 1 kV common mode on signal and control ports Performance criterion B		
Slow transients (surges)(10.6)	*	1 kV line/earth, 0,5 kV line/line AC power ports Performance criterion B		
Power supply short term variation (10.7)	*	± 20 % voltage for 1,5 s, ± 10 % frequency for 5 s AC power ports Performance criterion B		
Power supply failure (10.8)	*	60 s interruption a.c. and d.c. power ports Performance criterion C		
Electrostatic discharge (10.9)	6 kV contact 8 kV air Performance criterion B			*
* Not applicable				

10.2 Radio receiver equipment

If the EUT includes a radio receiver, then frequencies in the exclusion band, together with any narrow band receiver responses (spurious responses), are excluded from the immunity tests for conducted and radiated disturbance.

10.2.1 Exclusion band

The exclusion band for receivers is defined as the operating frequency band of the receiver, as declared by the manufacturer, extended at each end by 5% of the end of band frequency.

10.2.2 Assessment of receiver responses

The permissible narrow band responses (spurious responses) are identified by the following method.

If the test signal (unwanted signal) creates a degradation of performance at a discrete frequency, the test signal frequency is increased by an amount equal to twice the bandwidth of the receiver IF filter immediately preceding the demodulator, as declared by the manufacturer. The test signal is then decreased by the same amount.

If there is no degradation of performance at both of these offset frequencies, then the response is considered to be a permissible narrow band response. If the degradation remains, this may be due to the fact that the offset has made the frequency of the test signal correspond to the frequency of another narrow band response. This may be identified by repeating the procedure with the increase and decrease of the frequency of the test signal adjusted to two and one half times the bandwidth referred to previously.

If the degradation still remains then the response cannot be considered to be a permissible narrow band response.

10.3 Immunity to conducted radio frequency disturbance

10.3.1 Purpose

This test simulates the effects of disturbances induced in power, signal and control lines from ship's radio transmitters at frequencies below 80 MHz.

10.3.2 Method of test

The EUT shall be placed on an insulating support of 0,1 m height above a ground reference plane (figure 5). The auxiliary equipment (AE) necessary to provide the EUT with power, and the signals required for normal operation and verification of performance shall be connected by cables, which shall be provided with appropriate coupling and decoupling devices (CDNs) at a distance between 0,1 m and 0,3 m from the EUT (figure 6). IEC 61000-4-6 describes the design of CDNs and alternative injection clamps if the use of CDNs is not possible.

The test shall be performed with the test generator connected to each of the CDNs in turn, while the other non-excited RF input ports to the CDNs are terminated by a 50 Ω load resistor. The test generator shall be set for each CDN with the AE and the EUT disconnected and replaced by resistors of value 150 Ω. The test generator level shall be set to provide an unmodulated e.m.f. at the EUT port of the required test level.

The test shall be carried out as described in IEC 61000-4-6 with the following test levels:

– 3 V r.m.s. amplitude swept over the frequency range 150 kHz to 80 MHz (severity level 2);
– 10 V r.m.s. amplitude at spot frequencies: 2 MHz, 3 MHz, 4 MHz, 6,2 MHz, 8,2 MHz, 12,6 MHz, 16,5 MHz, 18,8 MHz, 22 MHz and 25 MHz.

During testing, amplitude modulation at 400 Hz ±10 % to a depth of 80 % ± 10 % shall be used.

The frequency sweep rate shall not exceed $1,5 \times 10^{-3}$ decades/s in order to allow for the detection of any malfunction of the EUT.

The above signals shall be superimposed on the power, signal and control lines of the EUT. An EMC performance check shall be applied during and after the test.

10.3.3 Required result

The requirements of the EMC performance check shall be met during and after the test in accordance with the performance criterion A, as described in 10.1.

10.4 Immunity to radiated radiofrequencies (all equipment categories except submerged)

10.4.1 Purpose

This test simulates the effects of radio transmitters at frequencies above 80 MHz, such as the ship's VHF transmitter and hand-held portable radios, close to the equipment.

10.4.2 Method of test

The EUT shall be installed in a suitably shielded room or anechoic chamber of a size commensurate with the size of the EUT (figure 7). The EUT shall be set in the area of uniform field and insulated from the floor by a non-metallic support. The uniform area is calibrated with the test room empty. The configuration of the EUT and associated cables shall be recorded in the test report.

If the wiring to and from the EUT is not specified, unshielded parallel conductors shall be used, and left exposed to the electromagnetic fields for a distance of 1 m from the EUT.

The test shall be carried out as described in IEC 61000-4-3, at severity level 3, with the generating antenna facing each of the four sides of the EUT. When equipment can be used in different orientations (that is vertical or horizontal), the test shall be performed on all sides. The EUT is initially placed with one face coincident with the calibration plane. The frequency range shall be swept at a rate in the order of $1{,}5 \times 10^{-3}$ decades/s for the frequency range 80 MHz to 1 GHz and $0{,}5 \times 10^{-3}$ decades/s for the frequency range 1 GHz to 2 GHz, and shall be slow enough to allow the detection of any malfunction of the EUT. Any sensitive frequencies or frequencies of dominant interest shall be discretely analyzed.

The EUT shall be placed in a modulated electric field of strength 10 V/m swept over the frequency range 80 MHz to 2 GHz. The modulation shall be at 400 Hz ± 10 % to a depth of 80 % ± 10 %.

10.4.3 Required result

The requirements of the EMC performance check shall be met during and after the test in accordance with the performance criterion A, as described in 10.1.

10.5 Immunity to fast transients on a.c. power, signal and control lines (all equipment categories except portable)

10.5.1 Purpose

This test simulates the fast, low-energy transients produced by equipment switching which causes arcing at contacts.

10.5.2 Method of test

The test shall be carried out as described in IEC 61000-4-4, at test severity level 3, using a test generator complying with 6.1.1 of IEC 61000-4-4, a coupling/decoupling network complying with 6.2 of IEC 61000-4-4 for power lines, and a capacitive coupling clamp complying with 6.3 of IEC 61000-4-4 for signal and control lines (figure 8).

Pulses of the following characteristics shall be applied to its power, control and signal lines:

– rise time:	5 ns (value between 10 % and 90 %)
– width:	50 ns (50 % value)
– amplitude:	2 kV differential on a.c. power lines
	1 kV common mode on signal and control lines
– repetition rate:	5 kHz (1 kV), 2,5 kHz (2 kV)
– application:	15 ms burst every 300 ms
– duration:	3 min to 5 min for each of positive and negative polarity pulses

10.5.3 Required result

The requirements of the EMC performance check shall be met during and after the test in accordance with the performance criterion B, as described in 10.1.

10.6 Immunity to surges on a.c. power lines (all equipment categories except portable)

10.6.1 Purpose

This test simulates the slow, high-energy surges produced by thyristor switching on a.c. power supplies.

10.6.2 Method of test

The test shall be carried out as described in IEC 61000-4-5 at test severity level 2 using a combination wave (hybrid) generator complying with 6.1 of IEC 61000-4-5 in combination with a coupling/decoupling network complying with 6.3.1.1 of IEC 61000-4-5 (figure 9)

Pulses of the following characteristics shall be applied to its power lines:

– rise time: 1,2 μs (value between 10 % and 90 %)
– width: 50 μs (50 % value)
– amplitude: 1 kV line/earth, 0,5 kV line/line
– repetition rate: 1 pulse/min
– application: continuous
– duration: 5 min for each of positive and negative polarity pulses

10.6.3 Required result

The requirements of the EMC performance check shall be met during and after the test in accordance with the performance criterion B, as described in 10.1.

10.7 Immunity to power supply short-term variation (all equipment categories except portable)

10.7.1 Waiver

This test is not applicable to d.c. powered equipment.

10.7.2 Purpose

This test simulates power supply variations due to large changes in load. It is additional to the tests under permanent power supply variation in extreme test conditions specified in table 1.

10.7.3 Method of test

Power supply variations shall be applied using a programmable power supply.

The EUT shall be submitted to the following power supply variations relative to nominal value 1/min for 10 min (figure 10):

a) voltage: nominal + (20 ± 1) %, duration 1,5 s ± 0,2 s,
frequency: nominal + (10 ± 0,5) %, duration 5 s ± 0,5 s, superimposed;

b) voltage: nominal – (20 ± 1) %, duration 1,5 s ± 0,2 s,
frequency: nominal – (10 ± 0,5) %, duration 5 s ± 0,5 s, superimposed.

Voltage and frequency variation rise and decay times are 0,2 s ± 0,1 s (from 10 % to 90 %).

Further information is given in IEC 61000-4-11.

10.7.4 Required result

The requirements of the EMC performance check shall be met during and after the test in accordance with the performance criterion B, as described in 10.1.

10.8 Immunity to power supply failure (all equipment categories except portable)

10.8.1 Waiver

This test is not applicable to EUT intended for operation from battery power sources or fitted with or connected to back-up batteries.

10.8.2 Purpose

This test simulates short breaks in the ship's power supply due to power supply changeover and breaker drop-out. It covers the break allowed by the IMO SOLAS Convention for changeover between main and emergency power supplies.

10.8.3 Method of test

The EUT shall be subjected to three breaks in power supply of duration 60 s each.

Further information is in IEC 61000-4-11.

10.8.4 Required result

The requirements of the EMC performance check shall be met after the test in accordance with the performance criterion C, as described in 10.1. There shall be no corruption of operational software or loss of essential data.

10.9 Immunity to electrostatic discharge (all equipment categories except submerged)

10.9.1 Purpose

This test simulates the effect of electrostatic discharges from personnel which may occur in environments which cause them to become charged, such as contact with artificial fibre carpets or vinyl garments.

10.9.2 Method of test

The test shall be carried out as described in IEC 61000-4-2 using an electrostatic discharge (ESD) generator, that is an energy storage capacitance of 150 pF and a discharge resistance of 330 Ω connected to a discharge tip.

The EUT shall be placed on, but insulated from, a metal ground plane which projects at least 0,5 m beyond the EUT on all sides (figures 11 and 12). Discharges from the generator shall be applied to those points and surfaces that are accessible to personnel during normal usage.

The ESD generator shall be held perpendicular to the surface, and the positions at which discharges can be applied selected by an exploration with 20 discharges per second. Each position shall then be tested with 10 discharges positive and negative with intervals of at least 1 s between discharges to allow for any mis-operation of the EUT to be observed. Contact discharge is the preferred method; but air discharge shall be used where contact discharge cannot be applied, such as on painted surfaces declared by the manufacturer to be insulating.

In order to simulate discharges on objects placed or installed near to the EUT, 10 single contact discharges, positive and negative, shall be applied to the ground plane at positions on each side of, and 0,1 m from, the EUT. A further 10 discharges shall be applied to the centre of one edge of a vertical coupling plane (VCP), with this plane in enough different positions so that the four faces of the EUT are completely illuminated.

The test levels shall be 6 kV contact discharge and 8 kV air discharge.

10.9.3 Required result

The requirements of the EMC performance check shall be met during and after the test in accordance with the performance criterion B, as described in 10.1.

11 Special purpose tests – Methods of testing and required test results

11.1 Acoustic noise and signals (all equipment intended for installation in wheelhouses and bridge wings)

(See 4.5.2)

11.1.1 Purpose

This test ensures that the acoustic noise generated by equipment which contributes to background noise level does not interfere with communication or audible warnings. The test also measures the signal alarm level generated by an equipment, when applicable.

11.1.2 Method of test

The EUT or parts thereof, intended for installation in wheelhouses or bridge wings, shall be examined for acoustic noise by means of a sound-level meter complying with IEC 60651. Audible alarms shall be switched off, and acoustic pressure radiated intentionally by any remote transducer of the EUT operating in its pass-band shall be discounted, unless it is likely to be detected in a noise-sensitive area. The EUT shall be mounted in a way which is identical to its installation on board and on a sound absorbing support in a sound absorbing environment.

The EUT shall be set to the operating condition that gives rise to the highest level of unwanted acoustic noise pressure.

The test shall be repeated with audible alarms switched on.

11.1.3 Required result

The acoustic pressure detected shall not exceed a level of 60 dB(A) at a distance of 1 m from any part of the EUT.

With audible alarms switched on, the acoustic noise pressure of an alarm shall be at least 75 dB(A) but not greater than 85 dB(A) at a distance of 1 m from any part of the EUT which is accessible for its operation.

11.2 Compass safe distance (all equipment categories except submerged)

(See 4.5.3)

11.2.1 Purpose

This test determines the distances above which equipment will not cause an unacceptable deviation of the ship's standard and steering compasses. The actual deviation varies with the strength of the earth's magnetic field around the world, but is of the order 0,1° for the standard compass, and 0,3° for the steering compass in equatorial regions, rising to 1° and 3°, respectively, in high latitudes.

11.2.2 Method of test

Each unit of the EUT shall be tested in the position and attitude relative to the compass or magnetometer at which the error produced at the compass would be a maximum, provided the item can be fitted in this way.

The compass-safe distance of any unit of the EUT is defined as the distance between the nearest point of the unit and the centre of the compass or magnetometer at which it will not produce a deviation in the standard compass of more than 5,4°/H where H is the horizontal component of the magnetic flux density in μT (microtesla) at the place of testing.

For the steering compass, the standby steering compass and the emergency compass, the permitted deviation is 18°/H, H being defined as above.

Each unit of the EUT shall be tested:

a) in the magnetic condition in which it is received with the EUT unpowered;

b) after normalizing with the EUT unpowered;

c) in the powered condition, if the unit is capable of being energized electrically.

Normalizing means a procedure to maximize the homogeneity of the magnetic flux in the EUT by placing it in Helmholtz coils or by other adequate means.

In each of the above tests, the unit shall be rotated to determine the direction in which it produces the maximum deviation.

Further information is given in ISO 694 and IEC 61000-4-8.

11.2.3 Required result

The greatest distance obtained under all these conditions is the safe distance. Distances are to be rounded up to the nearest 50 mm or 100 mm. The findings shall be noted in the test report.

The safe distance shall be marked on the EUT or recorded as described in 4.5.3.

12 Safety precautions – Methods of testing and required test results (all equipment categories)

12.1 Protection against accidental access to dangerous voltages

(See 4.6.1)

12.1.1 Purpose

The purpose is to ensure safety when installed equipment is accessible.

12.1.2 Method of test

The EUT shall be subjected to the test corresponding to IEC 60529, table I, first characteristic numeral 2: protected against access to hazardous parts with a finger.

The test shall be carried out by inserting the access probe through any openings of the enclosure of the EUT with the force specified in table VI of IEC 60529.

For the test, the jointed test finger may penetrate to its 80 mm length. Starting from the straight position, both joints of the finger shall be successively bent through an angle of up to 90° with respect to the access of the adjoining section of the finger and shall be placed in every possible position.

For low-voltage equipment (rated voltages not exceeding 1000 V a.c. and 1500 V d.c.) the test finger shall be connected to a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp connected between the access probe and the hazardous parts inside the enclosure

For high voltage equipment (rated voltages exceeding 1000 V a.c. or 1500 V d.c.), with the access probe placed in the most unfavourable positions, the EUT shall be submitted to the dielectric test as specified in the relevant equipment standard. Verification may be made either by dielectric test or by inspection of the specified clearance dimensions in air which would ensure that the test would be satisfactory under the most unfavourable electric field configuration (see IEC 60071-2).

When an enclosure includes sections at different voltage levels, the appropriate acceptance conditions for adequate clearance shall be applied for each section.

Finally, it shall be verified that any further access to the interior of the EUT is only possible by means of a tool, such as a spanner or screwdriver, and warning labels, if appropriate, are displayed within the EUT and on protective covers.

12.1.3 Required result

Adequate clearance shall be found between the access probe and the hazardous parts.

For the low voltage test, the lamp shall not light.

For the high voltage test, the EUT shall be capable of withstanding the dielectric test.

12.2 Electromagnetic radio frequency radiation

(See 4.6.2)

12.2.1 Purpose

The purpose is to enable safety rules to be applied in the vicinity of radiating equipment.

12.2.2 Method of test

Equipment which is designed to radiate electromagnetic radio frequency energy at frequencies above 30 MHz shall be subjected to measurements to determine the level of such radiated energy. The EUT shall be in the operational state and condition, which emits the maximum radiation. The method of measurement normally will be described in the relevant equipment standard.

12.2.3 Required result

Where appropriate, the maximum distance from the EUT at which the power density level of 100 W/m² and 10 W/m^2 of the radio frequency radiation has been measured shall be included in the equipment manual.

12.3 Emission from visual display unit (VDU)

(See 4.6.2)

12.3.1 Waiver

The safety test for visual display units (VDU) shall be waived where the manufacturer is able to produce evidence that the VDU would satisfy the tests.

12.3.2 Purpose

The purpose is to ascertain that emissions from a VDU, in respect of electrostatic field, alternating electric field and alternating magnetic field, are within safe limits. Higher limits are permitted for larger displays where the operating distance is larger. The requirements do not apply to displays used solely as machine status indicators or displays incapable of displaying more than 4 lines of text. The electrostatic test does not apply to a VDU employing a display technology which requires a d.c. potential of less than 500 V.

12.3.3 Method of test

Any de-gaussing arrangements of the EUT shall be switched off. Operator controls shall be adjusted so that luminance is set to maximum but not exceeding 100 cd/m^2, and contrast set so that the background raster is just visible in normal room lighting. The screen shall display a test pattern representative of the maximum density of information normally presented by the EUT, which shall be precisely described in the test report.

Where practicable, the EUT shall be orientated so that the plane of the display screen is vertical. The ground points of the EUT, the measurement probe and any ancillary equipment shall be connected to a common ground. There shall be at least 500 mm clearance between all parts of the EUT and the measuring system and any other electrically conductive or grounded object.

For in-front measurements, the field strength shall be measured at the required distance from the centre of the EUT display screen and normal to the plane of the screen. For all-round measurements, the field strength shall be measured, on a level with the centre of the EUT display screen, at a distance from the centre of the EUT equal to the nominal measurement distance plus one half of the depth of the EUT. The measurement probe shall be kept fixed and the EUT shall be rotated.

Samples at 90 degree intervals for the electric field, and at 45 degree intervals for the magnetic field shall be taken. In the case of the magnetic field, measurements shall be repeated at points 300 mm above and below the level of the display screen centre (figure 13).

For alternating field measurements, an EUT capable of multi-mode or multi-sync operation shall be measured in at least two modes, chosen to cause the EUT to operate in the lowest and the highest scan frequencies of which it is capable. A mode is defined as a unique combination of raster size, horizontal and vertical scan frequencies and display addressability.

12.3.3.1 Electrostatic field

The electrostatic field shall be measured using a suitable instrument mounted in the centre of a flat 500 mm × 500 mm square metal plate connected to the instrument ground. The metal plate shall be placed parallel to the plane of the display screen so that the measurement probe is 100 mm from the screen centre.

The EUT shall be wiped with a grounded conductive brush. The EUT shall then be switched on and the field strength measured after 10 min.

12.3.3.2 Alternating electric and magnetic field

The measurement shall be made using a suitable measuring system, having a suitable frequency response over the frequency range of the measurement, and suitable input waveform crest factor.

The EUT shall be switched on for at least 20 min before the field strength is measured.

12.3.4 Required result

The emissions shall be within the following limits:

	Display size ≤0,5 m diagonal	**Measurement distance**	**Display size >0,5 m diagonal**	**Measurement distance**
Electrostatic field:	≤ 5 ± 0,5 kV/m	at 100 mm in-front	≤5 ± 0,5 kV/m	*
Electromagnetic field:				
5 Hz to 2 kHz	≤10 V/m r.m.s.	at 300 mm in-front	≤15 V/m r.m.s.	*
2 kHz to 400 kHz	≤1 V/m r.m.s.	at 500 mm all-around and at 300 mm in-front	≤10 V/m r.m.s.	*
Magnetic field:				
5 Hz to 2 kHz	≤200 nT r.m.s.	at 500 mm all-around and at 300 mm in-front	≤250 nT r.m.s.	*
2 kHz to 400 kHz	≤25 nT r.m.s.	at 500 mm all-around	≤150 nT r.m.s.	*
* Measurement distance at the limit value to be recorded in the test report.				

12.4 X-radiation

(See 4.6.3)

12.4.1 Waiver

The X-radiation test shall be waived where the manufacturer is able to produce evidence that the equipment would satisfy the test.

12.4.2 Purpose

This test ascertains that emissions of the EUT are within safe limits.

12.4.3 Method of test

Equipment, which might emit X-radiation, shall be subjected to measurements to determine the level of such radiated energy. The setting of controls that may affect the levels of X-radiation shall be varied in order to ascertain the maximum levels. A search for any radiation detected above background level shall be carried out over each part of the EUT, using an approved X-ray survey instrument.

12.4.4 Required result

None of the equipment shall give rise to a dose rate >5 μJ/kgh (0,5 mrem/h) at 50 mm.

13 Maintenance (all equipment categories)

(See 4.7)

The EUT shall be checked for conformity with the requirements of 4.7, paying due regard to any restriction likely to be imposed by the installation spatial environment.

14 Equipment manuals (all equipment categories)

(See 4.8)

The equipment manuals shall be checked for compliance with 4.8. Examples of typical operational and equipment setting up procedures shall be checked for ease of use and effectiveness, and examples of typical fault-finding routines shall be checked for ease of use and effectiveness under simulated fault conditions. The installation procedures shall be checked.

15 Marking and identification (all equipment categories)

(See 4.9)

The EUT shall be checked for compliance with 4.9.

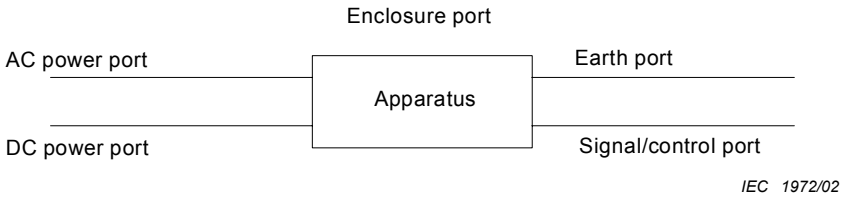


Figure 1 – Examples of ports referred to in electromagnetic emission and immunity tests

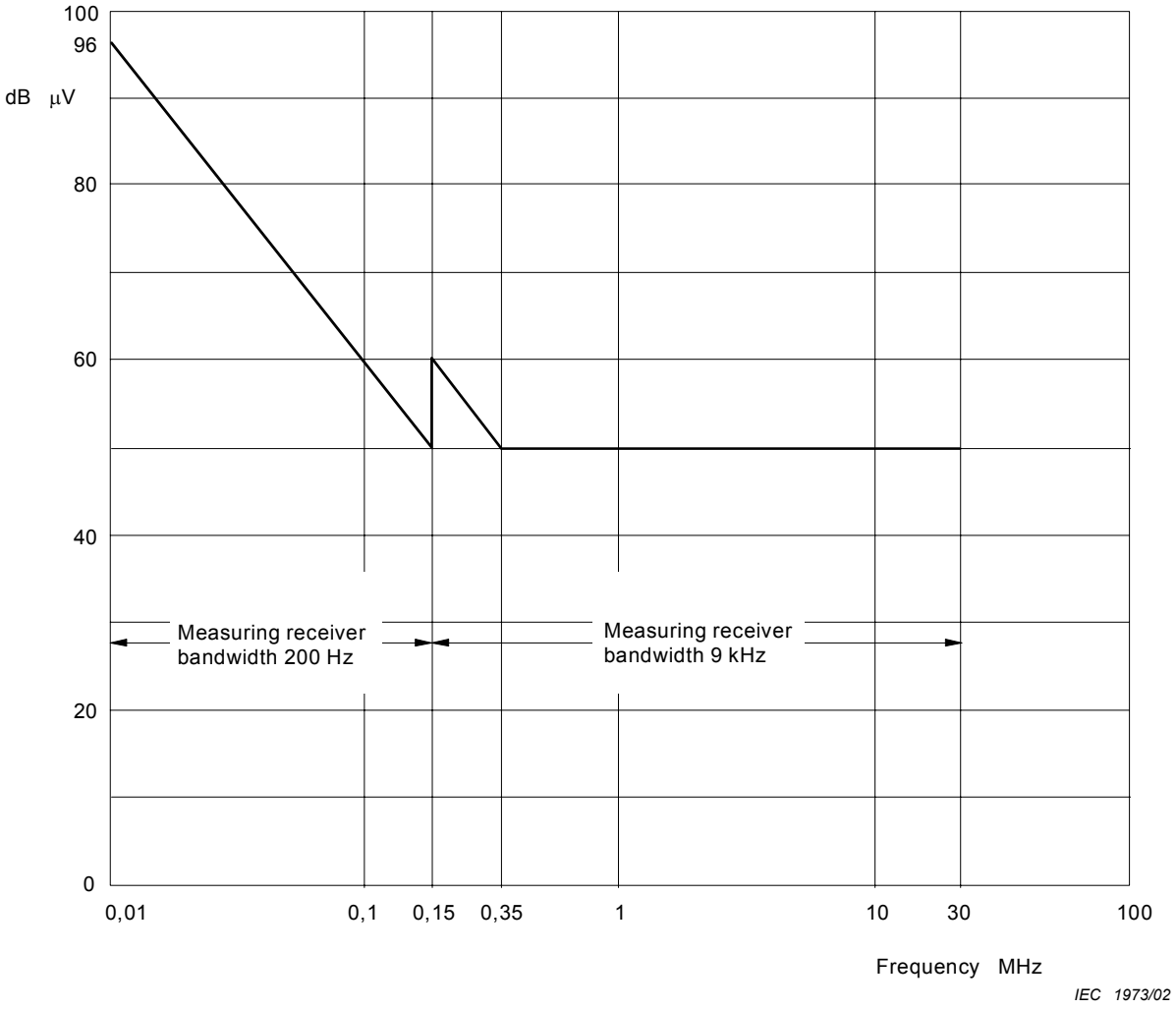


Figure 2 – Radio frequency terminal voltage limits for conducted emissions

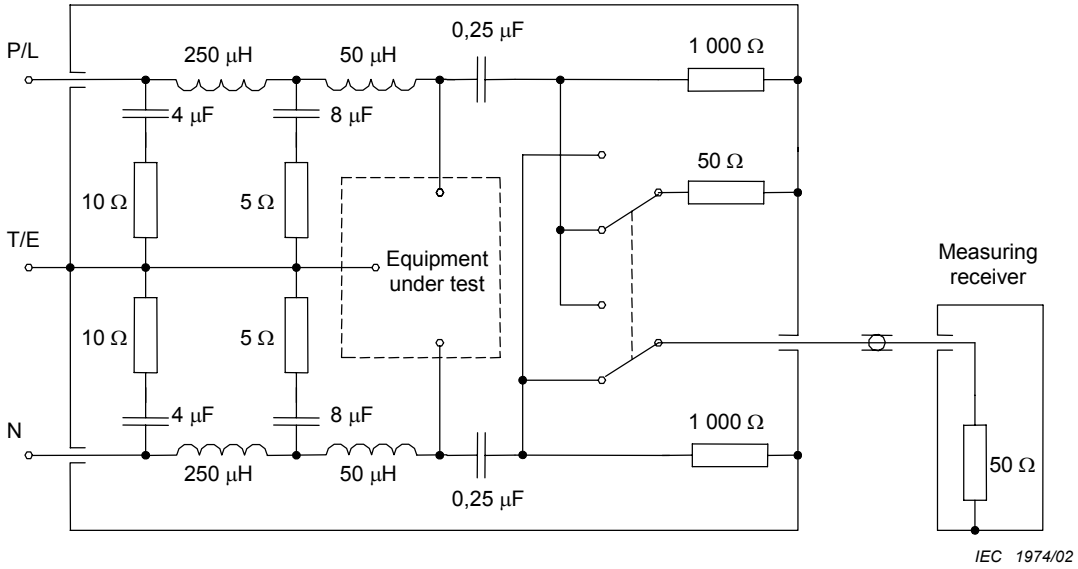


Figure 3a – Example of artificial mains 50 Ω/50 µH + 5 Ω V-network for use in the frequency range 10 kHz to 150 kHz

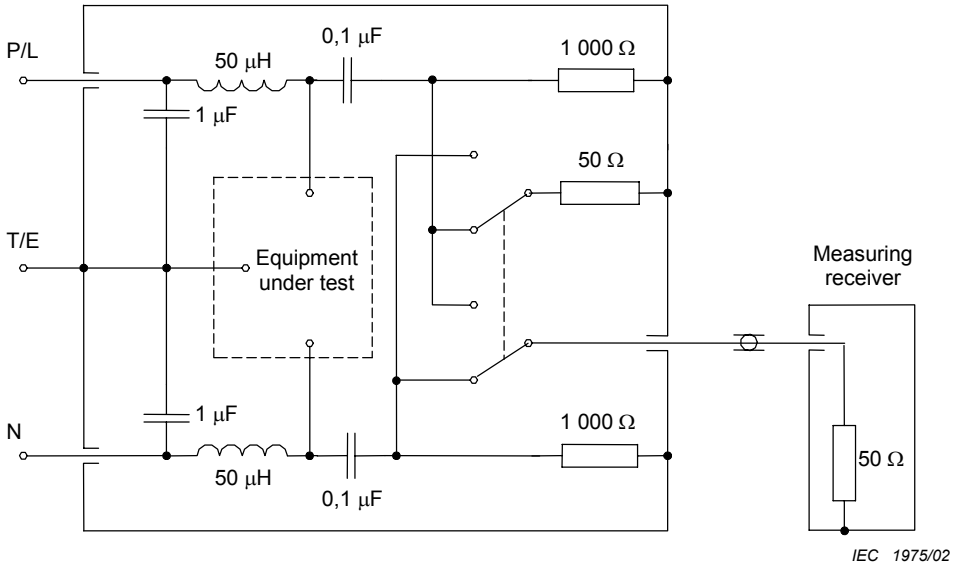


Figure 3b – Example of artificial mains 50 Ω/50 µH V-network for use in the frequency range 150 kHz to 30 MHz

Figure 3 – Artificial mains networks for tests for conducted emissions

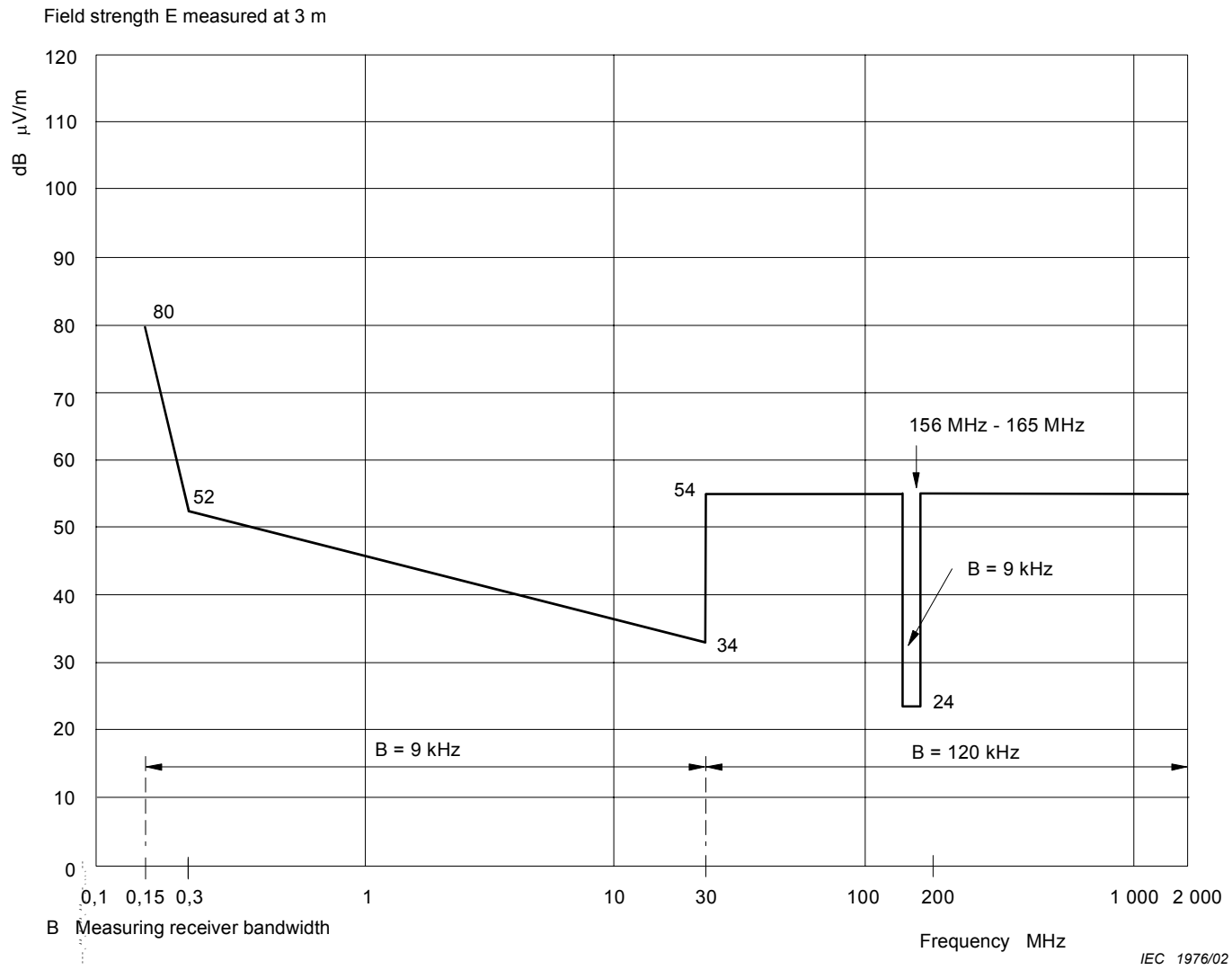
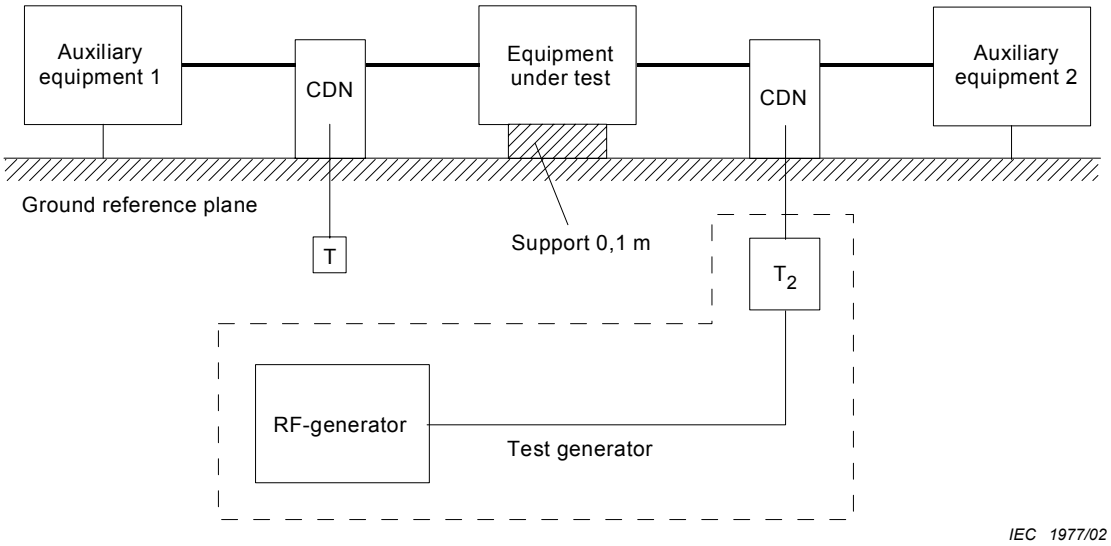


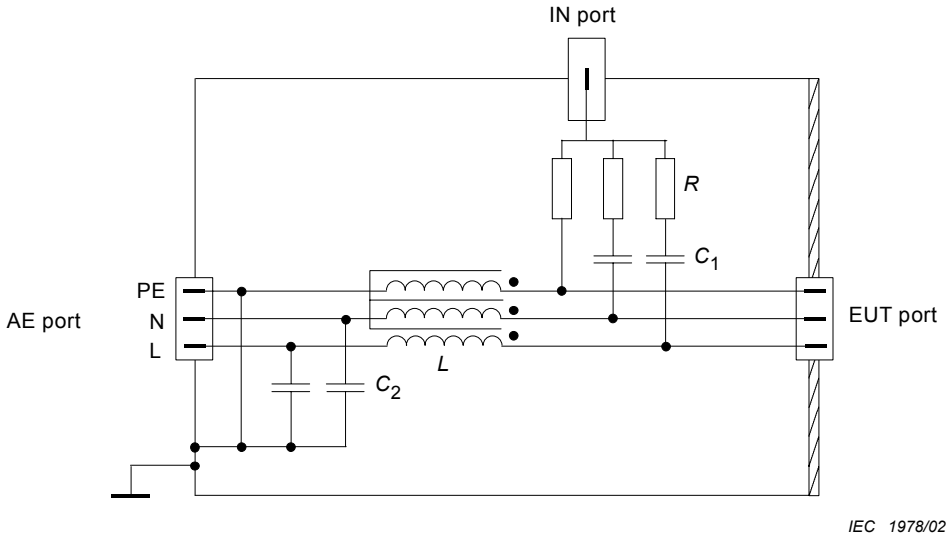
Figure 4 – Limiting values for radiated emissions from enclosure ports



Key

T	Termination 50 Ω
T_2	Power attenuator (6 dB)
CDN	Coupling and decoupling network

Figure 5 – Schematic set-up for immunity test to conducted radio-frequency disturbance



NOTE CDN-M3, C_1 (typ) = 10 nF, C_2 (typ) = 47 nF, R = 300 Ω, $L \geq$ 280 μH at 150 kHz.
CDN-M2, C_1 (typ) = 10 nF, C_2 (typ) = 47 nF, R = 200 Ω, $L \geq$ 280 μH at 150 kHz.
CDN-M1, C_1 (typ) = 22 nF, C_2 (typ) = 47 nF, R = 100 Ω, $L \geq$ 280 μH at 150 kHz.

Figure 6 – Example of a simplified diagram for CDN used with unscreened supply (mains) lines, in tests for conducted radio frequency disturbance

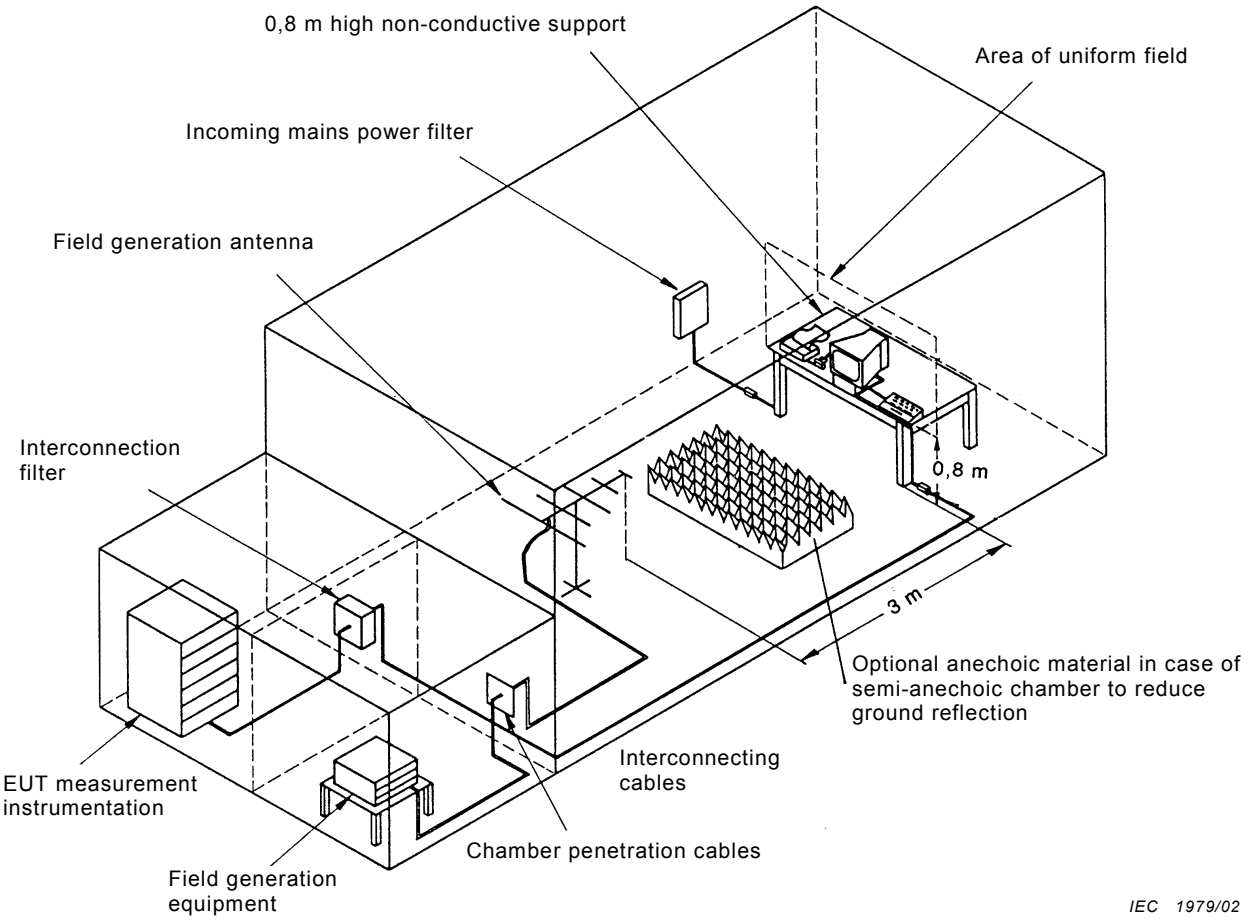
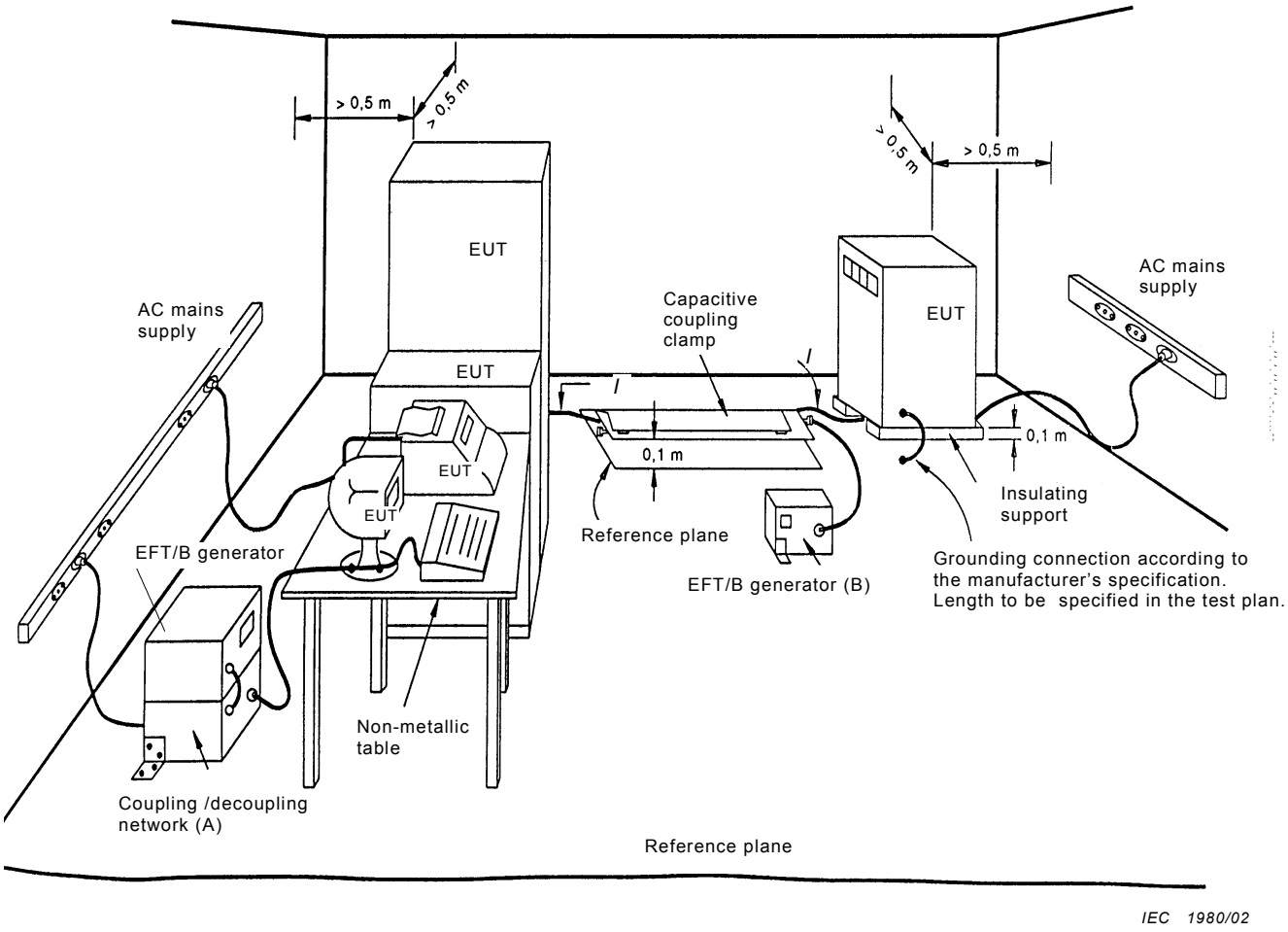


Figure 7 – Example of suitable test facility for immunity to radiated radiofrequencies



Key
l the length between clamp and EUT to be tested (not more than 1 m)
(A) the location for supply line coupling
(B) the location for signal lines coupling

Figure 8 – General test set-up for immunity to fast transient/burst

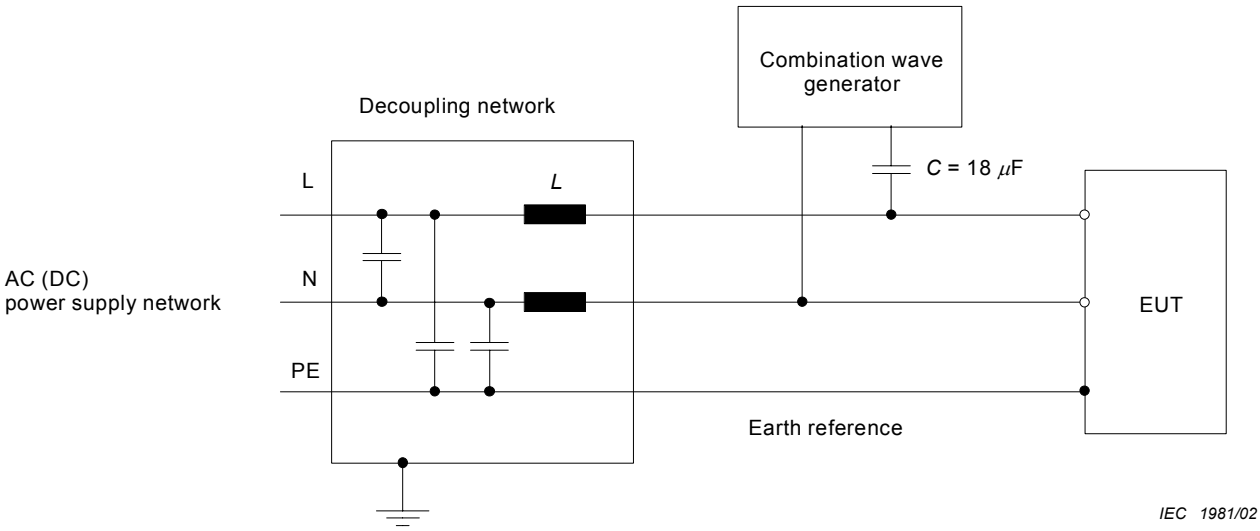


Figure 9a – Example of test set-up for capacitive coupling on a.c./d.c. lines; line-to-line coupling, generator output floating

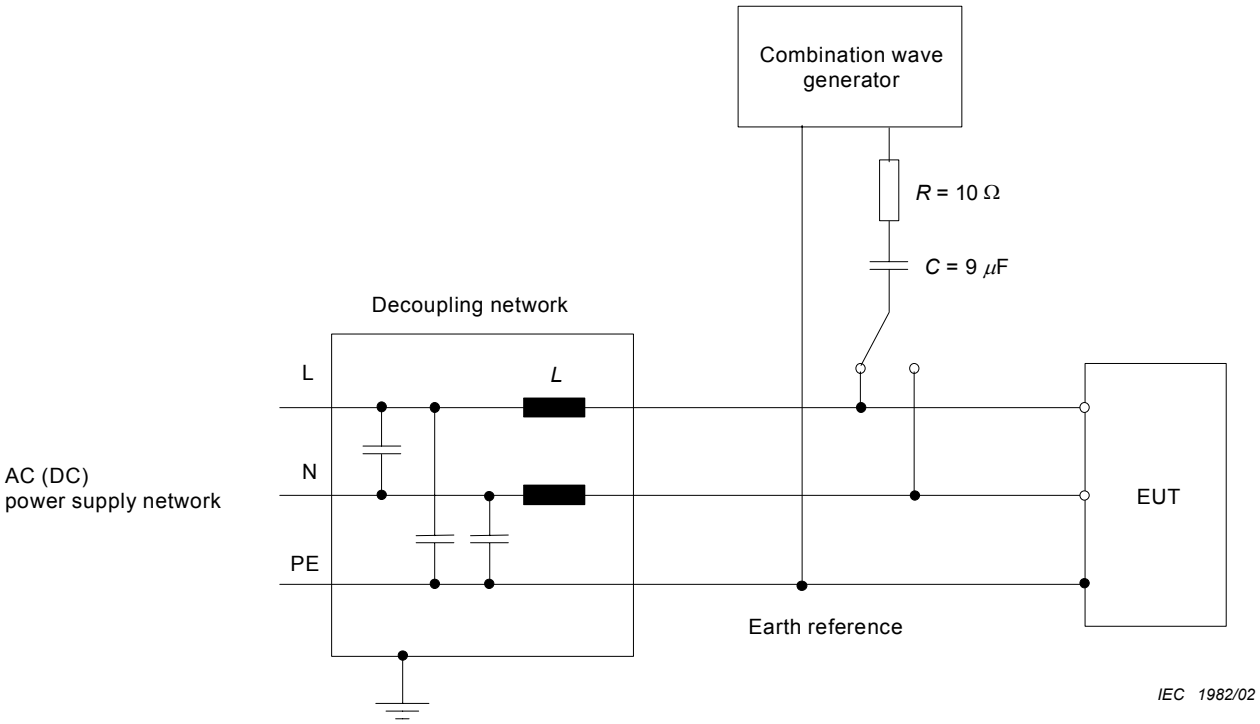


Figure 9b – Example of test set-up for capacitive coupling on a.c./d.c. lines; line-to-ground coupling, generator output grounded

Figure 9 – Test set-up for immunity to surges on power lines

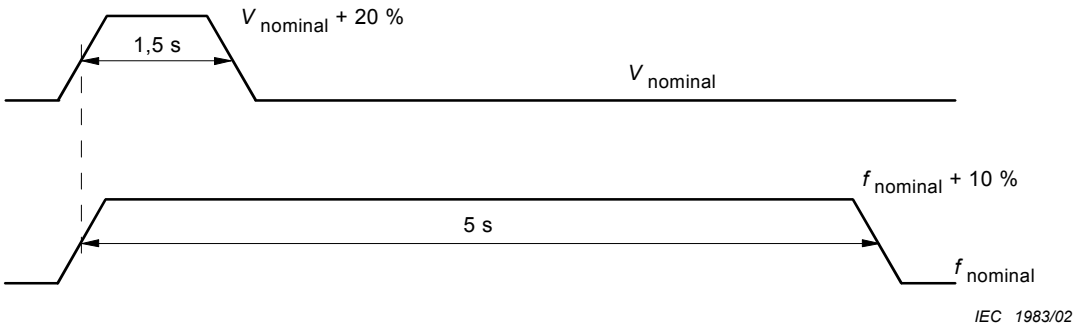


Figure 10a – Test 1: voltage (*V*) + 20 % and frequency (*f*) + 10 %

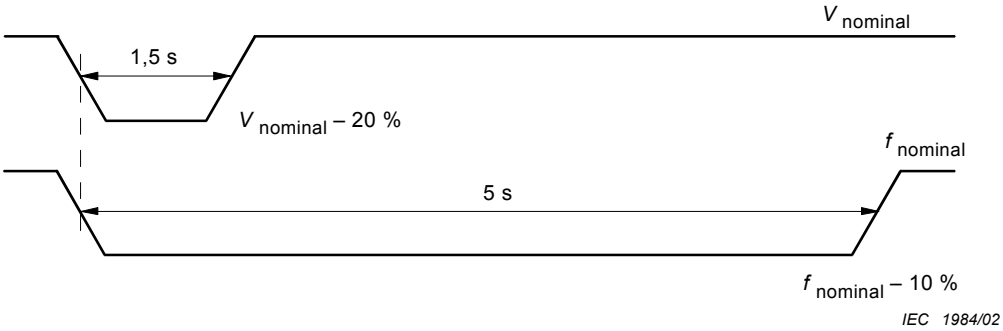


Figure 10b – Test 2: voltage (*V*) – 20 % and frequency (*f*) – 10 %

Figure 10 – Power supply variations for tests of immunity to power supply short-term transients

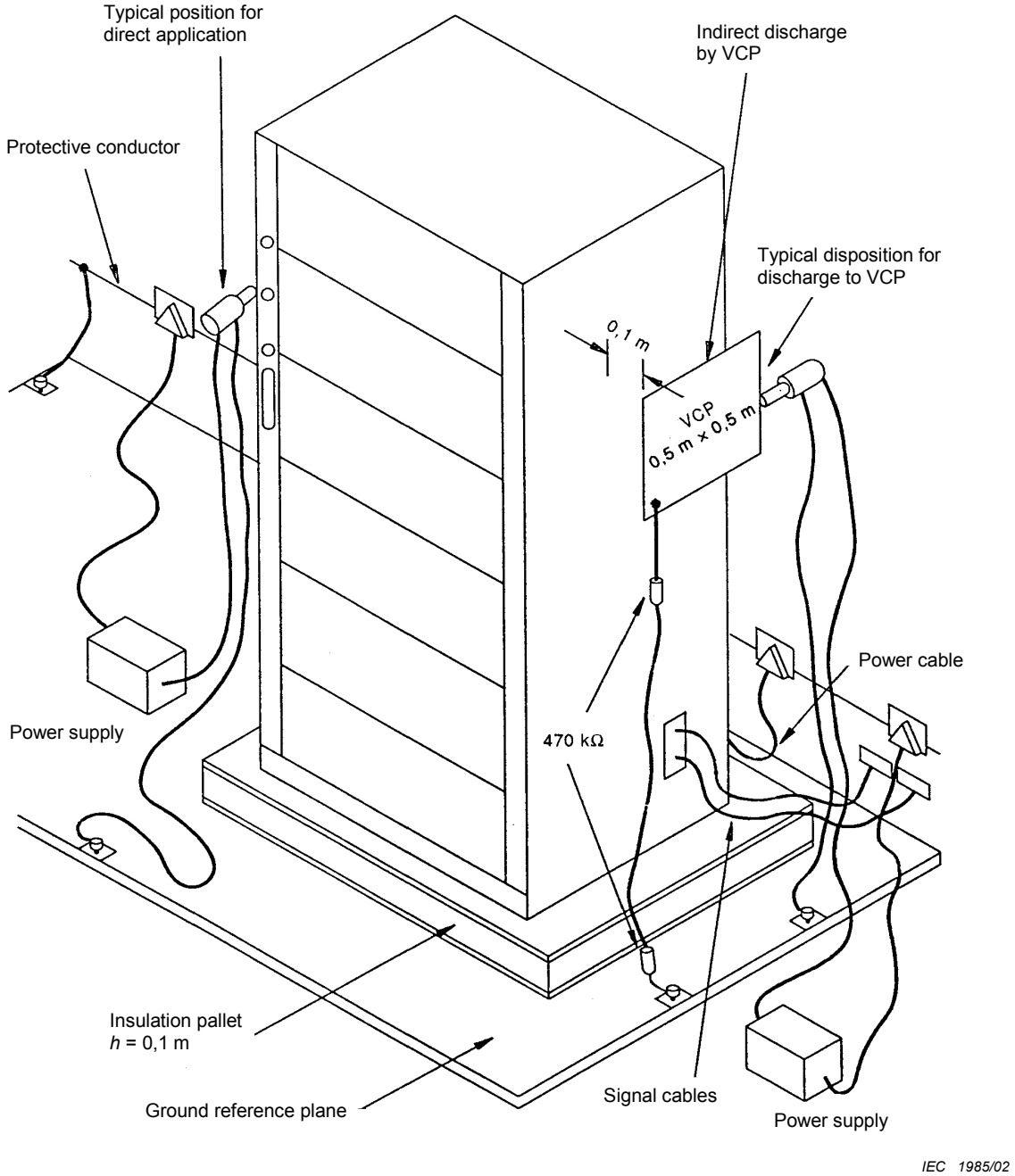


Figure 11 – Example of test set-up for floor-standing equipment, for tests of immunity to electrostatic discharge (ESD) showing typical positions of the ESD generator

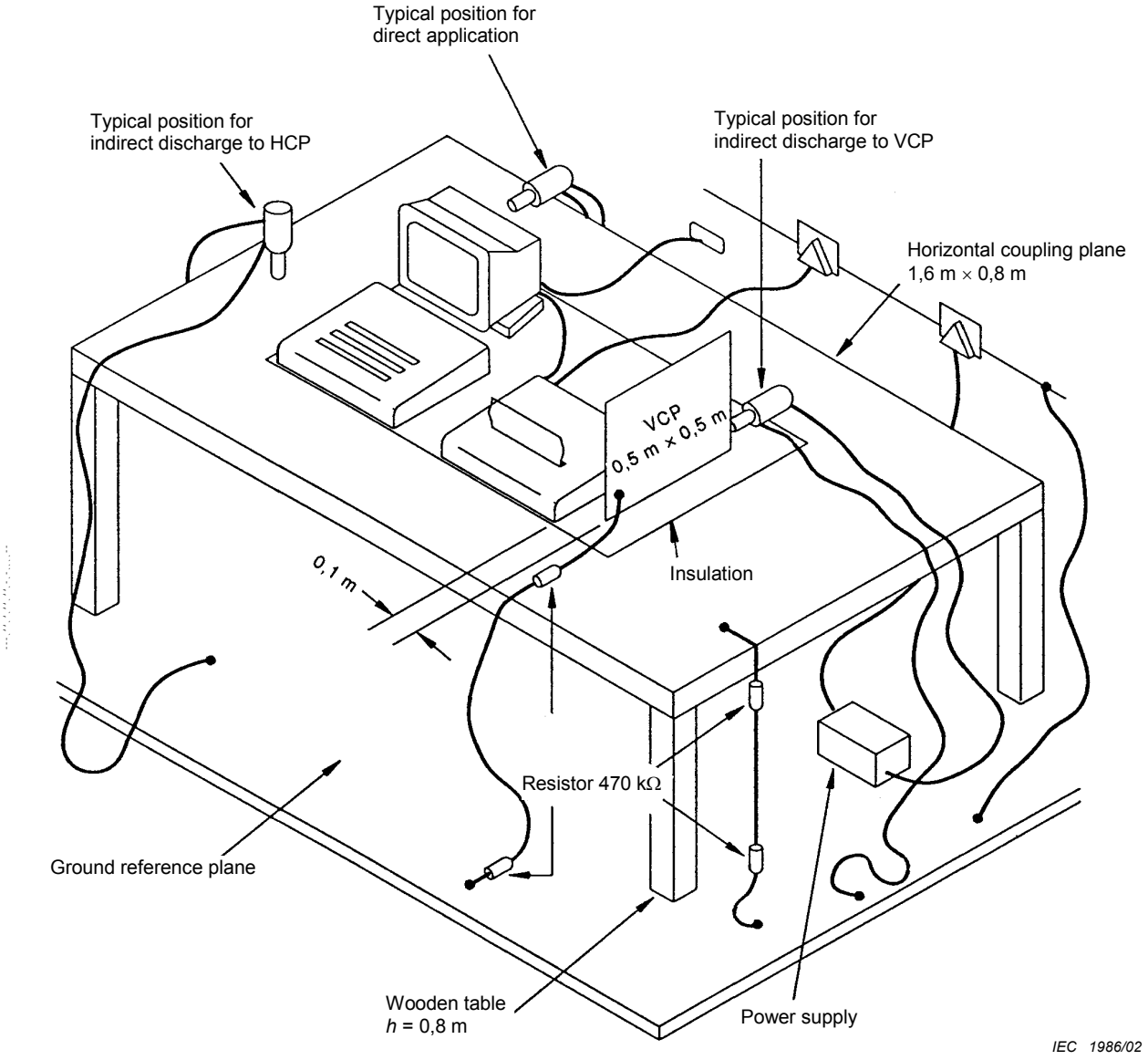


Figure 12 – Example of test set-up for table-top equipment, for tests of immunity to electrostatic discharge (ESD) showing typical positions of the ESD generator

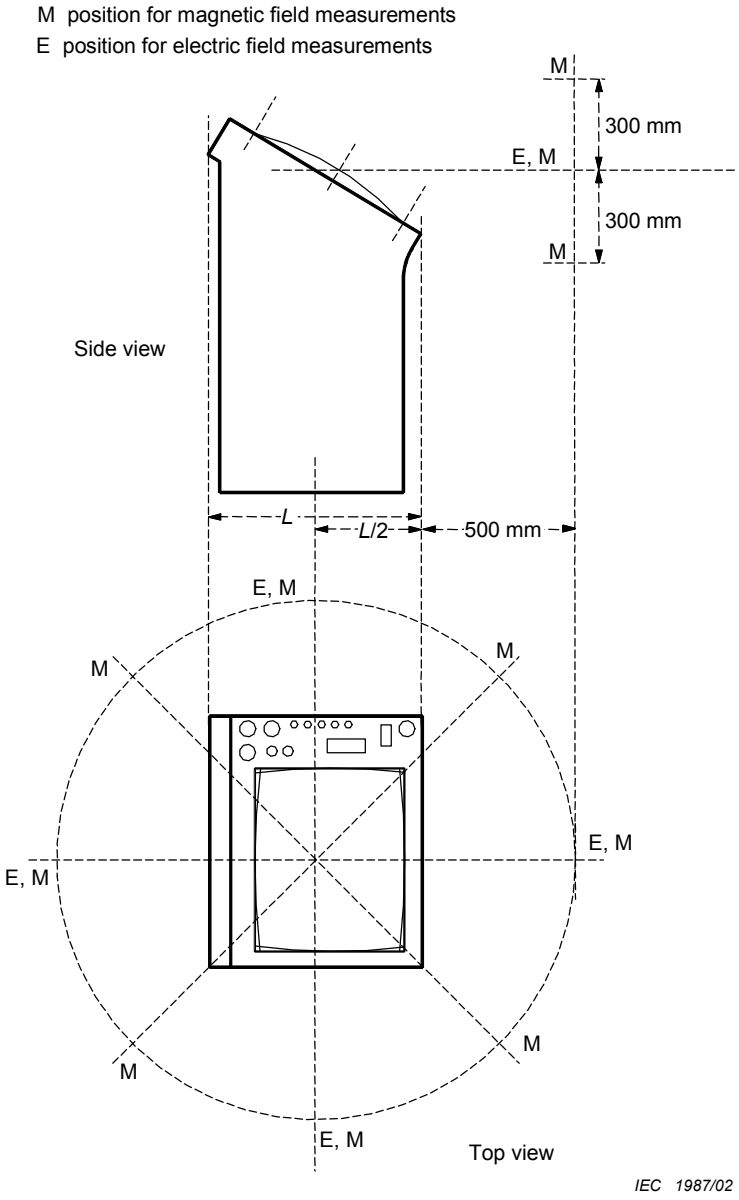


Figure 13 – Arrangements for all-round alternating field measurements

Annex A
(normative)

IMO Resolution A.694(17)
Adopted on 6 November 1991

GENERAL REQUIREMENTS FOR SHIPBORNE RADIO EQUIPMENT FORMING PART OF THE GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS) AND FOR ELECTRONIC NAVIGATIONAL AIDS

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,

RECOGNIZING the need to prepare performance standards for shipborne radio equipment to ensure operational reliability and suitability of equipment used for safety purposes,

NOTING that regulation IV/14.1 of the International Convention for the Safety of Life at Sea, 1974 (SOLAS), as amended, requires all equipment to which chapter IV of the Convention applies to conform to appropriate performance standards not inferior to those adopted by the Organization,

NOTING ALSO that SOLAS regulation V/12(r) requires all shipborne navigational equipment installed on ships on or after 1 September 1984 to conform to appropriate performance standards not inferior to those adopted by the Organization,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its fifty-ninth session,

1. ADOPTS the Recommendation on General requirements for Shipborne Radio Equipment Forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids set out in the annex to the present resolution;

2. RECOMMENDS Governments to ensure that shipborne radio equipment forming part of the GMDSS and shipborne electronic navigational aids conform to performance standards not inferior to those specified in the annex to the present resolution;

3. REVOKES resolutions A.569(14) and A.574(14);

4. DECIDES that any reference to resolutions A.569(14) or A.574(14) in existing IMO instruments read as a reference to the present resolution.

Annex to IMO A.694

RECOMMENDATION ON GENERAL REQUIREMENTS FOR SHIPBORNE RADIO EQUIPMENT FORMING PART OF THE GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS) AND FOR ELECTRONIC NAVIGATIONAL AIDS

1 INTRODUCTION

1.1 Equipment, which:

.1 forms part of the global maritime distress and safety system; or

.2 is required by regulation V/12 of the 1974 SOLAS Convention as amended and other electronic navigational aids, where appropriate;

should comply with the following general requirements and with all applicable performance standards adopted by the Organization.

1.2 Where a unit of equipment provides a facility which is additional to the minimum requirements of this Recommendation, the operation and, as far as is reasonably practicable, the malfunction of such additional facility should not degrade the performance of the equipment specified in 1.1.

2 INSTALLATION

Equipment should be installed in such a manner that it is capable of meeting the requirements of 1.1.

3 OPERATION

3.1 The number of operational controls, their design and manner of function, location, arrangement and size should provide for simple, quick and effective operation. The controls should be arranged in a manner which minimizes the chance of inadvertent operation.

3.2 All operational controls should permit normal adjustments to be easily performed and should be easy to identify from the position at which the equipment is normally operated. Controls not required for normal operation should not be readily accessible.

3.3 Adequate illumination should be provided in the equipment or in the ship to enable identification of controls and facilitate reading of indicators at all times. Means should be provided for dimming the output of any equipment light source which is capable of interfering with navigation.

3.4 The design of the equipment should be such that misuse of the controls should not cause damage to the equipment or injury to personnel.

3.5 If a unit of equipment is connected to one or more other units of equipment the performance of each should be maintained.

3.6 Where a digital input panel with the digits 0 to 9 is provided, the digits should be arranged to conform with relevant ITU-T recommendations.[1)] However, where an alphanumeric keyboard layout, as used on office machinery and data processing equipment, is provided, the digits 0 to 9 may, alternatively, be arranged to conform with the relevant ISO standard.[2)]

4 POWER SUPPLY

4.1 Equipment should continue to operate in accordance with the requirements of this Recommendation in the presence of variations of power supply normally to be expected in a ship.

4.2 Means should be incorporated for the protection of equipment from the effects of excessive current and voltage, transients and accidental reversal of the power supply polarity.

4.3 If provision is made for operating equipment from more than one source of electrical energy, arrangements for rapidly changing from one source to the other should be provided but not necessarily incorporated in the equipment.

5 DURABILITY AND RESISTANCE TO ENVIRONMENTAL CONDITIONS

Equipment should be capable of continuous operation under the conditions of various sea states, ship's motion, vibration, humidity and temperature likely to be experienced in ships.[3)]

6 INTERFERENCE

6.1 All reasonable and practicable steps should be taken to ensure electromagnetic compatibility between the equipment concerned and other radiocommunication and navigational equipment carried on board in compliance with the relevant requirements of chapter IV and chapter V of the 1974 SOLAS convention.[4)]

6.2 Mechanical noise from all units should be limited so as not to prejudice the hearing of sounds on which the safety of the ship might depend.

6.3 Each unit of equipment normally to be installed in the vicinity of a standard compass or a magnetic steering compass should be clearly marked with the minimum safe distance at which it may be mounted from such compasses.

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1 ITU-T Recommendation E.161.

2 ISO 3791.

3 IEC 60092-101 and IEC 60945.

4 IEC 60533 and IEC 60945.

7 SAFETY PRECAUTIONS

7.1 As far as is practicable, accidental access to dangerous voltages should be prevented. All parts and wiring in which the direct or alternating voltages or both (other than radio frequency voltages) combine to give a peak voltage greater than 55 V should be protected against accidental access and should be isolated automatically from all sources of electrical energy when the protective covers are removed. Alternatively, the equipment should be so constructed that access to such voltages may only be gained after having used a tool for this purpose, such as a spanner or screwdriver, and warning labels should be prominently displayed both within the equipment and on protective covers.

7.2 Means should be provided for earthing exposed metallic parts of the equipment but this should not cause any terminal of the source of electrical energy to be earthed.

7.3 All steps should be taken to ensure that electromagnetic radio frequency energy radiated from the equipment shall not be a hazard to personnel.

7.4 Equipment containing elements such as vacuum tubes which are likely to cause X-radiation should comply with the following requirement:

.1 External X-radiation from the equipment in its normal working condition should not exceed the limits laid down by the Administration concerned.

.2 When X-radiation can be generated inside the equipment above the levels laid down by the Administration, a prominent warning should be fixed inside the equipment and the precautions to be taken when working on the equipment should be included in the equipment manual.

.3 If malfunction of any part of the equipment can cause an increase in X-radiation, adequate advice should be included in the information about the equipment, warning of the circumstances which could cause the increase and stating the precautions which should be taken.

8 MAINTENANCE

8.1 The equipment should be so designed that the main units can be replaced readily, without elaborate recalibration or readjustment.

8.2 Equipment should be so constructed and installed that it is readily accessible for inspection and maintenance purposes.

8.3 Adequate information should be provided to enable the equipment to be properly operated and maintained. The information should:

.1 in the case of equipment so designed that fault diagnosis and repair down to component level are practicable, provide full circuit diagrams, component layouts and a component parts list; and

.2 in the case of equipment containing complex modules in which fault diagnosis and repair down to component level are not practicable, contain sufficient information to enable a defective complex module to be located, identified and replaced. Other modules and those discrete components which do not form part of the modules should also meet the requirements of .1 above.

9 MARKING AND IDENTIFICATION

Each unit of the equipment should be marked externally with the following information which should be clearly visible in the normal installation position:

.1 identification of the manufacturer;

.2 equipment type number or model identification under which it was type tested; and

.3 serial number of the unit.

Annex B
(informative)

Environmental conditions for ships

B.1 Introduction

Classification of environmental conditions are described in the IEC 60721 series of standards. In particular, IEC 60721-3-6 describes the ship environment. In this standard, severity levels are given in clause 8 which are applicable to the equipment covered by the scope, i.e. equipment which is mainly bridge and deck mounted. This informative annex gives the background to the choice of these severity levels.

B.2 Dry heat

Many records have been made of air temperatures over the sea. Using as a source document the US Navy “Marine Climatic Atlas of the World” Volume VIII, the maximum air temperature observed over the oceans of the world is 43 °C which occurs off Mexico in July. The 95 percentile, that is the value of which 95 % of the observed and analyzed temperatures were less than or equal to, is given as 32 °C. For the purposes of this standard, therefore, which defines conditions “likely to be experienced in ships”, a reasonable maximum ambient air temperature is 32 °C. Ambient air refers to the air responsible for dissipating heat losses from equipment.

Equipment which is exposed to solar radiation absorbs energy and becomes hotter than the surrounding air. An analysis of this process is given in IEC 60721-2-4. This defines an artificial air temperature t_s, which, under steady state conditions, results in the same surface temperature as the combination of the actual air temperature t_u and the solar radiation of irradiance (power density) E. The value may be obtained from:

$$t_s = t_u + \frac{a \cdot E}{h}$$

where

a is the absorbance which depends on the thermal colour, reflectance and transmittance of the surface;

h is the heat transfer coefficient for the surface.

Typical values are a = 0,7, h = 20 W/(m$^{2\,\circ C}$) giving an over-temperature due to solar radiation of 0,035 E.

IEC 60721-2-4 also gives values for the irradiance E. The radiant energy from the sun produces an irradiance of 1370 W/m^2. Various atmospheric losses reduce this to a maximum at the earth's surface of 1120 W/m^2 which gives an over-temperature of 39 °C. This occurs for short periods around noon on surfaces perpendicular to the sun in a cloudless sky. The irradiance reduces with water content. The maximum value to be experienced over the sea is 670 W/m^2 which gives an overtemperature of 23 °C. The maximum artificial air temperature to be expected is therefore 39 + 32 = 71 °C and the maximum at sea is 23 + 32 = 55 °C.

In clause 8, therefore, the representative test temperature for equipment operating in ventilated environments, that is, above decks or in spaces where people work, is 55 °C. The representative storage temperature to allow for storage in ventilated environments away from the ship is 70 °C.

IEC 60721-3-6 also gives 70 °C as the maximum temperature for non-ventilated environments in ships.

B.3 Damp heat

The quantity of water vapour in ambient air is described by the humidity of the air. Absolute humidity is the mass of water contained in a unit volume which, for the air to be fully saturated, is dependent on the temperature of the air, varying from 1 g/m^3 at –20 °C to 100 g/m^3 at 55 °C. Relative humidity (RH) is the ratio of the mass of water present in a given volume to that required to produce saturation at the same temperature. The presence of water vapour in the air changes both the thermal and electrical properties of the air. In particular, if humid air is cooled it will ultimately reach a “dew point” where liquid water is deposited on equipment surfaces.

Data on open-air temperatures and humidity has been collected and statistically processed for many years throughout the world, and examples are described in IEC 60721-2-1. Extreme values recorded for relative humidities greater than 95 % vary from 24 °C to 37 °C, which give absolute humidities of 20 g/m^3 and 40 g/m^3 respectively. The temperature of 37 °C occurs in warm damp equable climates.

In clause 8, therefore, the representative test temperature for equipment operating in ventilated environments is 40 °C with 95 % relative humidity.

B.4 Low temperature

The US Navy “Marine Climatic Atlas of the World” Volume VII gives minimum air temperatures of –50 °C in the polar regions in winter. Ships will not however normally navigate in such low temperatures as the sea generally is then permanently frozen. Sea water freezes at about –1,8 °C and low air temperatures create seasonal ice, much of which is “fast ice” which grows through the winter and breaks up or melts in the summer. The maximum thickness reached by fast ice is determined by the number of days in which winter air temperatures fall below –1,8 °C. This generates seasons around the summer period when the ice is thin enough to make navigation possible. On the major navigation routes, such as the Northern Sea Route in the Arctic, the minimum air temperature that may be expected while they are open to navigation is –25 °C.

In clause 8, therefore, the representative test temperature for equipment operating when exposed to the weather is –25 °C and storage –30 °C. Equipment protected from the weather should not experience such low temperatures, and IEC 60721-3-6 gives +5 °C as the minimum temperature. However, since this standard deals with vital navigation and radiocommunication equipment which will be required to start operating in a dead ship, clause 8 calls for –15 °C for protected equipment and –20 °C for portable (life saving) equipment.

B.5 Vibration

A ship is subject to three distinct motions in different frequency bands. Below about 1 Hz, the ship is subject to the effects of regular seas which give the translational components of surging, swaying and heaving, and the corresponding rotational components of rolling, pitching and yawing. Although the amplitudes of these motions can be large, the resulting accelerations are too small to be of consequence to electronic equipment, as the natural resonances are at higher frequencies. This standard, therefore, does not concern itself with these low frequency disturbances, although it should be noted that they determine the performance of certain types of stabilized antennas.

Above about 1 Hz the ship is subject to vibration induced in its hull by its propeller and machinery. The dominant exciter is the propeller shaft running at say 60 r.p.m. and therefore producing a fundamental disturbance of 1 Hz. The next largest exciter is likely to be the propeller, a three-bladed propeller for instance producing a fundamental disturbance of 3 Hz. There will be associated harmonics, and all these vibrations are predominantly vertical.

At frequencies above about 13 Hz vibrations are induced in the ship's hull due to the “slamming” which occurs in irregular seas. These vibrations are predominantly horizontal.

Measurements made in the bridge area, on various ships of between 700 g.r.t. (gross registered tonnage) and 130 000 g.r.t. indicate that up to about 13,2 Hz the vibration is limited to an amplitude excursion of +1 mm, and from 13,2 Hz to about 100 Hz the results fit a limit line of 7 m/s^2, and these have been adopted in clause 8.

Annex C
(informative)

EMC requirements for ships

C.1 Introduction

The EMC environment on a ship is sufficiently different from other EMC environments to justify including a product family standard for the equipment covered by the scope of this standard. A ship has machinery for propulsion, manoeuvring and cargo management which can involve high powers at the electrical power frequency. It also has navigation equipment, communication equipment and control equipment associated with its machinery. The radio frequencies that can be utilized on a ship cover a wide band from 90 kHz for LORAN to 9 GHz for radar. The bridge of a ship is a particularly dense concentration of radionavigation, radiocommunication and machinery control equipment which all has to work together.

The external environment of a ship, however, is by contrast benign, at least from an EMC point of view, as the ship is not connected to cables for power or communication which can introduce interfering signals. It is also well separated from sources of radiated interference. Even in port, where many of its systems do not in fact operate or are not permitted to operate, it is unlikely to be nearer than 500 m from residential, commercial or industrial environments and 1 km from radio transmitter sites. The sources of interfering emissions and the items with the least immunity to interference are therefore all on the ship itself and controllable to some extent as regards EMC.

The chief sources of interference on the ship are the ship's own radio transmitters and the most susceptible equipment is the ship's radio receivers. This standard defines limits for emissions and immunity which allow these radio equipments to operate together and with the power supplies likely to be encountered on ships. Other equipment on board the ship, by meeting the same limits, will also then be compatible as the demands will be less exacting.

Basic characteristics of the radio equipment on the ship for navigational purposes are given in table C.1.

Table C.1 – Characteristics of radio equipment

Frequency band	Equipment type	Receiver sensitivity	Transmitter power
90 kHz – 110 kHz	LORAN navigation	20 μV/m	Receiver only
283,5 kHz – 315 kHz (315 kHz – 325 kHz USA only)	Navigation differential corrections	5 μV/m	Receiver only
415 kHz – 535 kHz	MF radiotelegraphy	50 μV/m	150 W
490 kHz, 518 kHz	NAVTEX	2 μV e.m.f.	Receiver only
1605 kHz – 3800 kHz	MF radiotelephony	25 μV/m	400 W p.e.p.
4 MHz – 27,5 MHz	HF radiotelegraphy radiotelephony	25 μV/m	1500 W p.e.p.
121,5 MHz – 243 MHz	EPIRB/ELT	Transmitter only	0,5 W
156 MHz – 165 MHz	VHF radiotelephony	2 μV e.m.f.	25 W
406,025 MHz	COSPAS-SARSAT EPIRB	Transmitter only	5 W
1525 MHz – 1544 MHz	Inmarsat	0,03 μV (–167 dBW)	Receiver only
1575,42 MHz ±1,023 MHz	GPS navigation	0,07 μV (–160 dBW)	Receiver only
1602 MHz – 1615 MHz	GLONASS navigation	0,07 μV (–160 dBW)	Receiver only
1626,5 MHz – 1646,5 MHz	Inmarsat	Transmitter only	25 W
2,9 GHz – 3,1 GHz	S band radar	1,4 μV (–134 dBW)	25 kW peak
9,3 GHz – 9,5 GHz	X band radar	1,4 μV (–134 dBW)	25 kW peak
9,3 GHz – 9,5 GHz	SART	– 80 dBW	400 mW

C.2 Emission

This standard considers two types of emissions – conducted into the power supply and radiated from equipment cabinets. Typical sources of these emissions are oscillators in switched mode power supplies and clock oscillators in microprocessor circuits.

This standard does not consider emissions which are generated by radio equipment and radiated from antennas. Radio equipment also radiates unwanted emissions from antennas. Any requirements concerning these unwanted emissions are given in the relevant equipment standard.

In general, unwanted emissions will have greater permitted powers than the radiated emissions considered in this standard. This does not degrade compatibility on a ship as the maritime frequency planning of the International Telecommunication Union (ITU) has taken this into account. Further, the immunity requirements of this standard ensure that the equipment will operate in the larger intended radio fields radiated from antennas.

A consequence of this is that, in general, it will not be possible to allow radio transmitters to be operational during the emission tests. Stray radiation from “non-radiating” loads used with transmitters are likely alone to exceed the limits.

The limits for emissions are based on established values and the test methods on CISPR 16-1.

C.2.1 Conducted emissions

Conducted emissions are defined from power ports for the frequency range 10 kHz to 30 MHz, which reflects the frequency band where the ship has receivers, and where conducted emissions may cause a problem. Limits are given in 9.2. The allowable levels are small compared with the immunity limits for power ports, which is intended to allow multiple pieces of equipment to be connected to the same power supply.

C.2.2 Radiated emissions

Radiated emission limits are intended to protect the ship's radio receivers. Limits are given in 9.3 and are based on the established limit of 54 dBμV/m measured at 3 m. There are some additional considerations, however, which are discussed below.

Receivers external to the ship are very unlikely to be affected by these emissions because of physical separation. One important set of external receivers, however, that should be investigated are those on the satellites operated by COSPAS/SARSAT, which are designed to receive the signals from Emergency indicating radio beacons (EPIRBs). The powers that may be safely transmitted from the surface of the earth and not interfere with the operation of the satellites are 1 mW at 121,5 MHz and 243 MHz and 0,1 mW at 406 MHz. The limit level of 54 dBμV/m (500 μV/m) at 3 m requires a transmitter power of 75 nW so it can be seen that there is no need for special precautions on any of these frequencies.

Below 30 MHz, the ship may be carrying communications receivers in the band 0,5 MHz – 30 MHz, and navigation receivers in the lower frequency bands. Usable signal field strengths at lower frequencies increase, however, due to ever increasing cosmic and atmospheric noise. It is thus possible to relax the limit at these lower frequencies as is shown in figure 4, although it should be noted that the effect is somewhat obscured on the figure by the change in the bandwidth of the measuring receiver.

Above 30 MHz, all ships carry a VHF receiver operating in the band 156 MHz – 165 MHz. For the VHF band IMO requires a receiver sensitivity of 2 μV e.m.f which equates to a field strength of 3 μV/m at the antenna. For a typical separation of 15 m between the bridge and the VHF antenna, the free-space field strength at 3 m is 15 μV/m (23,5 dBμV/m) to give 3 μV/m at the antenna, so a tighter limit is a requirement for operation of VHF communications (figure 4).

At UHF a ship typically may be carrying receivers in the bands 430 MHz – 450 MHz (UHF on board) and around 900 MHz (cellular telephones). These are not IMO requirements and these bands do not contain distress and safety frequencies. On board use at 430 MHz – 450 MHz is completely under the control of the ship, which can effect local measures if there are interference problems, and therefore the band is not considered to require any special protection. Cellular telephones are designed for an interference-limited environment and do not require any special protection.

Above 1 GHz the ship may be carrying receivers in the bands 1525 MHz – 1544 MHz for Inmarsat, 1575,42 MHz ± 1,023 MHz for GPS and 1602 MHz – 1615 MHz for GLONASS. The band 1525 MHz – 1544 MHz is used for GMDSS distress and safety. Similarly Global Navigation Satellite Systems (GNSS) is becoming an IMO carriage requirement and the bands around 1575,42 MHz and 1602 MHz – 1615 MHz require protection. In this edition limits are therefore given in 9.3 extending to 2 GHz.

Above 2 GHz the ship may be carrying radar receivers at 3 GHz and 9 GHz. These are specialized receivers with very directional antennas for which there is no evidence of EMC problems. It is therefore considered that there is no need to test for such emissions at >2 GHz.

C.3 Immunity

This standard considers immunity from the effects of radiated signals from the ship's transmitter antennas, either directly or as induced signals in connecting cables, from the effects of sinusoidal and transient disturbances deriving from the ship's power supply and from electrostatic discharge.

Measurements made of field strengths on and around the bridges of 12 ships of different types are recorded in table C.2. The measurements indicate that although on average some screening is obtained by the superstructure, the peak value of the fields encountered are much the same in, around and outside of the ship's bridge. This standard, therefore, does not differentiate between different installed positions and assumes an immunity level requirement of 100 V/m at MF/HF (0,5 MHz – 30 MHz).

Table C.2 – Field strengths experienced on ships generated by the ships transmitters

	MF/HF V/m	**VHF** V/m	**Portable equipment** V/m
On bridge	0 – 80 average 17	1	10
On bridge wings	4 – 100 average 27	1	10
On deck	8 – 75 average 37	1	10

At VHF, the fields experienced from the ships' transmitters are much smaller, generally not exceeding 1 V/m, but stronger fields are generated by portable radio transmitters. Since portable radios are now universally used on and around the ship's bridge, the appropriate immunity level at VHF is taken to be 10 V/m.

Further measurements made on 22 commercial vessels of under 20 m length and mainly non-metallic construction gave field strengths of 4 V/m to 110 V/m with an average of 51 V/m at MF/HF. At VHF, the field strengths did not exceed 1 V/m. The immunity requirements above are therefore also applicable to small craft.

C.3.1 Conducted low-frequency disturbance

The previous edition of this standard included an immunity test whereby voltages were applied differentially across the power supply port over the frequency range 50 Hz to 10 kHz with a test level based on the likely harmonic levels to be encountered on a.c. supplies and alternator ripple on d.c. supplies. Experience has since shown that electronic equipment covered by the scope of this standard, is very immune from the effects of power supply harmonics due to the a.c. to d.c. conversion within the equipment. Furthermore, installation practices employ batteries for d.c. supplies which are very immune from alternator ripple. This edition, therefore, does not include a test for conducted low frequency disturbance.

C.3.2 Conducted radio frequency disturbance

The previous edition of this standard included an immunity test whereby voltages were applied differentially across all the equipment ports over the frequency range 10 kHz to 80 MHz. This edition restricts the frequency range to 150 kHz to 80 MHz to allow better conformity with the test method of IEC 61000-4-6 and noting that the OMEGA navigation system operating at 10 kHz has now ceased operation.

A test level of 3 V r.m.s. is adopted over the frequency range 150 kHz to 80 MHz. It is recognized, however, that the 100 V/m fields generated by the ship's MF/HF transmitters are likely to require a higher simulated test level. The relationship between the incident field strength and the test level is subject to further study. In the meantime, as a result of experience a test level of 10 V r.m.s. is adopted at defined spot frequencies.

C.3.3 Radiated disturbance

The previous edition of this standard included an immunity test whereby an equipment cabinet was subjected to an RF field over the frequency range 80 MHz to 1 GHz. The test for immunity against RF fields at lower frequencies is contained in the conducted test of 10.2. In this edition the upper frequency is extended to 2 GHz to take account of the increased use of Inmarsat equipment and the increasing use of other mobile satellite equipment. The field strength of 10 V/m is retained to simulate portable radios.

C.3.4 Power supply transients

An immunity test for fast transients is included in 10.5. The actual disturbances found on the power supply of ships are subject to further study. In the meantime, a level of 2 kV is adopted for power ports and 1 kV for signal and control ports to reflect the likely coupling between cables in the ship’s wiring. A slow transient test is included in 10.6 to simulate possible disturbances due to thyristor switching. This test is limited to the power port, as it is not thought that the slow transients will couple into signal and control lines from power lines. A realistic 1 pulse/min repetition rate has been specified. Lightning surges are not considered, as there are no external cables to conduct these into the ship.

C.3.5 Power supply variations and failure

A test for short-term variations in the power supply is included in 10.7, based on experience of ship's power supplies reacting to changes in load. A test for a 60 s interruption is adopted in 10.8, based on the IMO specification for interswitching between main and emergency power supplies. No further testing is considered necessary at present pending further study of the actual disturbances in ship's power supplies.

C.3.6 Electrostatic discharge

To simulate possible problems of electrostatic discharge in ships, a test to IEC 61000-4-2 is included.

Annex D
(informative)

Examples of equipment by environmental class

	Portable	Protected	Exposed	Submerged
NAVTEX (A.525)	–	*	Antenna	–
HF MSI (A.700)	–	*	Antenna	–
SES (A.808)	–	*	Antenna	–
VHF radio (A.803)	–	*	Antenna	–
MF radio (A.804)	–	*	Antenna tuning unit and antenna	–
MF/HF radio (A.806)	–	*	Antenna tuning unit and antenna	–
406 MHz EPIRB (A.810)	*	–	–	–
SART (A.802)	*	–	–	–
VHF EPIRB (A.805)	*	–	–	–
INMARSAT-C (A.807)	–	*	Antenna	–
EGC (A.664)	–	*	Antenna	–
INMARSAT EPIRB (A.812)	*	–	–	–
EPIRB release (A.662)	*	–	–	–
VHF survival craft (A.809)	*	–	–	–
Radar (MSC.64(67) annex 4)	–	*	Antenna	–
Echo sounder (MSC.74(69) annex 4)	–	*	–	Transducer
Speed and distance (A.824)	–	*	Repeater	Transducer
ARPA (A.823)	–	*	–	–

NOTE 1 Numbering within parentheses refers to the relevant IMO Resolution (see Bibliography).

NOTE 2* Applicable equipment to the particular class.

Annex E
(informative)

Test Report

A test report should include at least the following information:

a) name and address of testing laboratory and location where the test was carried out when different from the address of the testing laboratory;

b) unique identification of the report (such as serial number) and of each page, and total number of pages of the report;

c) name and address of client;

d) description and identification of the test item;

e) date of receipt of test item and date(s) of performance of test;

f) identification of the test specification or description of the method or procedure;

g) description of sampling procedure, where relevant;

h) any deviations, additions to or exclusions from the test specification, and any other information relevant to a specific test;

i) identification of any non-standard test method or procedure utilized;

j) measurements, examinations and derived results, supported by tables, graphs, sketches and photographs as appropriate, and any failures identified;

k) a statement on measurement uncertainty (where relevant);

l) a signature and title or an equivalent marking of person(s) accepting technical responsibility for the test report and date of issue;

m) a statement to the effect that the test results relate only to the items tested;

n) a statement that the report shall not be reproduced except in full without the written approval of the testing laboratory.

Annex F
(informative)

Cross-references between the requirements of IMO Resolution A.694 and the tests/checks in this standard

IMO A.694	Requirement IEC 60945	Test/check IEC 60945
	Clause or subclause	
1.1	1	Not applicable
1.2	4.1	5.3
2	4.1	Not applicable
3.1	4.2.1.2	6.1.2
3.1 / 3.2	4.2.1.3	6.1.3
3.2	4.2.1.4	6.1.4
	4.2.1.5	6.1.5
	4.2.1.6	6.1.6
	4.2.1.7	6.1.7
	4.2.1.8	6.1.8
3.3	4.2.2.3	6.2.3
3.4	4.2.2.1	6.2.1
	4.2.2.2	6.2.2
3.5	4.2.4	6.4
3.6	4.2.2.1	6.2.1
4.1	4.3.1	5.2.2 / 7.1
4.2	4.3.2	5.2.3 / 7.2
4.3	4.3.3	7.3 / 7.4
5	4.4	8
6.1	4.5.1	9/10
6.2	4.5.2	11.1
6.3	4.5.3	11.2
7.1	4.6.1	12.1
7.2	4.6.1	5.3
7.3	4.6.2	12.2 / 12.3
7.4	4.6.3	12.4
8.1	4.7.1	13
8.2	4.7.1	13
8.3	4.8	14
8.3.1	4.8	14
8.3.2	4.8	14
9	4.9	15
9.1	4.9	15
9.2	4.9	15
9.3	4.9	15

Annex G
(informative)

Summary of significant changes to test requirements from Edition 3 of IEC 60945

Clause Edition 3		Clause Edition 4	
6	**Operational checks**	6	Additional guidance is given together with additional requirements for hardware and software.
9.3	**Radiated emissions from enclosure port**	9.3	A peak detector is permitted as an alternative in the band 156 MHz to 165 MHz. Length of cables may be limited to 20 m. Additional measurements are required for the frequency range 1 GHz to 2 GHz.
10.2	**Immunity to conducted low-frequency interference**	This test has been deleted.	
10.3	**Immunity to conducted radiofrequency interference**	10.3	The requirement for measurements between 10 kHz and 150 kHz has been deleted.
10.4	**Immunity to radiated radiofrequencies**	10.4	Additional measurements are required for the frequency range 1 GHz to 2 GHz.
11.1	**Acoustic noise and signals**	11.1	The test method has been changed from a power measurement to a pressure measurement. The limits are unchanged.
12.3	**Emission from visual display unit (VDU)**	12.3	The limits to be met have been relaxed for display sizes greater than 0,5 m.
13	**Maintenance**	13	There is an additional requirement for maintenance of software.
14	**Equipment manuals**	14	There is an additional requirement for installation information.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-161	1990	International Electrotechnical	-	-
A1	1997	Vocabulary (IEV)	-	-
A2	1998	Chapter 161: Electromagnetic compatibility	-	-
IEC 60068-2-1	1990	Environmental testing	EN 60068-2-1	1993
A1	1993	Part 2: Tests - Tests A: Cold	A1	1993
A2	1994		A2	1994
IEC 60068-2-2	1974	Part 2: Tests - Tests B: Dry heat	EN 60068-2-2 [1)]	1993
A1	1993		A1	1993
A2	1994		A2	1994
IEC 60068-2-5	1975	Part 2: Tests - Test Sa: Simulated solar radiation at ground level	EN 60068-2-5	1999
IEC 60068-2-6	1995	Part 2: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	1995
+ corr. March	1995			
IEC 60068-2-9	1975	Part 2: Tests - Guidance for solar radiation testing	EN 60068-2-9	1999
+ A1	1984			
A1/corr. August	1989			
IEC 60068-2-30	1980	Part 2: Tests - Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)	EN 60068-2-30	1999
+ A1	1985			
IEC 60068-2-48	1982	Part 2: Tests - Guidance on the application of the tests of IEC 60068 to simulate the effects of storage	EN 60068-2-48	1999
IEC 60068-2-52	1996	Part 2: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)	-	-
corr. July	1996			
IEC 60071-2	1996	Insulation co-ordination Part 2: Application guide	EN 60071-2	1997

[1)] EN 60068-2-2 includes supplement A:1976 to IEC 60068-2-2.

Publication	Year	Title	EN/HD	Year
IEC 60092-101 A1 A1/corr. November	1994 1995 1996	Electrical installations in ships Part 101: Definitions and general requirements	-	-
IEC 60417	Series	Graphical symbols for use on equipment	EN 60417	Series
IEC 60529 A1	1989 1999	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May A1	1991 1993 2000
IEC 60533	1999	Electrical and electronic installations in ships - Electromagnetic compatibility	-	-
IEC 60651 A1	1979 1993	Sound level meters	EN 60651 A1	1994 1994
IEC 61000-4-2	1995	Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	1995
IEC 61000-4-3 (mod)	1995	Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	1996 [2)]
IEC 61000-4-4	1995	Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	1995
IEC 61000-4-5	1995	Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	1995
IEC 61000-4-6	1996	Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	1996
IEC 61000-4-8	1993	Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8	1993
IEC 61000-4-11	1994	Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	1994
CISPR 16-1	1999	Specification for radio disturbance and immunity measuring apparatus and methods Part 1: Radio disturbance and immunity measuring apparatus	-	-

[2)] EN 61000-4-3:1996 is superseded by EN 61000-4-3:2002, which is based on IEC 61000-4-3:2002.

Publication	Year	Title	EN/HD	Year
ISO 694	2000	Ships and marine technology - Positioning of magnetic compasses in ships	EN ISO 694	2001
ISO 3791	1976	Office machines and data processing equipment - Keyboard layouts for numeric applications	-	-
IMO SOLAS	1997	International Convention for the Safety of Life at Sea (SOLAS)	-	-
IMO Torremolinos Protocol	1993	Modification of the Torremolinos International Convention for the Safety of Fishing Vessels:1977	-	-
IMO MSC/ Circular 794	1997	Standard Marine Communication Phrases (SMCPs)	-	-
IMO Resolution A.694	1991	General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids	-	-
IMO Resolution A.803	1995	Performance standards for shipborne VHF radio installations capable of voice communication and digital selective calling	-	-
IMO Resolution A.813	1995	General requirements for electromagnetic compatibility (EMC) for all electrical and electronic ship's equipment	-	-
ITU-T Recommendation E.161	1993	Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network	-	-

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Germanischer Lloyd:1994, *Regulations for the Use of Computers and Computer Systems*

EN 50279: *Visual Display Units – Measuring methods for low frequency electric and magnetic near fields*

IEC 60068-2-32:1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall (Procedure 1)*

IEC 60068-3-4: 2001, *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

IEC 60073:1996, *Basic and safety principles for man–machine interface, marking and identification – Coding principles for indication devices and actuators*

IEC 60092-504:2001, *Electrical installations in ships – Part 504: Special features – Control and instrumentation*

IEC 60300-1:1993, *Dependability management – Part 1: Dependability programme management*

IEC 60721-2-1:1982, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature. Temperature and humidity*
Amendment 1 (1987)

IEC 60721-2-4:1987, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature. Solar radiation and temperature*
Amendment (1988)

IEC 60721-3-6:1987, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities. Ship environment*
Amendment 1 (1991)
Amendment 2 (1996)

IEC 61162 (all parts), *Maritime navigation and radiocommunication equipment and systems – Digital interfaces*

IEC 61209:1999, *Maritime navigation and radiocommunication equipment and systems – Integrated bridge systems (IBS) – Operational and performance requirements, methods of testing and required test results*

IEC 61508-1:1998, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety – Related Systems* (see www.iec.ch/61508)

ISO/IEC 17025:2000, *General requirements for the competence of testing and calibration and testing laboratories*

ISO 8468:1990, *Ship's bridge layout and associated equipment – Requirements and guidelines*

ISO 9241-3:1992, *Ergonomic requirements for office work with visual display terminals (VDTs) – Visual display requirements*

ISO 9241-10:1996, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 10: Dialogue principles*

ISO 9241-11:1998, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11: Guidance on usability*

IMO MSC/Circ.891:1998, *Guidelines for the on-board use and application of computers*

IMO Resolution A.224:1973, *Performance standards for echo-sounding equipment*

IMO Resolution A.278:1973, *Symbols for controls on marine navigational radar equipment*

IMO Resolution A.477:1981, *Performance standards for radar equipment*

IMO Resolution A.525:1983, *Performance standards for narrow-band direct-printing telegraph equipment for the reception of navigational and meteorological warnings and urgent information to ships*

IMO Resolution A.662:1989, *Performance standards for float-free release and activation arrangements for emergency radio equipment*

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IMO Resolution A.802:1995, *Performance standards for survival craft radar transponders for use in search and rescue operations*

IMO Resolution A.804:1995, *Performance standards for shipborne MF radio installations capable of voice communication and digital selective calling*

IMO Resolution A.805:1995, *Performance standards for float-free VHF emergency position-indicating radio beacons*

IMO Resolution A.806:1995, *Performance standards for shipborne MF/HF radio installations capable of voice communication, narrow-band direct-printing and digital selective calling*

IMO Resolution A.807:1995, *Performance standards for INMARSAT standard-C ship earth stations capable of transmitting and receiving direct-printing communications*

IMO Resolution A.808:1995, *Performance standards for ship earth stations capable of two-way communications*

IMO Resolution A.809:1995, *Performance standards for survival craft two-way VHF radiotelephone apparatus*

IMO Resolution A.810:1995, *Performance standards for float-free satellite emergency position-indicating radio beacons (EPIRBs) operating on 406 MHz*

IMO Resolution A.812:1995, *Performance standards for float-free satellite emergency position-indicating radio beacons operating through the geostationary INMARSAT satellite system on 1,6 GHz*

IMO Resolution A.823:1995, *Performance standards for automatic radar plotting aids (ARPA)*

IMO Resolution A.824:1995, *Performance standards for devices to indicate speed and distance*

IMO NAV 45/6:1999, *Ergonomic criteria for bridge equipment and layout – Report of the Correspondence Group on ergonomic criteria for bridge equipment and layout*

IACS Unified requirement E10:1997, *Unified environmental test specification for testing procedure for electrical control and instrumentation equipment, marine computers and peripherals covered by classification*

Lloyds Register of Shipping:1998, *Rules and Regulations for the Classification of Ships – Part 6 Control Engineering Systems.*

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