

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

ICS 47.020.70

National foreword

This British Standard is the UK implementation of EN 60945:2002. It is identical with IEC 60945:2002, incorporating corrigendum April 2008. It supersedes BS EN 60945:1997 which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum April 2008 is indicated in the text by AC1 AC1.

The UK participation in its preparation was entrusted to Technical Committee EPL/80, Maritime navigation and radiocommunication equipment and systems.

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

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English version

**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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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:

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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).

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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)

AC1 IEC 60068-2-1, *Environmental testing – Part 2: Tests – Tests A: Cold* AC1

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)

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

AC1 IEC 60068-2-30, *Environmental testing – Part 2: Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)* AC1

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*

AC1 IEC 60092-101, *Electrical installations in ships – Part 101: Definitions and general requirements*

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

IEC 60529:2001, *Degrees of protection provided by enclosures (IP code)*

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

IEC 61672:2002, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61000-4-2:2001, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test* – Basic EMC publication AC1

AC1 IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test* – Basic EMC publication

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61000-4-6:2006, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2001, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test* – Basic EMC publication

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests*

CISPR 16-1-1:2006, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2:2006, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-1-4:2007, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances* AC1

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*

AC1 IMO Convention for Safety of Life at Sea (SOLAS):1974 as amended AC1

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

AC1 IMO Resolution A.918(22) IMO Standard Marine Communication Phrases (SMCPs):2001 AC1

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*

AC1 ITU-T Recommendation E.161:2001, *Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network* AC1

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.