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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – RADAR FOR CRAFT NOT IN COMPLIANCE WITH IMO SOLAS CHAPTER V – PERFORMANCE REQUIREMENTS, METHODS OF TEST AND REQUIRED TEST RESULTS

FOREWORD

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International Standard IEC 62252 has been prepared by IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.

This standard is based on the standards for radar and radar plotting used on SOLAS vessels, IEC 60872 series, IEC 60936 series and IEC 60945.

The text of this standard is based on the following documents:

FDIS	Report on voting
80/393/FDIS	80/397/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This IEC radar standard is produced specifically for radar not fully compliant with the IMO Performance Standard for radar/radar plotting and applies to the following:

- radar (class A) intended for commercial craft under 150 gross tonnage, where no SOLAS radar carriage requirement currently exists, where the antenna beamwidth is not more than 4,0° and the display minimum effective diameter is limited to not less than 150 mm.
- radar (class B) intended for recreational craft or other maritime use and where the antenna beamwidth is not more than 5,5° and the display minimum effective diameter is limited to not less than 85 mm.
- radar (class C) intended for small recreational craft where the antenna beamwidth is not more than 7,5° and the display minimum effective diameter is limited to not less than 75 mm.

The requirements for commercial craft radar are covered in the main body of this specification. The requirements, where different, for radar (class B and C) are shown in parenthesis where applicable.

NOTE 1 The IMO performance standard for radar/radar plotting is in Resolution MSC.64(67) which is implemented in the IEC 60872 series and the IEC 60936 series of standards.

NOTE 2 For the purposes of this IEC standard, the words 'craft' and 'ship' are interchangeable and have the same meaning.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – RADAR FOR CRAFT NOT IN COMPLIANCE WITH IMO SOLAS CHAPTER V – PERFORMANCE REQUIREMENTS, METHODS OF TEST AND REQUIRED TEST RESULTS

1 Scope

This International Standard specifies the minimum performance requirements for testing and required test results for conformance of radar not fully compliant with the IMO Performance Standard for radar/radar plotting (RP) (MSC.64(67)). In addition, it takes into account IEC 60945. When a requirement of this standard is different from that of IEC 60945 the requirement in this standard shall take precedence.

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

IEC 60417:1998, *Graphical symbols for use on equipment – Part 1: Overview and application*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

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

IEC 60872-2:1999, *Maritime navigation and radiocommunication equipment and systems – Radar plotting – Part 2: Automatic tracking aids (ATA) – Methods of testing and required test results*

IEC 60872-3:1999, *Maritime navigation and radiocommunication equipment and systems – Radar plotting – Part 3: Electronic plotting aid (EPA)*

IEC 60936-1:1999, *Maritime navigation and radiocommunication equipment and systems – Radar – Part 1: Shipborne radar – Methods of testing and required test results*

IEC 60936-2:2000, *Maritime navigation and radiocommunication equipment and systems – Radar – Part 2: Shipborne radar for high-speed craft (HSC) – Methods of testing and required test results*

IEC 60936-3:2000, *Maritime navigation and radiocommunication equipment and systems – Radar – Part 3: Shipborne radar with chart facilities – Methods of testing and required test results*

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

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 61108 (all parts), *Maritime navigation and radiocommunication equipment and systems GNSS/DGNSS*

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

IEC 61672, *Electroacoustics - Sound level meters*

IEC/PAS 60936-5, *Guidelines for the use and display of AIS information on Radar*

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*

ITU Radio Regulations 2001

ITU-R Recommendation M.1177-3, *Techniques for measurement of unwanted emissions of radar systems*

ITU-R Recommendation M.1313, *Technical characteristics of maritime radionavigation radars*

ITU-R Recommendation SM.328, *Spectra and bandwidth of emissions*

ITU-R Recommendation SM.329, *Unwanted emissions in the spurious domain*

ITU-R Recommendation SM.1539, *Variation of the boundary between the out-of-band and spurious domains required for the application of Recommendations ITU-R SM.1541 and ITU–R SM.329*

ITU-R Recommendation SM.1540, *Unwanted emissions in the out-of-band domain falling into adjacent allocated bands*

ITU-R Recommendation SM.1541, *Unwanted emissions in the out-of-band domain*

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

IHO S.52, *Specifications for chart content and display aspects of ECDIS*

3 Terms, definitions and abbreviations

3.1 Definitions

For the purposes of this document, the following definitions apply.

3.1.1
accuracy
measure of the error between the point desired and the point achieved, or between the position indicated by measurement and the true position

3.1.2
by inspection
visual check of the EUT or its documentation

3.1.3
hazards
objects, potentially leading to grounding or collision

3.1.4
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

3.1.5
manufacturer
organization responsible for the production of the radar

3.1.6
mode – functional
applicable to functions where the system can be used to display alternative modes such as chart mode, speed log mode, i.e. multi-function mode or composite mode (when the system can simultaneously display a combination of two or more modes)

3.1.7
mode – radar stabilized
true motion – heading and speed input required

course up – heading input required

north up – heading input required

3.1.8
mode – radar unstabilized
relative motion head up – no heading input required

3.1.9
mode – standard operating
display modes selectable by the operator (for example, relative motion head-up, true motion north up, etc.)

3.1.10
navigational aid
shipborne item, for example, instrument, device or chart, intended to assist in the navigation of a ship

NOTE Aids to navigation (AtoN) are different from navigational aid.

3.1.11
operational check
check by a suitably qualified person to confirm that the equipment complies with the operational requirements in this standard

3.1.12
performance check
short functional test carried out during or after a technical test to confirm that the equipment operates

3.1.13
performance check (EMC)
short functional test carried out during or after an EMC test to confirm that the equipment complies with the required immunity performance criteria

3.1.14
performance check (operational)
short functional test carried out by reconfiguration of the EUT and checking by non-quantitative visual means that the system is still operative for the purposes of Annex E. Operation of the gain, tune, clutter, EBL, VRM and plotting facilities to confirm normal operation during or after environmental and EMC tests

3.1.15
performance test (operational)
for radar EUT, shall be identical to the performance check for the purposes of Annex E, with the addition of the display test specified in 4.7

3.1.16
performance test
measurement or a group of measurements carried out during or after a technical test to confirm that the EUT complies with selected parameters as defined in the equipment standard

3.1.17
pre-conditioning
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 Pre-conditioning 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 stabilized before measurements and test

3.1.18
product family EMC standard
definition of specific EMC 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

3.1.19
radar echo
signal detected by a radar receiver that is processed and capable of being clearly displayed at the correct range and bearing on a radar display

3.1.20
radar effective area
area where radar echoes, radar plotting (RP) and other reported targets (for example AIS) may be displayed and which falls inside of the radar bearing scale

3.1.21
radar information area
area where radar menus and associated information may be shown and which falls outside of the radar bearing scale

3.1.22
radar plotting (RP)
radar plotting as implemented in ATD or EPD (see Annex F and Annex G respectively)

3.1.23
radar target
object that reflects transmitted radar signals

3.1.24
sensor
navigational aid, with or without its own display and/or control as appropriate, providing information to the radar

3.1.25
standard operating mode
in the operational condition defined in 4.18.7 and in the optional true motion mode described in 4.18.8, manual or simulated forward speed of 10 knots shall be applied, unless otherwise specified in the test clause

3.1.26
synthetic information
information, in addition to radar echoes, consisting of graphical objects with or without alphanumerical information within the effective radar display. This information may consist of target identifiers, vectors and other symbols

3.1.27
technical test
tests, for which a repeatable method of measurement is defined in this standard

3.1.28
warning
visual indication which may be accompanied by a short audible signal, giving information about a condition of which the operator needs to be aware

3.2 Abbreviations

a.c.	Alternating current
AIS	Automatic Identification System
ATA	Automatic Tracking Aid
ATD	Automatic Tracking Device
d.c.	Direct current
EBL	Electronic Bearing Line
ECDIS	Electronic Chart Display and Information System
EMC	Electromagnetic compatibility
e.m.f.	Electromotive force
EPA	Electronic Plotting Aid
EPD	Electronic Plotting Device
EPFS	Electronic Position Fixing System
EUT	Equipment Under Test
GPS	Global Positioning System
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
ISO	International Organisation for Standardization
ITU	International Telecommunication Union
PC	Performance Check

PT	Performance Test
RCS	Radar Cross-Section
r.m.s.	Root Mean Square
RF	Radio-frequency
RP	Radar Plotting incorporating ATD and EPD
SDME	Speed and Distance Measuring Equipment
SMCPs	Standard Marine Communication Phrases
SOLAS	Safety Of Life At Sea
THD	Transmitting Heading Device
VRM	Variable Range Marker
VCP	Vertical Coupling Plane
VDU	Visual Display Unit

NOTE See also Annex B for abbreviations in relation to controls.

4 Performance requirements

4.1 Radar indication

The radar equipment shall provide an indication, in relation to own ship, of the position of other surface craft/obstructions, buoys, shorelines and navigational marks, in a manner which will assist in navigation and in avoiding collision.

4.2 Safety of options

The equipment, including facilities that are provided in addition to those required herein, shall not degrade the radar performance as specified in 4.1. The manufacturer shall provide information for all options available.

4.3 Technical information

Adequate information shall be provided and shall include a manual to enable the equipment to be properly installed, set up, routinely maintained and operated. The manufacturer shall declare that the manual contains adequate information to meet this requirement.

4.4 Quality assurance

The manufacturer shall have a quality control system in place for production, final-product inspection and testing that is audited by a competent authority to ensure continuous compliance with the certified product. Alternatively, the manufacturer may use final product verification procedures where a competent authority verifies compliance with the equipment certification before the product is installed.

4.5 Radio-frequency spectrum requirements

The operational radio-frequency of the equipment shall be within the appropriate bands allocated for radionavigation defined in the ITU Radio Regulations at all times. (see also Annex D).

4.6 Range

With the radar antenna mounted at a height of 7,5 m above sea level, the operational requirement under normal propagation conditions is that the equipment shall, in the absence of clutter, paint the radar target echoes as detailed in 4.6.1 and 4.6.2 for at least 8 out of 10 radar scans.

4.6.1 Coastlines

- At 9 nautical miles class A (5 nautical miles class B and C) when the ground rises to 60 m.
- At 5 nautical miles class A (3 nautical miles class B and C) when the ground rises to 6 m.

4.6.2 Surface objects

- At 5 nautical miles class A (3 nautical miles classes B and C) a radar reflector, having an effective echoing area of 400 m^2, mounted at a height of 7,5 m.
- At 2 nautical miles class A (1 nautical mile classes B and C) a radar reflector, having an effective echoing area of 10 m^2, mounted at a height of 3,5 m.
- At 1 nautical mile class A (classes B and C not applicable) a radar reflector, having an effective echoing area of 5 m^2, mounted at a height of 3,5 m.

NOTE The 7,5 m and the 3,5 m height referred to in 4.6 are test criteria only and not an installation requirement.

This can be achieved using triangular corner reflectors of 201 mm, 225 mm and 570 mm for the “a” dimension, calculated for X-band are equivalent to echoing areas of 5 m^2, 10 m^2 and 400 m^2 respectively.

4.6.3 Minimum range

A 10 m^2 test target, set at a height 3,5 m shall be clearly displayed from a minimum horizontal range of 50 m for class A, (60 m for class B) and (75 m for class C) from the antenna position. Without changing the setting of controls other than the range selector, the test target shall remain visible from the minimum horizontal range, up to a range of 1 nautical mile.

NOTE The minimum range is the shortest distance at which a stationary target echo ahead is still presented separately from the point representing the antenna position.

4.7 Display

4.7.1 Display size

The equipment shall provide, without external magnification, a display with a minimum effective diameter within the bearing scale of not less than 150 mm class A (85 mm class B) (75 mm class C).

Other technologies that achieve the same functional requirements are permitted.

4.7.2 Standard ranges

The equipment shall provide the following set of range scales of display; 0,75, 1,5, 3, 6 and 12 nautical miles. Intermediate range scales are not permitted for class A but may be provided for class B and class C.

An additional range of 0,25 nautical miles for class B and C shall be provided.

4.7.3 Additional range scales

Larger and smaller range scales may be provided. See 4.7.2.

4.7.4 Additional range units

Units of measurement other than nautical miles are permitted. If other units are provided, the selection of the units shall be possible only when in the standby mode. The relationship between the scales shall be maintained. For statute miles 0,75, 1,5, 3, 6 and 12 miles, and, for kilometres 1,5, 3, 6, 12 and 24 km.

4.7.5 Range scale in use

The range scale in use and the distance between range rings when in use shall be clearly indicated. Range UNIT consistency shall be maintained throughout.

4.7.6 Displayed information

Within the effective diameter of the display radar video area under normal operation, the display shall only contain information that pertains to the use of the radar display for navigation and collision avoidance and which has to be displayed there because of its association with a target (e.g. target identifiers, vectors) or because of some other direct relationship with the radar display.

NOTE The effective diameter of the display is the diameter of the central area into which any angular scale marking around its edge does not intrude. In the case of displays that are other than circular, the effective diameter is that of the smallest effective display dimension

Other information, not associated with the use of the radar/RP presentation for navigational and collision avoidance purposes, may be shown within the effective diameter of the display when such information is operator initiated.

The display shall automatically revert to the normal operating mode for radar/RP after 10 s following the last operator action in initiating the presentation of this other information. In the event of an alarm condition occurring, the display shall immediately revert to the normal operating mode for radar/RP.

An alarm status may be displayed in a window within the radar effective area.

4.7.7 Radar video origin

The origin of the range scale (radar video) shall start at own ship, be linear and shall not be delayed.

4.7.8 Zoom function

A zoom function may be provided and a clear indication shall be given to the user when active. The origin of own ship shall not be moved out of the radar effective area when the zoom function is activated. The scale used in the zoomed area shall be limited to a x 2-zoom of the range scale in use.

(A zoom function may be implemented using alternative methods or scaling factors for classes B and C).

4.7.9 Display colour presentation

Multiple colour displays are permitted but the following requirements shall be met:

- target echoes shall be displayed by means of the same basic colours and the echo strength shall not be displayed in different colours;
- information, in addition to target echoes, may be shown in different colours;
- different colours shall be provided for day and night presentation.

4.7.10 Display view under various light conditions

The radar picture and information shall be readable under all ambient light conditions. There shall be a means of adjusting display brilliance. If a light shield is necessary to facilitate operation of the display in high ambient light levels, then means shall be provided for its ready attachment and removal.

4.8 Frequency band

It is permissible to use either X band or s band frequencies. Where both frequency bands are available, the frequency band in use shall be indicated to the operator.

4.9 Range markers

4.9.1 Fixed range rings

Fixed electronic range rings equally spaced from the origin shall be provided for range measurement class A (and class B) as follows:

a) on the 0,75 nautical miles range scale and greater at least three and not more than six range rings shall be provided. At range scales of less than 0,75 nautical miles at least two range rings shall be provided;

b) where off-centred facilities are provided (see 4.18.9), additional range rings shall be provided at the same range intervals as on the range scales indicated in 4.7.2;

c) where a zoom function is provided and in use, a different number of range rings may be displayed.

(For class C, fixed electronic range rings are optional, where provided the range rings shall be equally spaced from the origin).

4.9.2 Range ring thickness

The thickness of the fixed range rings shall not be greater than the maximum permissible thickness of the heading line

4.9.3 Variable range marker

An electronic variable range marker (VRM) in the form of a ring shall be provided for classes A and B (optional for class C, if provided it shall meet the stated requirement), with a numeric read-out of range. This read-out shall not display any other data. Temporary overlaying of the data fields is permitted. For ranges of less than 1 nautical mile, there shall be only one ‘zero’ before the decimal point.

Additional variable range markers meeting the same requirements may be provided. In this case, separate identifiable read-outs shall be provided.

4.9.4 VRM thickness

The thickness of the VRM shall be not greater than the maximum permissible thickness of the heading line.

4.9.5 Time to set VRM

On all range scales, it shall be possible to set the variable range marker with the required precision within 10 s in all cases. A range that is set by the user shall not change automatically when the range scale is changed.

4.9.6 Fixed range ring and VRM accuracy when off-centred

The accuracy of fixed range rings and VRM shall be maintained when the display is off-centred class A (and class B).

4.9.7 Fixed range ring and VRM display

It shall be possible to remove the fixed range rings and the VRM independently and completely from the display.

4.10 Range measurement using range rings and VRM

The fixed range rings and the VRM shall enable the range of an object to be measured with an error not exceeding 1,5 % of the maximum range of the scale in use or 50 m, whichever is greater.

NOTE Range measurement is the determination of the distance of a target from the radar antenna.

4.11 Heading line

4.11.1 Heading line indication

The heading of the ship shall be indicated by a continuous line on the display with a maximum error of not greater than ±1°.

4.11.2 Heading line thickness

The thickness of the displayed heading line shall be not greater than 1° class A (and class B) (2° class C) measured, at the edge of the radar display, in the head-up unstabilized mode with the display centred.

4.11.3 Heading line origin

The heading line shall extend from the trace origin (own ship's position) to the edge of the display.

4.11.4 Heading line bearing scale

A bearing scale shall be provided to give an indication of the heading to within ±1° for class A (and class B) (±2° for class C if provided) (when the display is centred). A heading marker (line or mark) shall be displayed on the bearing scale in class A (classes B and C not applicable). The marker shall appear at scale zero to facilitate viewing the heading line orientation on the head-up off-centred display.

4.11.5 Heading line off facility

Provision shall be made to switch off the heading indicator (heading line) by a device which cannot be left in the "heading line off" position.

4.12 Electronic bearing line (EBL)

4.12.1 EBL indication

The EBL for class A (and class B) shall be displayed on the screen in such a way that it is clearly distinguishable from the heading line (optional for class C, when provided it shall meet the stated requirement). The EBL shall be not thicker than the heading line.

4.12.2 EBL rotation

The rotation of the EBL shall be possible in both directions continuously or in steps of not more than 2° class A (and class B) (class C not applicable).

4.12.3 EBL display

It shall be possible to remove the EBL completely from the display.

4.12.4 Time to set EBL

An EBL shall be provided with a numeric read-out to enable the bearing of any object whose echo appears on the display to be obtained within 10 s class A (and class B) (class C not applicable).

4.12.5 EBL read-out

The numeric read-out of the bearing of the EBL shall be displayed with at least a resolution of 1°. The EBL read-out shall not be used to display any other data. Temporary overlaying of the data fields is permitted. There shall be a positive identification of whether the bearing indicated is a relative bearing or a true bearing class A (and class B) (class C not applicable).

4.12.6 EBL measurement accuracy

The EBL shall enable the bearing of a target whose echo appears at the edge of the display to be measured with a maximum error of not greater than ±2° class A (and class B) (class C not applicable), excluding external sensor errors.

4.12.7 EBL origin shift

It shall be possible to move the position of the EBL origin away from the own ship to any desired point on the effective display area class A (and class B) (class C not applicable).

- By a fast simple operation it shall be possible to move the EBL origin back to own ship's position on the screen.
- On the EBL, it shall be possible to display a variable range mark.

4.12.8 Additional EBLs

Additional EBLs meeting the above requirements may be provided. In this case, separate identifiable read-outs shall be provided. These may be centred on own ship or off-centred.

4.13 Bearing scale

4.13.1 Linear or non-linear bearing scale

A bearing scale around the edge of the display shall be provided. Linear or non-linear bearing scales may be provided. The radar picture shall be within this scale for class A (and class B) (class C not applicable).

4.13.2 Minimum division marks on bearing scale

The bearing scale shall have as a minimum division marks for each 5° increment. All 30° divisions are to be clearly distinguishable from the minimum division marks.

4.13.3 Labelling of bearing scale division marks

Numbers shall be shown as a minimum at 30°, 60°, 120°, 150°, 210°, 240°, 300° and 330° points of the screen. Numbers may be omitted at the extreme top, bottom, and sides of the screen. (Optional for class B, when provided it shall meet the stated requirement) (Class C not applicable)

4.13.4 Bearing measurement using EBL

By using the EBL, it shall be possible to measure the bearing relative to the heading line. It shall also be possible to measure true bearings relative to North where stabilized modes are provided.

4.14 Discrimination

4.14.1 Range

The equipment shall be capable of displaying two small similar (10 m^2) targets in the absence of clutter at a range of between 50 % and 100 % of the range scale as separate indications on a range scale of 0,75 nautical miles or less. These two targets shall have the same bearing and be separated by not more than 60 m class A (and class B)(75 m class C) in range.

4.14.2 Off-centred display

The range discrimination shall be maintained when the display is off-centred.

4.14.3 Bearing

The equipment shall be capable of displaying as separate indications, two similar small (10 m^2) targets both situated at the same range, and located between 50 % and 100 % of the 0,75 nautical mile range scale. Both targets shall be individually viewable when separated by not more than: 4,5° class A (6° class B) (8° class C) in bearing.

4.15 Antenna radiation pattern

4.15.1 Antenna horizontal radiation pattern

An antenna horizontal radiation pattern shall be produced in order to ensure that picture quality is not impaired by side-lobes.

4.15.2 Antenna side-lobes

The effective side-lobes shall not adversely affect the radar system performance. The effective side-lobes are defined in Table 1.

Table 1 – Effective side-lobes

Position relative to maximum of main beam degrees	**Maximum power relative to maximum of main beam** dB
Within ±10 (A)	–20
Outside ±10 (A)	–23
Within ±10 (B)	–18
Outside ±10 (B)	–19
Within ±10 (C)	–18
Outside ±10 (C)	–19

4.16 Roll or pitch performance

The performance of the equipment shall be such that when the ship is rolling or pitching up to ±10°, the range performance requirements of 4.6.1 and 4.6.2 shall continue to be met.

4.17 Antenna scan

4.17.1 Antenna rotation

a) The antenna rotation shall be clockwise as viewed from above and continuous through 360° of azimuth.

b) The antenna rotation rate shall be not less than 20 rpm.

c) Open antenna arrays shall start and operate satisfactorily in relative wind speeds of up to 60 knots. (This requirement is not applicable to radom enclosed turning elements).

Alternative methods of scanning are permitted, provided that the performance is not inferior to that of a rotating scanner.

4.17.2 Sector blanking

To suppress unwanted indirect reflected echoes in blind arcs, sector blanking of the transmission may be used. If used, the blanked sector shall be clearly indicated on the display.

4.18 Modes

4.18.1 Head-up mode

A head-up display mode shall be provided.

4.18.2 Azimuth stabilization – optional

A stabilized mode, north-up or course-up, may be provided.

4.18.3 Automatic reversion to head-up mode

Where other display modes are provided the display shall revert to head-up mode within 1 min of the azimuth stabilization becoming inoperative. The equipment shall operate satisfactorily in the head-up unstabilized mode when the azimuth stabilization is inoperative.

An alarm shall be given within 5 s of azimuth stabilization failure.

4.18.4 Azimuth stabilization mode where no heading sensor is available

Where no heading sensor is available, selection of this mode shall not be possible.

4.18.5 Display mode indication

Where more than one mode is provided there shall be a positive indication of the display mode in use.

4.18.6 Display mode changeover

Where provided, the changeover from one display mode to the other shall be possible within 15 s and a bearing accuracy of 2° shall be achieved within this time for class A (and class B). (class C not applicable).

4.18.7 Relative motion mode

The equipment shall be capable of operating in relative motion mode.

4.18.8 True motion mode – option

The equipment may be capable of operating in true motion mode.

Where true motion mode is provided this shall be available on all range scales between 0,75 nautical miles to 12 nautical miles.

4.18.9 Origin offset

A radar origin offset may be provided, if available the origin shall not be capable of being offset from the centre to more than 75 % of the radius of the display.

4.18.10 Stabilization indication

Where provided the stabilization mode in use shall be indicated.

4.19 Tuning indication

Means shall be provided to indicate the tuning function.

4.20 Anti-clutter devices

4.20.1 Clutter suppression

Suitable means shall be provided for the suppression of unwanted echoes from sea clutter, rain or other forms of precipitation and interference from other radars.

4.20.2 Clutter controls

Where applicable, it shall be possible to adjust, manually and continuously, the anti-clutter controls in order to suppress unwanted echoes. Automatic anti-clutter functions may be provided.

Adjustment of anti-clutter controls in small discrete steps shall be regarded as continuous adjustment.

Alternatively, adjustment by controls which operate by other than circular movement are acceptable on condition that:

- they shall be inoperative in the fully left or down position; or
- if they operate by a pair of push buttons, operation of the left or lower button shall render the device inoperative;
- an indication of the operative conditions of the anti-clutter control shall be provided.

4.21 Range performance in clutter

4.21.1 Range performance using manual/automatic anti clutter

The operational requirement when the radar antenna is mounted at a height of 7,5 m above sea level, is that, the equipment shall, even in the presence of sea clutter, paint the radar target echo for at least 5 out of 10 radar scans for a target with an effective RCS at X band of 200 m^2 for class A. (400 m^2 for class B and class C) when at a distance between 100 m and 1 nautical mile.

NOTE Using a selection of RCS targets, sea states, ranges and distances determine a test scenario where a radar echo can be displayed with the sea clutter control on and adjusted and will not be detectable when the sea clutter is off.

4.21.2 Range performance using automatic anti clutter

Where automatic anti-clutter is provided the manufacturer shall provide details and limitations of this function in their documentation.

4.22 Operation

4.22.1 Language

The operation manuals and user menus in addition to being presented in English may be presented in other languages or scripts.

The user action to change the equipment to another language or script shall be within a user accessible menu function only available on switch on.

4.22.2 Availability

a) After switching on from cold, the equipment shall be available to be operational within 4 min.
b) A standby mode shall be provided and from which, upon switching to on, the equipment shall be operational within 15 s.

For radar displays that can be used for displaying other information and when the radar transceiver is switched to standby mode, the display of radar shall be operational within 15 s from selection of the radar mode.

4.23 Controls

Operational controls shall be identified and easy to operate (see E.4.2.1.4.)

The equipment shall be capable of being switched on and off and operated from the designated master display control position.

For radars with additional synthetic information (e.g. target identifiers, vectors, navigational information), means shall be provided to remove this additional synthetic information from the screen by dedicated controls or primary access in an associated menu.

4.24 Manual speed set and drift input

4.24.1 Manual speed input

Where manual speed input is provided it shall be possible to input the ship's speed manually from 0 (zero) knots to at least 30 knots in steps of not more than 0,2 knots.

4.24.2 Manual set and drift input

If a manual input of set and drift is provided, an indication shall be given. The relevant set and drift values shall be available on demand.

4.25 Interference from external magnetic fields

After installation and adjustment on board, the bearing accuracy as prescribed in this performance standard shall be maintained without further adjustment, irrespective of the movement of the ship in the earth's magnetic field. The effect of external magnetic fields shall be sufficiently restricted to ensure that performance is not affected.

Effective means shall be provided for the operator to degauss or to employ an equivalent technique, where applicable, to reduce the observable effect of external magnetic fields.

4.26 Radar installation

The manufacturer shall provide guidelines on installation of the radar system, including the antenna, to ensure that the equipment’s performance will not be substantially impaired if these provided guidelines are followed.

4.27 Failure warnings (alarms) and status indication

4.27.1 Signal failures

An alarm shall be provided if:

a) a failure of any of the following signals occurs:
   1) raw radar video,
   2) trigger, and
   3) heading line;
b) a failure of data from the following connected/functioning sensors occurs:
   1) azimuth (where provided), and
   2) other configured sensors (where provided).

If the audible alarm sound level is less than 75 dB(A) (IEC 60945 requires a minimum of 75 dB(A) and a maximum of 85 dB(A)), specify the maximum level in the equipment manual.

4.27.2 Radar picture update failure

A fault that prevents graphic radar video update shall clear or obscure the radar display area or an appropriate alarm shall be given.

4.27.3 Input sensor failure

Functions and data that depend on a failed sensor or signal shall be indicated and inhibited within 1 min of occurrence of such failure.

4.27.4 Alarm acknowledgement

Means shall be provided to acknowledge individual alarms.

4.28 Interfacing

4.28.1 Radar input interface

Where the radar system is capable of exchanging information with other sensors, class A (and class B) shall have as minimum interfaces compliant with international standards (IEC 61162 series – see Tables 2 and 3). In addition, other suitable interfaces are permitted (class C may have any suitable interface). The manufacturer shall either provide simulators for alternative or additional proprietary interfaces or confirm that these do not degrade the performance of the radar. (see 4.2).

The source of received information shall be capable of being displayed.

Table 2 – Recommended input data sentences – IEC 61162-1/IEC 61162-2

	Class A		Class B	
	With RP	**No RP**	**With RP**	**No RP**
Position	GGA GLL GNS	GGA GLL GNS	GGA GLL GNS	GGA GLL GNS
Speed	VBW/RMC	VBW/RMC	VBW/RMC	VBW/RMC
Heading	HDT/HDG	HDT/HDG	HDT/HDG	HDT/HDG
Stabilization		VTG/RMC		VTG/RMC

Table 3 – Output data sentences – IEC 61162-1/IEC 61162-2 where available

	Class A		Class B	
	With RP	No RP	With RP	No RP
Target data	TTM		TTM	
System data	RSD	RSD	RSD	RSD

4.28.2 Input sensor failure

The radar shall provide an indication when an intended input from an external sensor is not available or is invalid. The manufacturer shall provide details of the functions that are dependent on any sensor.

4.28.3 AIS input interface

An interface for input of data for the display of AIS symbology may be provided according to IEC 61162. If provided AIS symbology shall be in accordance with IEC PAS 60936-5 and IMO SN Circ 217 Interim guidelines for the presentation and display of AIS target information or any current relevant document.

4.28.4 Radar output interface standards

If any radar serial outputs are provided, they shall be in accordance with international standards (IEC 61162 series). In addition, other suitable interfaces are permitted.

4.29 Navigational information

4.29.1 Radar mapping

The radar display may be capable of presenting positions, navigational lines and maps in graphical form (see Annex C). Where these facilities are provided, details shall be described in the manufacturer's documentation.

4.29.2 Radar plotting

Plotting facilities Automatic Tracking Device (ATD) and/or Electronic Plotting Device (EPD) are optional but where provided, they shall comply with the "requirements, tests and required results", as in Annex F and/or Annex G respectively.

NOTE Annex F is based on IEC 60872-2 Automatic Tracking Aid (ATA) and Annex G is based on IEC 60872-3 Electronic Plotting Aid (EPA).

4.29.3 Connected sensors

Details of all sensors/sensor interfaces, capable of being used for the radar plotting functions to this standard, shall be detailed within the manufacturer's documentation.

4.30 Ergonomics

4.30.1 Independent controls

For the purposes of this standard the following functions shall be directly accessible by an independent control(s) or via a first level menu for class A (and not below a second level menu for class B and C) and available for immediate use:

On/off switch	Gain
Standby	Brightness

Anti-clutter sea	Variable range marker
Tuning (if manual)	Marker (cursor)
Range selection	Acknowledge alarm
Electronic bearing line	

and where provided or applicable;

Contrast	Presentation mode
Anti-clutter rain	Vector true/relative
Pulse length	Dimmer for panel illumination

NOTE EBL and VRM controls may be combined.

Inappropriate pulse lengths shall be either inhibited or clearly indicated.

These functions may be executed by alternative solutions that meet the functional requirements.

4.30.2 Functional controls

For the purpose of this standard, the following functions shall be directly accessible and immediately effective:

Range selection	Anti-clutter sea (class C optional)
Tuning (if manual) (classes B and C optional)	Variable range marker (class C optional)
Anti-clutter rain (classes B and C optional)	Marker (cursor)
Electronic bearing line (class C optional)	On /off
Standby	Gain

4.30.3 Visibility of setting

The settings of the following shall be visible in all light conditions class A (and class B) (class C optional):

Tuning (if manual)	Gain
Anti-clutter rain	Anti-clutter sea

The control of the dimmer and monitor brilliance may be located and adjusted by tactile (feel or touch) means.

4.30.4 Automatic adjustment

For the following functions, automatic adjustment may be provided:

Tuning	Gain
Anti-clutter rain	Anti-clutter sea

Where manual and automatic adjustment is available, the use of the automatic mode shall be indicated and capable of being switched off.

4.30.5 EBL and VRM controls

If discrete controls are available for the EBL and VRM, they shall be situated on the left-hand side and right hand side respectively. (classes B and C optional)

If EBL and VRM control functions are combined there shall be a clear indication of which function is selected.

4.31 Display of information

A clear and logical arrangement of data fields shall be provided. Overlaying of the data fields is permitted providing that the original data field remains available for re-display on demand.

4.32 Safety precautions

4.32.1 RF radiation

During normal operation, radiation from the antenna shall be possible only when the beam is scanning. The maximum distances from the antenna at which radio-frequency radiation levels of 100 W/m^2 and 10 W/m^2 can be expected shall be included in the equipment handbook.

NOTE An override facility to stop the antenna while radiation continues may be provided for maintenance purposes only.

4.32.2 Working at the antenna

Means shall be provided to prevent the turning of open array scanners for maintenance and other purposes.

4.33 Spurious/unwanted frequency emissions (Annex D)

The spurious/unwanted emissions shall meet the ITU requirements and be tested in accordance with Annex D.

5 Methods of test and required test result

General

This clause defines test methods and required results to ensure that the radar equipment complies with the requirements of Clause 4.

General conditions of measurement

The relevant requirements of Annex E according to the EUT's class and category, i.e. 'protected' (from the weather) or 'exposed' (to the weather) shall be carried out on the sample equipment under test (EUT) to verify whether the EUT meets these technical requirements.

NOTE Annex E is based on IEC 60945.

The manufacturer shall declare which equipment or units are 'protected', 'exposed' or 'antenna system'. The manufacturer shall declare the 'preconditioning' required before environmental checks.

Where test requirements are given in a non-quantitative manner, the results shall be the aggregate obtained over a number of observations.

All performance tests shall be carried out under normal environmental conditions unless otherwise specified.

Test sites

Performance tests shall be carried out at a test site that can present an over water test range containing the test targets and features needed for the specified tests. Operational, environmental and other checks or tests may be carried out at alternative sites. The manufacturer shall, unless otherwise agreed, set up the equipment and ensure that it is operating normally before type testing commences.

Height of radar antenna

During all appropriate tests, the radar antenna shall be mounted at a height of about 7,5 m above the surface of the water.

Test targets for range performance

For range performance tests the effective echoing area of the test target, height and distance may be adjusted in accordance with the methods given in Annex A.

Sea state

Range performance measurements shall be conducted using a test target in a calm sea (sea states 0 or 1). Measurements may be taken in other sea states, but in case of conflict, measurements taken at sea states 0 or 1 shall take precedence.

Radio-frequency

Where tests relating to the radio-frequency are specified, these shall be carried out only at the nominal operating radio-frequency of the equipment unless specified otherwise.

Power supply, cabling distances and technical information

The supply voltage applied to the equipment during the tests shall be the nominal voltage; a.c. supplies shall be at their nominal frequency unless specified otherwise.

Antenna/RF head feeder length

When equipment with separated RF head (transmitter/receiver) and antenna is tested in accordance with this standard, the RF head shall be connected to the antenna by a feeder of the length as specified by the manufacturer.

The manufacturer shall supply the appropriate cable and antenna feeder.

The manufacturer shall define the maximum and minimum distances by which units of the equipment must be separated in order to comply with the requirements of this standard. The actual distances and the lengths of cable used shall be recorded in the test report.

5.1 Radar indication

Check that the EUT paints the radar target echo of all objects in view within the allowable tolerances.

5.1.1 Method of test

Set up the EUT where several target types are present and check that these targets are detected and presented on the radar display (4.1).

5.1.2 Result required

Confirm that the requirement is met.

5.2 Safety of options

Check that manufacturer's declared options do not degrade the radar performance (4.2).

5.2.1 Method of test

Repeat the test in 5.1 with all options incorporated.

5.2.2 Result required

Confirm that the requirement is met.

5.3 Technical information

5.3.1 Method of test

By inspection (4.3).

5.3.2 Result required

Confirm that the requirement is met.

5.4 Quality assurance

5.4.1 Method of test

Check in accordance with the requirements. (4.4)

5.4.2 Result required

Confirm that the requirement is met.

5.5 Radio-frequency spectrum requirements

During testing for the requirements defined in Annex D, a record shall be made of the transmitted radio-frequency of the EUT. (4.5)

5.5.1 Method of test

Inspect the manufacturer's documentation.

5.5.2 Result required

Confirm that the documentation includes a result of the transmitted radio-frequency and that it complies with the limits shown in Annex D for the appropriate allocated band.

5.6 Range

Set the tune, gain and clutter controls of the radar so that the reference target echo paints 8 or more out of 10 radar scans. (4.6)

5.6.1 Detection of test-coastlines

Confirm the detection and display of coastlines. (4.6.1)

5.6.1.1 Method of test

With the EUT operating at the correct distance from a suitable coastline ensure that the target echoes are painted for coastlines as specified in 4.6.1.

5.6.1.2 Results required

The EUT paints target echoes for coastlines.

5.6.2 Detection of surface objects

Confirm the detection of surface objects (4.6.2).

5.6.2.1 Method of test

Set up one of the test target as specified in 4.6.2.

5.6.2.2 Results required

The EUT paints target echoes for the test target.

5.6.3 Minimum range

5.6.3.1 Method of test

Place a test target at 0,5 nautical miles approximately, and then reduce the distance between the radar antenna and the test target. (4.6.3)

a) Record on the test report the distance at which the test-target echo ceases to be presented separately from the antenna position (main bang) on the display. For this measurement, only the range, sea and gain controls may be adjusted.
b) Without any further adjustments of sea or gain controls, increase the distance between the test target and the antenna up to 1 nautical mile.

5.6.3.2 Results required

a) The minimum range shall be 50 m for class A, (60 m for class B) and (75 m for class C) or less measured horizontally.
b) The test target return remains visible from the minimum-recorded range up to 1 nautical mile.

5.7 Display

5.7.1 Display size

5.7.1.1 Method of test

Measure the linear effective diameter of the display area with a rigid ruler. Visually inspect the range scales and number of range rings provided on each scale while the equipment is operating. (4.7.1)

5.7.1.2 Result required

The size of the screen meets the requirement for each class; not less than 150 mm for class A (85 mm for class B) (75 mm for class C) and the range scales/rings comply with the requirement.

5.7.2 Standard ranges

5.7.2.1 Method of test

By measurement and inspection. (4.7.2)

5.7.2.2 Results required

Confirm that the requirement is met.

5.7.3 Additional range scales

Check that if any additional range scale is provided the requirement is met. (4.7.3)

5.7.3.1 Method of test

By inspection.

5.7.3.2 Results required

Confirm that the requirement is met.

5.7.4 Additional range units

Check that the selection of alternative range units can only be carried out in the standby mode and the relationship between the standard range units and the alternative range units is maintained as detailed in the requirement. (4.7.4)

5.7.4.1 Method of test

By inspection.

5.7.4.2 Result required

Confirm that the requirement is met.

5.7.5 Displayed range scales

Check that the range scale in use and the distance between range rings is clearly indicated. (4.7.5)

5.7.5.1 Method of test

By inspection.

5.7.5.2 Result required

Confirm that the requirement is met.

5.7.6 Displayed information

5.7.6.1 Method of test

a) Check that the displayed information meets the requirement. (4.7.6)

b) Display a user menu and take no further action. Ensure that the display reverts to normal radar/RP mode within 10 s.

5.7.6.2 Result required

a) Confirm that the requirement is met.

b) Confirm that the requirement is met.

5.7.7 Radar video origin

5.7.7.1 Method of test

Check that the radar video origin starts at own ship, is linear and is not delayed. (4.7.7)

5.7.7.2 Results required

Confirm that the requirement is met.

5.7.8 Zoom function

5.7.8.1 Method of test

If a zoom function is provided, check that the radar origin cannot be moved outside the radar effective area. Check that the resultant zoom image is 2x the original and the spacing of the range rings is equal. Check that an indication of zoom is provided and the associated scale is half of the original, prior to zoom. (4.7.8)

5.7.8.2 Result required

Confirm that the requirement is met.

5.7.9 Display colour presentation

5.7.9.1 Method of test

By inspection. (4.7.9)

5.7.9.2 Result required

Confirm that the requirement is met.

5.7.10 Display view under various light conditions

5.7.10.1 Method of test

By inspection. (4.7.10)

5.7.10.2 Result required

Confirm that the requirement is met.

5.8 Frequency band

5.8.1 Method of test

By inspection. (4.8)

5.8.2 Results required

Confirm that the requirement is met.

5.9 Range markers

5.9.1 Fixed range rings

5.9.1.1 Method of test

Check that the requirement is met for the class under examination (4.9.1):

a) check that the range rings are equally spaced;

b) exercise the ranges of the EUT and check that at least two and not more than six range rings are displayed;

c) if off-centre facility is available, check that additional range rings are provided and meet the requirement;

d) if a zoom function facility is provided, check that, if a different number of range rings are provided, they meet the requirement.

5.9.1.2 Results required

a) Confirm that the requirement is met.

b) Confirm that the requirement is met.

c) Confirm that the requirement is met.

d) Confirm that the requirement is met.

5.9.2 Range ring thickness

5.9.2.1 Method of test

By inspection. (4.9.2)

5.9.2.2 Results required

Confirm that the requirement is met.

5.9.3 Variable range marker

5.9.3.1 Method of test

By inspection. (4.9.3)

5.9.3.2 Results required

Confirm that the requirements are met.

5.9.4 VRM thickness

5.9.4.1 Method of test

By inspection. (4.9.4)

5.9.4.2 Results required

Confirm that the requirement is met.

5.9.5 Time to set VRM

5.9.5.1 Method of test

A known target shall be placed at approximately 75 % of the selected range scale and at relative bearing of 90°. A range measurement shall be taken, using the variable range marker starting at the radar origin, or by using other means as appropriate. (4.9.5)

5.9.5.2 Results required

A range measurement with a precision of ±2 % of the range scale in use shall be capable of being taken within 10 s of switching on a VRM.

5.9.6 Fixed range rings and VRM accuracy when off-centred

5.9.6.1 Method of test

Off-centre the display and check that the accuracy of the range rings is maintained. (4.9.6)

5.9.6.2 Results required

Confirm that the requirement is met.

5.9.7 Fixed range ring and VRM display

5.9.7.1 Method of test

Check that the fixed range rings and VRM can be independently and completely removed from the display. (4.9.7)

5.9.7.2 Results required

Confirm that the requirement is met.

5.10 Range measurement using range rings and VRM

5.10.1 Method of test

Using the ‘standard operating mode’, measure the accuracy of the range rings and VRM using known targets echoes or other means as appropriate. Check, at least one known target echo on each range scale up to 12 nautical miles. (4.10)

5.10.2 Results required

Confirm that the requirement is met.

5.11 Heading line

5.11.1 Heading line indication

5.11.1.1 Method of test

Check the requirements for the heading indication by inspection. (4.11.1)

5.11.1.2 Result required

Confirm that the requirement is met.

5.11.2 Heading line thickness

5.11.2.1 Method of test

Check that the requirement is met. (4.11.2)

5.11.2.2 Results required

Confirm that the requirement is met.

5.11.3 Heading line origin

5.11.3.1 Method of test

By inspection. (4.11.3)

5.11.3.2 Results required

Confirm that the requirement is met.

5.11.4 Heading line bearing scale

5.11.4.1 Method of test

By inspection. (4.11.4)

5.11.4.2 Results required

Confirm that the requirement is met.

5.11.5 Heading line off facility

5.11.5.1 Method of test

Operate heading line off, hold and release. (4.11.5)

5.11.5.2 Result required

The heading line is removed from the display during the time that the heading line off operation is held and returns when heading line off operation is released.

5.12 Electronic bearing line (EBL)

5.12.1 EBL indication

5.12.1.1 Method of test

By inspection. (4.12.1)

5.12.1.2 Result required

Confirm that the requirement is met.

5.12.2 EBL rotation

5.12.2.1 Method of test

Rotate the EBL in both directions using the control provided. (4.12.2)

5.12.2.2 Results required

Confirm that the requirement is met.

5.12.3 EBL display

5.12.3.1 Method of test

Check that the EBL can be completely removed from the display. (4.12.3)

5.12.3.2 Results required

Confirm that the requirement is met.

5.12.4 Time to set EBL

5.12.4.1 Method of test

Switch on the EBL and simultaneously start a timer, obtain the bearing of a target. (4.12.4)

5.12.4.2 Result required

The bearing of a target can be obtained within 10 s.

5.12.5 EBL read-out

5.12.5.1 Method of test

By inspection. (4.12.5)

5.12.5.2 Result required

Confirm that the requirements are met.

5.12.6 EBL measurement accuracy

5.12.6.1 Method of test

With the display centred, align the EBL with at least 12 equally spaced bearing marks in 360° and ensure that the EBL read-out indicates the same angle as the corresponding bearing mark. (4.12.6)

5.12.6.2 Result required

Confirm that the requirement is met.

5.12.7 EBL origin shift

5.12.7.1 Method of test

Check that the EBL origin can be moved away from own ship, returned to origin by a fast simple operator action and that a VRM mark can be applied to the EBL. (4.12.7)

5.12.7.2 Required result

Confirm that the requirements are met.

5.12.8 Additional EBLs

5.12.8.1 Method of test

Check that any EBL provided meets the requirements of 4.12.2 through to 4.12.7 and that separate identifiable read-outs are provided. (4.12.8)

5.12.8.2 Results required

Confirm that the requirements are met.

5.13 Bearing scale

5.13.1 Linear or non linear bearing scale

5.13.1.1 Method of test

By inspection. (4.13.1)

5.13.1.2 Results required

Confirm that the requirement is met.

5.13.2 Minimum division marks around bearing scale

5.13.2.1 Method of test

By inspection. (4.13.2)

5.13.2.2 Results required

Confirm that the requirement is met.

5.13.3 Labelling of bearing scale division marks

5.13.3.1 Method of test

By inspection. (4.13.3)

5.13.3.2 Results required

Confirm that the requirement is met.

5.13.4 Bearing measurement using EBL

5.13.4.1 Method of test

Using the ‘standard operating mode’, with own ship at zero. Compare the overall accuracy of bearings taken by the radar equipment with the known bearings of identifiable point targets. (4.13.4)

Mount the antenna unit on a rotating table and using the EBL, with reference to the heading line, measure the bearing of a known identifiable point target, then rotate the table clockwise by 30°. Re-measure the bearing of the same identifiable point target and ensure that the EBL bearing measurement matches the angular movement of the antenna unit. Repeat this test by progressively moving the table by 30° until the antenna unit has been fully rotated back to the original orientation. Repeat this test rotating the table in the counter clockwise direction.

Repeat the above test at any one position with reference to North in the stabilized mode, if provided.

Alternative equivalent methods of testing may be used.

5.13.4.2 Results required

Confirm that the requirements are met.

5.14 Discrimination

5.14.1 Range

5.14.1.1 Method of test

Place two equivalent test targets with a radar cross-section of 10 m^2 at 3,5 m height, on the same bearing with respect to the radar antenna. The two test targets are to be placed at a range of between 0,375 nautical miles and 0,75 nautical miles and separated from each other by a distance of not more than 60 m class A, (60 m class B) and (75 m class C). Set the radar to a range scale of 0,75 nautical miles, set the effective pulse length of the range scale in use and the rain control (where available) to their minimum values. Adjust the sea clutter (where possible) and gain control so that the two target echoes are displayed separately for at least 8 out of 10 antenna scans. (4.14.1)

5.14.1.2 Results required

The two test target echoes are displayed separately and the recorded separation distance of the two targets is included in the test report.

5.14.2 Off-centred display

5.14.2.1 Method of test

With the display off-centred repeat the test as detailed in 5.14.1. (4.14.2)

5.14.2.2 Results required

Confirm that the two test target echoes are displayed separately and the recorded separation distance of the two targets is included in the test report.

5.14.3 Bearing

5.14.3.1 Method of test

Make the following measurements at display inter-cardinal points ±5° i.e. 40° to 50°, 130° to 140° etc. (4.14.3)

Place two equivalent test targets with a radar cross-section of 10 m^2 at a height of 3,5 m and at the same range, between 0,5 nautical miles and 0,75 nautical miles, with respect to the radar antenna. These test targets are to be separated from each other in bearing by 4,5° class A (6° class B) (8° class C).

Set the radar to a range scale of 0,75 nautical miles, set the effective pulse length of the range scale in use and the rain control (where available) to their minimum values. Adjust the sea clutter (where possible) and gain control such that the two target echoes are displayed separately for at least 8 out of 10 antenna scans. Decrease the angular separation between the two targets until they cease to be displayed separately. Measure the linear distance between the two targets and calculate the angle with respect to the known range of the test targets.

Alternative methods of testing may be used.

5.14.3.2 Results required

Measure and record the angular separation at which the targets cease to be displayed separately. The angle of separation meets the requirement.

5.15 Antenna radiation pattern

5.15.1 Antenna horizontal radiation pattern

Is defined as a graph to show the relative response of the antenna plotted against angular displacement in the horizontal plane.

5.15.1.1 Method of test

Examine the polar diagram provided by the manufacturer. The polar diagram contents shall be from direct measurements in the far field region at the nominal operating radio-frequency of the equipment.

The far field distance (D) value must be calculated for the antenna length (L) under test as per the following equation (all in SI units):

$$D \geq 2L^2 / \lambda$$

Alternative test method using the near field region (from 3λ to $2L^2 / \lambda$) for meeting these requirements may be demonstrated by submission of the measurements and of the processing methods for achieving the required results.

Measurement method in the Evanescent region ($< 3\lambda$) shall not be used.

Table 4 – 3 dB points for main beam

Class of radar	Position relative to maximum of main beam (X-band) degrees	Position relative to maximum of main beam (S-band) degrees
A	4,0	4,0
B	5,5	4,0
C	7,5	4,0

5.15.1.2 Results required

Confirm that the limits defined in Table 4 are met.

5.15.2 Antenna side-lobes

Antenna horizontal radiation pattern: Is defined as a graph to show the relative response of the antenna plotted against angular displacement in the horizontal plane. (4.15.2)

5.15.2.1 Method of test

Examine the polar diagram provided by the manufacturer. The polar diagram contents shall be from direct measurements in the far field region at the nominal operating radio-frequency of the equipment.

The far field distance (D) value shall be calculated for the antenna length (L) under test as per the following equation (all in SI units):

$$D \geq 2L^2 / \lambda$$

Alternative test method using the near field region (from 3λ to $2L^2/\lambda$) of meeting these requirements may be demonstrated by submission of the measurements and of the processing methods for achieving the required results.

Measurement method in the Evanescent region ($< 3\lambda$) may not be used.

5.15.2.2 Results required

Confirm that the effective side-lobe parameters meet the values shown in Table 5.

Table 5 – Effective side-lobes

Class of radar	Position relative to maximum of main beam degrees	Maximum power relative to maximum of main beam dB
A	Within ± 10	–20
	Outside ± 10	–23
B	Within ± 10	–18
	Outside ± 10	–19
C	Within ± 10	–18
	Outside ± 10	–19

5.16 Roll or pitch performance

Determine the vertical radiation pattern. (4.16)

5.16.1 Method of test

Tilt the antenna both up and down by 10°. Verify that the test target detailed in 4.6.1 and 4.6.2 continues to present a clear indication.

Alternative testing methods may be used.

5.16.2 Results required

Confirm that the requirements 4.6.1 and 4.6.2 continue to be met.

5.17 Antenna scan

5.17.1 Antenna rotation

5.17.1.1 Method of test – Open array type antenna

Place the EUT rotating open arrays antenna/pedestal combinations in a wind tunnel capable of producing an air stream of up to 60 knots (31 m/s). Alternative approved methods may be used. Provide the antenna motor with a power source at its nominal voltage and frequency. (4.17.1)

a) Ensure the antenna rotates continuously and clockwise as viewed from above through 360° of azimuth.

b) Ensure the antenna rotation rate is not less than 20 rpm.

c) The equipment starts and operates satisfactorily in relative wind speeds of up to 60 knots.

Alternative methods of scanning are permitted, if adopted, ensure that the performance is not inferior to that of a rotating scanner.

5.17.1.2 Required results – Open array type antenna

a) Confirm the scanner rotates continuously in a clockwise direction as viewed from above through 360° of azimuth.

b) Confirm the antenna rotation rate is not less than 20 rpm.

c) Confirm the equipment starts and operates satisfactorily in relative wind speeds of up to 60 knots.

If alternative methods of scanning are used confirm that the performance is not inferior to that of a rotating scanner.

5.17.1.3 Method of test – Radom enclosed type array antenna

Provide the antenna motor with a power source at its nominal voltage and frequency. (4.17.1)

a) Ensure the antenna rotates continuously and clockwise as viewed from above through 360° of azimuth.

b) Ensure the antenna rotation rate is not less than 20 rpm.

Alternative methods of scanning are permitted, if adopted, ensure that the performance is not inferior to that of a rotating scanner.

5.17.1.4 Required results – Radom enclosed type array antenna

a) Confirm the scanner rotates continuously in a clockwise direction as viewed from above through 360° of azimuth.

b) Confirm the antenna rotation rate is not less than 20 rpm.

If alternative methods of scanning are used confirm that the performance is not inferior to that of a rotating scanner.

5.17.2 Sector blanking

5.17.2.1 Method of test

If a sector blanking facility is provided, blank sector or sectors shall be checked to confirm that they are clearly identifiable on the display. (4.18.2)

5.17.2.2 Result required

Confirm that the requirements are met.

5.18 Modes

Check by inspection during operation of the equipment. (4.18)

Exercise the display modes described in the requirement by use of THD/compass and speed log simulators. If provided, the manual input of speed, set and drift are also to be verified.

NOTE Simulator signals should be in accordance with IEC 61162. Where proprietary interfaces are used the manufacturer is to provide alternative means for testing.

5.18.1 Head-up mode

5.18.1.1 Method of test

Check the radar operates in the head-up mode. (4.18.1)

5.18.1.2 Results required

Confirm that the requirement is met.

5.18.2 Azimuth stabilization -optional

5.18.2.1 Method of test

Where applicable, connect the output from an HSD or HSD simulator in compliance with the manufacturer's standards to the radar. Check that the HSD information is provided. (4.18.2)

Change from one presentation mode to another (e.g. north-up to head-up). Check that an accuracy of 2,0° within 5 s is achieved.

5.18.2.2 Results required

Confirm that the requirements are met.

5.18.3 Automatic reversion to head-up mode

5.18.3.1 Method of test

Where applicable, with the radar working in a stabilized mode remove the HSD input, simultaneously start a timing device and observe the display. (4.18.3)

5.18.3.2 Result required

The display reverts to head-up unstabilized mode within 1 min and the appropriate alarm is initiated within 5 s of azimuth stabilization failure.

5.18.4 Azimuth stabilization where no heading sensor is available

5.18.4.1 Method of test

Where applicable, ensure that azimuth selection is not possible. (4.18.4)

5.18.4.2 Result required

Confirm that the requirement is met.

5.18.5 Display mode indication

5.18.5.1 Method of test

By inspection, where applicable. (4.18.5)

5.18.5.2 Results required

Confirm that the requirement is met.

5.18.6 Display mode changeover

5.18.6.1 Method of test

Where applicable, with the radar working in any display mode, change the mode and measure the time for the changeover. (4.18.6)

5.18.6.2 Results required

Confirm that the change from one display mode to another occurs within 15 s and that a bearing display accuracy of 2° is achieved.

5.18.7 Relative motion mode

5.18.7.1 Method of test

By inspection. (4.18.7)

5.18.7.2 Result required

Confirm that the requirement is met.

5.18.8 True motion mode (option)

5.18.8.1 Method of test

By inspection. (4.18.8)

5.18.8.2 Result required

Confirm that the requirement is met.

5.18.9 Origin offset

5.18.9.1 Method of test

By inspection. (4.18.9)

5.18.9.2 Result required

Confirm that the requirement is met.

5.18.10 Stabilization indication

5.18.10.1 Method of test

By inspection. (4.18.10)

5.18.10.2 Result required

Confirm that the requirement is met.

5.19 Tuning indication

5.19.1 Method of test

By inspection. (4.19)

5.19.2 Results required

Confirm that the requirement is met.

5.20 Anti-clutter devices

5.20.1 Clutter suppression

5.20.1.1 Method of test

Check by inspection the requirements for anti-clutter and anti-interference devices during operation of the equipment. If an optional automatic device is provided, check both manual and automatic functions. (4.20.1)

5.20.1.2 Results required

Confirm that the requirement is met.

5.20.2 Clutter controls

5.20.2.1 Method of test

The documentation shall be checked to show that adequate explanation of the controls is included. (4.20.2)

With manual clutter function selected, adjust the manual control to confirm that it is operational.

Where provided, exercise the automatic function and ensure that it is operational.

5.20.2.2 Results required

Confirm that the requirement is met.

5.21 Range performance in clutter

With a test target of 200 m^2, (400 m^2 for class B and class C) (at X band) set at 3,5 m height and with the radar antenna at a height of 7,5 m operate the radar in the presence of sea clutter. (4.21)

NOTE The reduced radar cross-section at S-band is offset by a corresponding reduction in clutter.

5.21.1 Range performance using manual anti-clutter

5.21.1.1 Method of test

a) Observe that the clutter field extends to at least 1 nautical mile for X-band (0,5 nautical miles for S-band).
b) Ensure that the target within the clutter field is initially obscured with the anti-clutter control off.
c) Adjust the anti-clutter control to obtain a target echo for at least 5 out of 10 radar scans.
d) Repeat for the target set at three different distances from the antenna, approximately equally spread between 100 m and the extent of the clutter field, which may be up to a maximum of 2,0 nautical miles.

5.21.1.2 Results required

Check that the test target is present for at least 5 out of 10 radar scans.

5.21.2 Range performance using automatic anti-clutter

5.21.2.1 Method of test

Repeat the tests as detailed in 5.21.1.1 with automatic anti-clutter in operation considering the limitations explained in the manufacturer's documentation also for (class B).

(Class C) For the test as detailed in 5.21.1.1 d) ensure that the anti-clutter operates at a distance of 0,25 nautical miles.

5.21.2.2 Results required

Confirm that the requirement is met.

5.22 Operation

5.22.1 Language

5.22.1.1 Method of test

Check the manufacturer's documentation and user menus are presented in English as a minimum. (4.22.1)

If provided, check that during the equipment initialisation a change of language or script option is accessible and that this facility is only available on switch on.

Warning operation of this facility should only be activated if the operator understands the new language or script to be selected.

5.22.1.2 Results required

Confirm that the requirement is met.

5.22.2 Availability

5.22.2.1 Method of test – availability

Pre-condition the radar system by disconnection from the power source for at least 1 h. (4.22.2)

a) Reconnect to a power source and switch on, simultaneously start a timing device such as a stopwatch. As soon as available set the radar to transmit mode. Stop the timing device when the full display of a radar picture is achieved and observe the elapsed time.
b) Following a period of being in the transmit mode, set the radar to the standby mode for at least 2 min. Set the radar to transmit and simultaneously start the timing device. When full presentation of the radar picture is resumed, stop the timing device and observe the elapsed time.

5.22.2.2 Results required

a) Confirm the equipment is fully operational from cold within 4 min.
b) Confirm the equipment is fully operational from standby within 15 s.

5.23 Controls

5.23.1 Method of test

Check the requirements by inspection. Operate control functions during the testing of the equipment. (4.23)

5.23.2 Results required

Confirm that the requirement is met.

5.24 Manual speed set and drift

5.24.1 Manual speed input

5.24.1.1 Method of test

Using the manual speed control, set up a speed input and check that the radar follows the input. (4.24.1).

5.24.1.2 Results required

Confirm that the requirement is met.

5.24.2 Manual set and drift input

5.24.2.1 Method of test

Using the manual set and drift control, set up an input and check that the radar follows the input. (4.24.2)

5.24.2.2 Results required

Confirm that the requirement is met.

5.25 Interference from external magnetic fields

5.25.1 Method of test

Check the requirements, as far as practicable, by visual inspection, during operation of the equipment. (4.25)

5.25.2 Results required

Confirm that the requirements and the bearing accuracy of the equipment, as prescribed in the requirements are maintained without further adjustment, irrespective of the movement of the equipment in the earth's magnetic field.

5.26 Radar installation

5.26.1 Method of test

Check that the manufacturer’s documentation includes installation guidelines. (4.26)

5.26.2 Results required

Confirm that installation guidance is given in the manufacturer’s documentation.

5.27 Failure warnings (alarms) and status indications

5.27.1 Signal failures

5.27.1.1 Method of test

a) Simulate a failure of any of the following signals (4.27.1):
   – raw radar video;
   – trigger;

– heading line.

b) Simulate a failure of data from the following connected/functioning sensors:

– azimuth (where provided);

– other configured sensors (where provided).

5.27.1.2 Results required

Ensure an alarm is activated in line with the requirement.

5.27.2 Radar picture update failure

5.27.2.1 Method of test

Reproduce the failures defined in the requirement. Observe the “alarm” display and note any audible alarms. Ensure that one or more moving targets are displayed during these tests and their motion is confirmed after each test. (4.27.2)

5.27.2.2 Required result

Confirm that appropriate indications are given.

5.27.3 Input sensor failure

5.27.3.1 Method of test

Remove any connected sensor input. (4.27.3)

5.27.3.2 Required result

Ensure that an indication occurs within 1 min and that any function reliant on the disconnected input is inhibited.

5.27.4 Alarm acknowledgement

5.27.4.1 Method of test

Ensure that a means for acknowledging alarms is provided. (4.27.4)

5.27.4.2 Result required

Confirm that the requirement is met.

5.28 Interfacing

5.28.1 Radar input interface

Simulate the input signals on the IEC 61162 interface where available or other suitable interface from gyrocompass, SDME and EPFS, and if appropriate AIS equipment using HDT for gyrocompass, VBW for SDME and GLL, GLC for position. The manufacturer will either provide simulators for alternative or additional proprietary interfaces or confirm that these do not degrade the performance of the radar (see 4.2). (4.28.1)

5.28.1.1 Method of test

Check that any interfaces provided meet the requirement and that the source identification is capable of being displayed. (4.28.1)

5.28.1.2 Results required

Confirm that the requirement is met.

5.28.2 Input sensor failure

5.28.2.1 Method of test

Connect an appropriate simulator to the interface of the radar and check the following error scenarios:

a) invalidation of sensor data;

b) change mode of operation as available (e.g. change from DGPS to GPS);

c) simulate a break of the interconnection or turn off the sensor. Check the manufacturer's documentation for details;

d) switch off the equipment, disconnect the simulator and restart the equipment.

5.28.2.2 Required result

a) Confirm that the status change is indicated within 1 min.

b) Confirm that the status change is indicated within 1 min and note availability of the different modes of operation.

c) Confirm that an alarm is generated within 1 min and that any function reliant on the disconnected input is inhibited. Confirm the manufacturer's documentation includes details.

d) Ensure that any function reliant on the disconnected input is inhibited.

5.28.3 AIS input interface

5.28.3.1 Method of test

Check by inspection. (4.28.3)

5.28.3.2 Results required

Confirm that the requirement is met.

5.28.4 Radar output interface standards

5.28.4.1 Method of test

Any IEC 61162 outputs provided are to be connected via an interface cable that gives the correct electrical loading, to a computer capable of displaying these digital messages. (4.28.4)

Check the IEC 61162 messages, including status information.

5.28.4.2 Results required

Confirm that the message content meets the approved sentence formats appropriate to a radar device.

5.29 Navigational information

5.29.1 Radar mapping

Where the facilities are provided details shall be described in the manufacturer's documentation. Tests of all declared functions are to be carried out. (see Annex C) (4.29).

5.29.1.1 Method of test

a) Generate and install two radar maps in compliance with the manufacturer's documentation, each utilising at least three waypoints visible on the current range scale. One map to be in an area that includes the equator and the 000° meridian, the other in an area that includes the equator and the 180° meridian.
b) Apply methods of "geographic referencing" with clear indications and check display.
c) Check that the loss of "geographic referencing" results in an appropriate alarm and indication.
d) Check that any other feature declared in the manufacturer's documentation is available.
e) Check by inserting a test shape using the manufacturer's mapping facilities (as described in the manual) and subsequent measurements on all appropriate ranges.

5.29.1.2 Results required

a) Confirm that the waypoints and the routes appear in the correct positions.
b) Confirm that the methods of "geographic referencing" are clearly indicated.
c) Confirm that a loss of "geographic referencing" results in an appropriate alarm and indication.
d) Confirm that any other feature described in the manufacturer's documentation operates as described.
e) Confirm that test shapes are reproduced and the requirements are met.

5.29.2 Radar plotting

The manufacturer shall declare for which types of plotting facilities the equipment is designed. (4.29.2)

5.29.2.1 Method of test

Refer to Annex F for ATD and Annex G for EPD.

5.29.2.2 Results required

Confirm that the requirements of the appropriate annex(es)s is/are met.

5.29.3 Connected sensors

5.29.3.1 Method of test

By inspection of the manufacturer's documentation.

5.29.3.2 Results required

Confirm that the requirement is met.

5.30 Ergonomics

5.30.1 Independent controls

5.30.1.1 Method of test

By inspection. (4.30.1)

5.30.1.2 Results required

Confirm that the requirement is met.

5.30.2 Functional controls

5.30.2.1 Method of test

With the EUT operational, check the functions and controls. (4.30.2)

5.30.2.2 Results required

Confirm that the requirement is met.

5.30.3 Visibility of settings

5.30.3.1 Method of test

By inspection. (4.30.3)

5.30.3.2 Results required

Confirm that the requirement is met.

5.30.4 Automatic adjustment

5.30.4.1 Method of test

By inspection. (4.30.4)

5.30.4.2 Results required

Confirm that the requirement is met.

5.30.5 EBL and VRM controls

5.30.5.1 Method of test

By inspection. (4.30.5)

5.30.5.2 Results required

Confirm that the requirement is met.

5.31 Display of information

5.31.1 Method of test

By inspection. (4.31)

5.31.2 Results required

Confirm that the requirement is met.

5.32 Safety precautions

5.32.1 RF radiation

5.32.1.1 Method of test

Stop the antenna rotating and ensure that no radiation is transmitted. (4.32.1)

NOTE An override facility to stop the antenna while radiation continues is permitted for maintenance purposes only.

Check the manufacturer's documentation for power density/distance.

5.32.1.2 Results required

Ensure that there is no radiated transmission with the antenna stopped.

Ensure that the following information is included in the manufacturer's documentation:

a) the maximum distance from the scanner where a power density of 100 W/m^2 is exceeded;

b) the maximum distance where one tenth of the above power density is measured.

5.32.2 Working at the antenna

5.32.2.1 Method of test

Operate the provided facility to prevent the antenna turning. (4.32.2)

5.32.2.2 Results required

Confirm that the requirement is met.

5.33 Spurious/unwanted frequency emissions

5.33.1 Method of test

Inspect the recorded test results in accordance with Annex D provided by the manufacturer. (4.33)

5.33.2 Results required

A copy of the resultant tests shall be provided showing compliance with the requirements in Annex D.

Annex A
(normative)

Method for relating the radar cross-section (echoing area) of one radar target with another

A.1 Effect of a change of target size

Where a target of radar cross-section or "echoing area" σ_1 is substituted for σ_2 in the same circumstances, the corresponding change in power from p_2 to p_1 received back at the radar is given by

$$p_1/p_2 = \sigma_1/\sigma_2 \quad \text{(A.1)}$$

Hence $$10 \log (p_1/p_2) = 10 \log (\sigma_1/\sigma_2) \text{ dB} \quad \text{(A.2)}$$

Example 1: When a 30 m^2 radar reflector is substituted for one of 10 m^2, the change in power received back at the radar will be:

$$10 \log (30/10) = 4{,}8 \text{ dB}$$

A.2 Effect of a change of distance ("range")

Apart from other possible effects described in subsequent clauses, the relationship between power p_1 reflected back from a target at distance d_1, and power p_2 reflected back from the same target at distance d_2, is given by the inverse fourth power law as:

$$\frac{p_2}{p_1} = \frac{{d_1}^4}{{d_2}^4} \quad \text{(A.3)}$$

In decibels, equation (A.3) becomes: $10 \log (p_2/p_1) = -40 \log (d_2/d_1)$ dB (A.4)

Example 2: A change of distance from 2 nautical miles to 3 nautical miles will give, apart from other possible changes described below, a power change of

$$-40 \log (3/2) = -7{,}0 \text{ dB}$$

A.3 Effect of target height and radar height on discrete (non-distributed) targets ("lobing")

In calm to moderate sea states, a radar wave train that is reflected from the sea surface (with the angle of incidence equal to the angle of reflection) before striking the target will add vectorially with the wave train that travels directly to the target. This vector addition gives rise to a power enhancement Y seen at the radar. When Y is expressed in decibels it can vary between the limits +12 dB and $-\infty$ dB. This is of considerable importance when "discrete" or "point source" targets are used.

For the 3 cm band (9 410 MHz) and for the 10 cm band (3 050 MHz) values for the enhancement Y (in decibels) can be read from Figures A.1 and A.2. The formulae on which the values in Figures A.1 and A.2 are based are given in Clause A.6.

Example 3:

Question: Referring to an X-band radar whose antenna height above the sea is 7,5 m, at what height above the sea must a physically small 10 m^2 target be mounted, at a distance of 2 nautical miles, in order to give a net effect of 10 m^2 at this distance?

Answer: This will be the condition where enhancement Y = 0 dB.

By inspection of the curve for 9 410 MHz in Figure A.1, the minimum such height is 1,45 m.

A.4 Effects of frequency sensitivity

Certain types of target are frequency sensitive, as will be indicated in the formula relating the physical dimensions of the particular device to its radar cross-section. For a trihedral corner reflector the radar cross-section varies as the square of frequency.

For example, the performance of a trihedral corner reflector will be reduced by 9,9 dB at S-band compared with X-band. It must be borne in mind also that a change of operating frequency will affect in addition the considerations described in Clause A.3 above.

A.5 Conclusion

Factors that affect the performance of given radar targets under normal propagation conditions are described above. This gives a theoretical method whereby one target may be compared with another, by simple addition of the various factors expressed in decibels.

Example 4:

Question: It is calculated from the dimensions of a particular corner reflector that its radar cross-section (echoing area) is 30 m^2 (in free space) at a frequency of 9 410 MHz (X-band). This reflector is mounted at a height of 3,5 m above sea level, at a distance of three nautical miles from a radar antenna mounted at a height of 7,5 m and operating at X-band.

How might the power returned to the radar from this reflector be expected to compare with that from a 10 m^2 target situated at 2 nautical miles from the radar at a height of 1,45 m (as used in example 3)?

Answer: Considering the various relevant factors:

a) power change due to greater target size is 10 log (30/10)	= +4,8 dB
b) power change due to greater distance is –40 log (3/2)	= –7,0 dB
c) power change (enhancement) due to lobing at 3 nautical miles is seen by inspection of Figure A.1 (9 410 MHz, target height 3,5 m) is	= +6,0 dB
Adding the above three factors, the following answer is obtained	= +3,8 dB

A.6 Formulae for Figures A.1 and A.2

$$Y = 16 \sin^4 \frac{4\pi h_1 h_2 f}{2c\,D} \tag{A.5}$$

where

h_1 is the radar height
h_2 is the target height
} above the tangent plane to the earth at the reflection point;

f is the frequency of operation;

c is the velocity of microwave propagation;

D is the radar-to-target distance.

NOTE For horizontal polarisation only.

In the case of the curved earth, the heights h_1 and h_2 above the tangent have to be determined from the corresponding heights h_r and h_t of the radar and target respectively above the surface, by use of the approximate relationships (obtained from geometrical considerations):

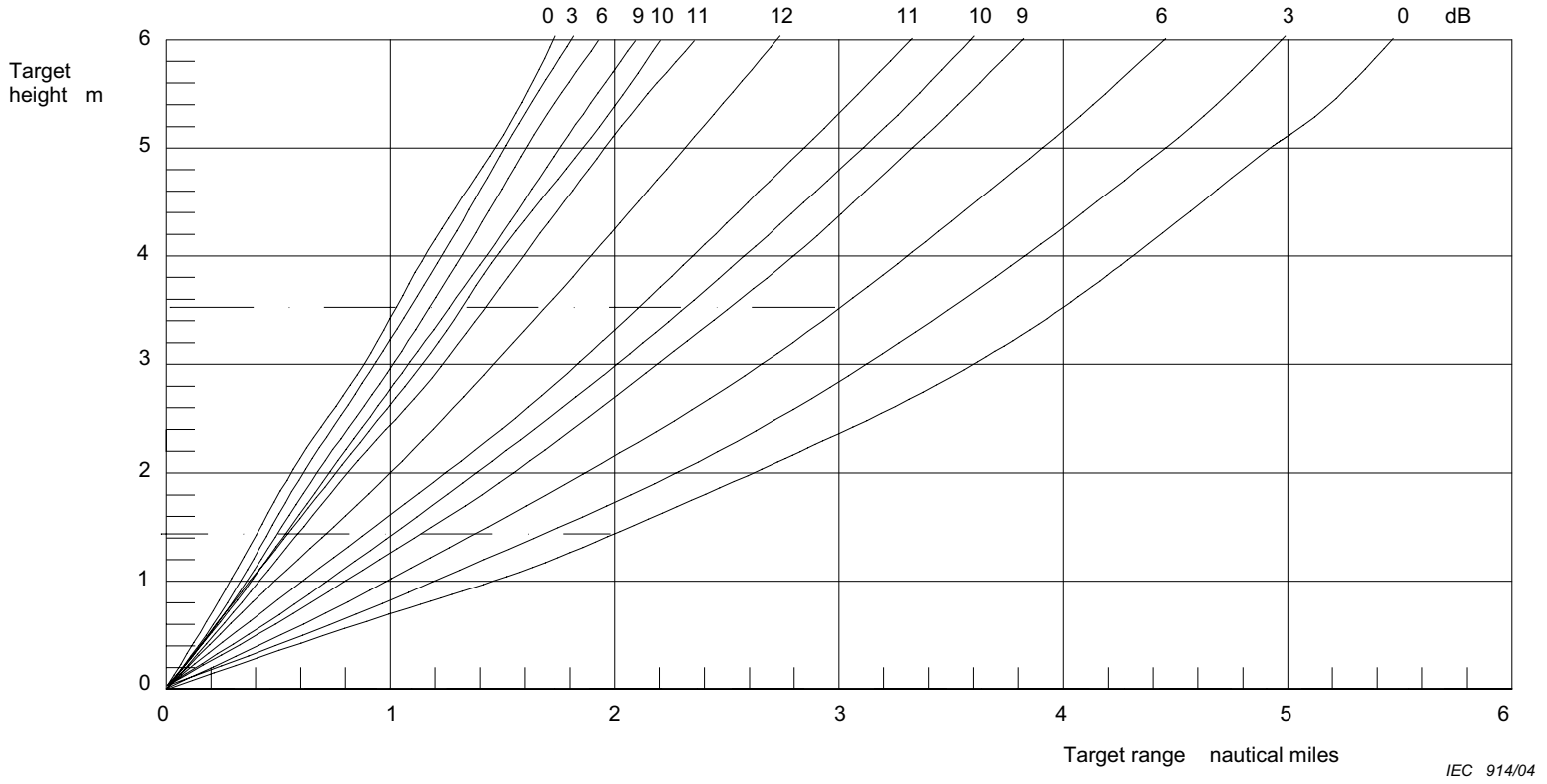
$$h_1 = h_r - \frac{(h_r D)^2}{d(h_r + h_t)^2} \tag{A.6}$$

and

$$h_2 = h_t - \frac{(h_r D)^2}{d(h_r + h_t)^2} \tag{A.7}$$

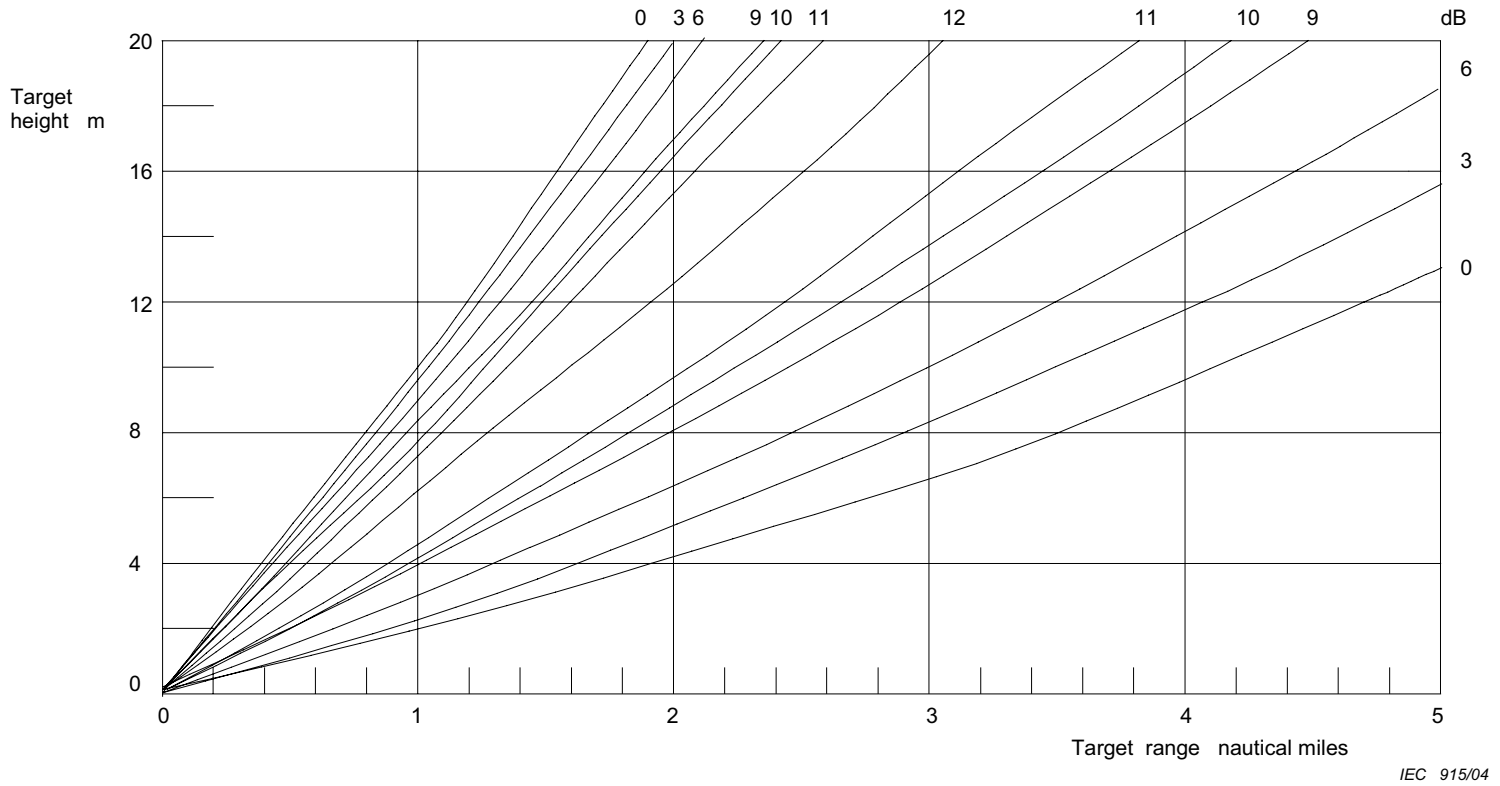
where d is the effective diameter of the "radio" earth (taken here as 6 371 × 4/3 × 2 = 16 990 km).

The formulae do not take the influence of "beam divergence" during reflection at the curved earth into account, which will reduce the maximum enhancement and "fill in" the nulls, thus increasing the minimum values of Y above $-\infty$.



Antenna height = 7,5 m
Frequency = 9410 MHz (3 cm band)

Figure A.1 – Enhancement by reflection (dB) over free space



Antenna height = 7,5 m
Frequency = 3050 MHz (10 cm band)

Figure A.2 – Enhancement by reflection (dB) over free space

Annex B
(normative)

Standard names, abbreviations and symbols for control functions on marine navigational radar equipment (as referenced by IEC 60945)

B.1 List of controls

When any of the following controls are used, they shall be identified in English by the relevant name or abbreviation given in the following list. In addition, they may be identified by standard symbols.

Standard names	Standard abbreviations	Standard symbols	Descriptions
OFF	OFF	1	Off. e.g. radar or display
ON	ON	2	On. e.g. radar or display
STAND-BY	STBY	3	Standby
NORTH-UP	N UP	4	North stabilized display mode
HEAD-UP	H UP	5	Head-up unstabilized display mode
HEADING LINE OFF	HL OFF	6	Heading line on display to be switched off momentarily
RANGE	RANGE	7	Range scale in use. Plus (+) or minus (–) to indicate range up or down
SHORT PULSE	SP	8	Short pulse
LONG PULSE	LP	9	Long pulse
TUNE	TUNE	10	Tune
GAIN	GAIN	11	Gain of the receiver
RAIN	RAIN	12	Anti-clutter rain
SEA	SEA	13	Anti-clutter sea
PANEL ILLUMINATION	PANEL	14	Display panel brilliance
DISPLAY BRILLIANCE	BRILL	15	Brilliance of the picture on the display
RANGE RINGS	RR	16	Fixed range rings on the display
VARIABLE RANGE MARKER	VRM	17	Variable range marker on the display
ELECTRONIC BEARING LINE	EBL	18	Electronic bearing line on the display
PERFORMANCE MONITOR	MON	19	Performance monitor

B.2 Code of practice for symbols

The following code of practice shall be used when marking radar sets with optional symbols.

a) The maximum dimension of a symbol shall be not less than 9 mm on a radar of 340 mm size display. For smaller diameter displays, the size may be proportionally smaller. (see E.4.2.1.5).

b) The distance between the centres of two adjacent symbols shall be not less than 1,4 times the size of the larger symbol.

c) Switch function symbols shall be linked by a line. A linked line infers controlled action.

d) Variable control function symbols shall be linked by a line, preferably an arc. The direction of increase of the controlled function shall be indicated.

e) Symbols shall be presented with a high contrast against their background.

f) The various elements of a symbol shall have a fixed ratio one to another.

g) Multiple function of controls and switch positions may be indicated by a combined symbol.

h) Where concentric controls or switches are fitted, the outer of the symbols should refer to the larger diameter control.

B.3 Symbols

The symbols listed in this clause may be used for controls on marine navigational radar equipment.

The circles shown around the following symbols are optional:

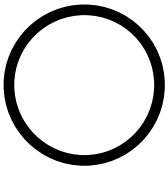
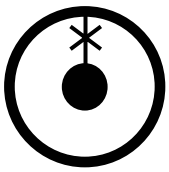
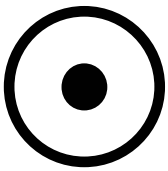
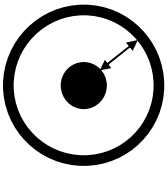
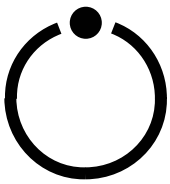
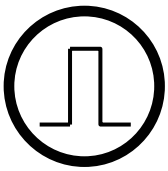
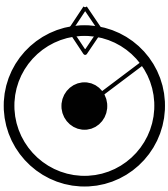
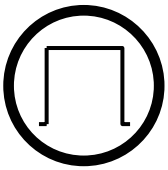
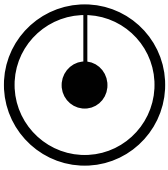
a) symbol 8: short pulse;

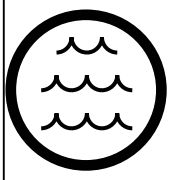
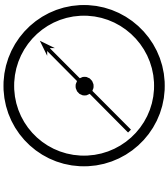
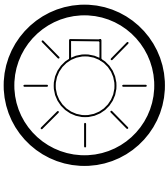
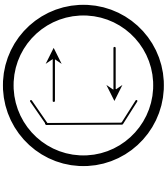
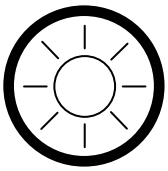
b) symbol 9: long pulse;

c) symbol 14: panel illumination;

d) symbol 19: performance monitor.

B.3.1 Symbols for controls on marine navigational radar equipment

	Symbol	Name	Explanation			Symbol	Name	Explanation
1		**OFF**	To identify the “off” position of the control or switch		6		**HEADING LINE OFF**	To identify the “heading line” off position
2		**ON**	To identify the “radar on” position of the switch		7		**RANGE**	To identify the range selection switch
3		**STAND -BY**	To identify the “radar stand-by” position of the switch		8		**SHORT PULSE**	To identify the “short pulse position of the pulse length selection control
4		**NORTH -UP**	To identify the “north-up ” position of the mode of presentation switch		9		**LONG PULSE**	To identify the “long” pulse position of the pulse length selection control
5		**SHIP’S HEAD-UP**	To identify the “ship’s head-up” position of the mode of presentation switch		10		**TUNE**	To identify the “tuning control”

	Symbol	Name	Explanation			Symbol	Name	Explanation
11		**GAIN**	To identify the “gain” control		16		**RANGE RINGS**	To identify the maximum position of the “range rings brilliance” control
12		**RAIN**	To identify the position of the “rain” control or switch		17		**VARIABLE RANGE MARKER**	To identify the “variable range marker” control
13		**SEA**	To identify the minimum position of the “anti-clutter sea” control		18		**ELECTRO-NIC BEARING LINE**	To identify the “electronic bearing line” control
14		**PANEL ILLUMI-NATION**	To identify the maximum position of the “scale illumination” control or switch		19		**TRANSMIT /RECEIVE MONITOR**	To identify the position of the performance monitor switch
15		**DISPLAY BRILL-IANCE**	To identify the maximum position of the “display brilliance” control					

B.4 Code of practice for standard names and abbreviations

English standard names and abbreviations listed in Clause B.5 are not exhaustive.

a) Upper case and lower case letters may be used.

b) Full stops and hyphens shall not be used.

c) Standard abbreviations can be divided when used in menus, for example MAP, SYMBOL, LINE.

d) New names and abbreviations may be used for new functions provided they do not conflict with Clause B.4.

e) Names and abbreviations marked with an * are for use in text areas and not in the radar picture area.

f) It is permissible to use a single first letter abbreviation when unambiguously used with a second abbreviation, for example T.BRG, L.SPD. Alternative abbreviations may be used for class B and class C, where used details shall be included in the operation manual.

B.4.1 Descriptions

The descriptions are not a mandatory glossary, but are given for informative reasons.

B.4.2 Modes

In order to standardise the motion modes of operation, the names True motion, Relative motion–true trails and Relative motion–Relative trails, are to be used. The standard abbreviation for these modes shall be TM, RM (T) and RM (R).

B.5 Marine radar

Standard names	Standard abbreviations	Descriptions
ACKNOWLEDGE	ACK	Acknowledge or accept, e.g. alarm
ADJUST	ADJ	Make changes
ALARM	ALM	Alarm
Automatic Identification System	AIS	Automatic Identification System
AUDIBLE	AUD	Audible, e.g. alarms
AVAILABLE	AVAIL	Available, e.g. function/sensor available
AUTOMATIC	AUTO	Automatic, e.g. sea clutter
AZIMUTH	Zn	Azimuth, e.g. azimuth error, azimuth stabilized
AZIMUTH INDICATOR	AZI	Azimuth indicator
BACKGROUND	BKGND	Background of display
BEARING	BRG	Bearing
BUILT-IN TEST EQUIPMENT	BITE	Built-in test equipment
CALIBRATE	CAL	Calibrate, e.g. radar, performance monitor and touch
CANCEL	CNCL	Cancel, e.g. a command or exit
CENTRE	CENT	Centre
*CHANGE	CHG	Change
CIRCULAR POLARISED	CP	Circular polarised, e.g. antenna
CLEAR	CLR	Clear, e.g. remove data, video, synthetics currently entered
COMPASS	COMPASS	Compass, e.g. compass error
CONTRAST	CONTR	Contrast on display
CORRECTION	CORR	Correction
COURSE	CRS	Course, e.g. next course, new course
COURSE OVER (The) GROUND	COG	Course made good over the ground, e.g. true
COURSE TO STEER	CTS	Course is the direction which a vessel is steering or intended to be steered
COURSE-UP	C UP	Course-up stabilized display mode
CURSOR	CURS	A moveable reference used in reading bearings or a highlighted input point on the screen
DATA	DATA	Data
DATE	DATE	Date
DAY/NIGHT	DAY/NT	Day and night, e.g. background, brilliance
DEAD RECKONING	DR	A position based on true course steered and speed through the water
DECREASE	DECR or -	Decreasing a value
DEGAUSS	DEGAUSS	Degauss the display
DEGREES	DEG or °	Degree. A measure of angle
DELETE	DEL	Delete
DISPLAY	DISP	Display, e.g. radar screen
DISTANCE	DIST	Distance
DRIFT	DRIFT	Distance covered solely due to current, tidal stream and surface drift

Standard names	Standard abbreviations	Descriptions
ELECTRONIC BEARING LINE	EBL	Electronic bearing line on the display
ELECTRONIC RANGE AND BEARING LINE	ERBL	Electronic range and bearing line
ENHANCE	ENH	Enhance, e.g. video
ENTER	ENT	Enter, e.g. selected data
EQUIPMENT	EQUIP	Equipment
ERROR	ERR	Error, e.g. operator, alarm
ESTIMATED POSITION	EP	Estimated position. The position derived from DR, leeway and drift
EXTERNAL	EXT	External, e.g. input, alarm
Global Navigation Satellite System	GLONASS	Global Navigation Satellite System
GROUND STABILIZED	GND STAB	Ground stabilized mode
GROUND TRACK	GND TRK	Ground track
Global Positioning System	GPS	GPS
GYRO	GYRO	Gyro
HEADING	HDG	Heading. The direction in which the bows of a ship are pointing, expressed as an angular displacement from north. From 000 to 360 clockwise
HEADING LINE	HL	Heading line
HOURS	HR	Hours
INCREASE	INCR or +	Increase a value
INFORMATION	INFO	Information
INITIALISATION	INIT	Initialisation, e.g. starting a process or setting up parameters
INTERFERENCE REJECTOR	IR	Interference rejecter e.g. rejection of other ship's radar interference (pulse to pulse correlation)
INTERSWITCH	ISW	Inter-switch function
INPUT	IN	Input
INPUT/ OUTPUT	I/O	Input/output
KNOTS	kn	Knots
*LABEL	LBL	Labels used to identify objects, e.g. to manually label a plot or target
LEEWAY	LWY	Leeway is the effect of wind in moving a vessel bodily to leeward at right angle to the course steered
LIMIT	LIM	Limit, e.g. the maximum or minimum range of a value
LOG	LOG	Log, e.g. sensor for determining ship's speed
MAGNETIC	MAG	Magnetic
MAGNETIC VARIATION	MAG VAR	Magnetic variation
MANUAL	MAN	Manual, e.g. acquisition, operation, and system input and "MAN SPD”
MARKER	MKR	Marker
MASTER	MSTR	Master, e.g. display, radar
MAXIMUM	MAX	Maximum (used before the value)
MEDIUM PULSE	MP	Medium pulse
MENU	MENU	Menu. A list of commands and/or options
MINIMUM	MIN	Minimum(before the value or in association with MAX)

Standard names	Standard abbreviations	Descriptions
MINUTES	MIN	Minutes (used after the value)
MISSING	MISSING	Missing, e.g. HL missing
MUTE	MUTE	Mute or silence, e.g. alarm
NAUTICAL MILE	NM	Nautical mile
NORMAL	NORM	Normal
OFFCENTRE	OFF CENT	Off-centre, e.g. off-centre set or reset
OFFSET	OFFSET	Offset, e.g. where EBL is offset from own ship
OUTPUT	OUT	Output
OWN SHIP	OS	Own ship
PARALLEL INDEX LINE	PI	Parallel index line, referenced to own ship
PERMANENT	PERM	Permanent, e.g. permanent track
PERSONAL IDENTIFICATION CODE	PIN	Personal identification code, e.g. for user settings
POSITION	POSN	Position
POWER	PWR	Power
PULSE LENGTH	PL	Pulse length
PULSES PER REVOLUTION	PPR	Number of pulses during the revolution of antenna
PULSE REPETITION FREQUENCY	PRF	Pulse repetition frequency
RADAR	RDR	Radar
RANGE	RNG	The range, e.g. of a target. Not to be used for range scale
RECEIVER	Rx	Receiver
RELATIVE	REL	Relative
RELATIVE BEARING	R BRG	Relative bearing; relative to ship's head
RELATIVE COURSE	R CRS	Relative course
RELATIVE MOTION	RM	Relative motion
RM (TRUE TRAILS)	RM (T)	Relative motion with true trails
RM (RELATIVE TRAILS)	RM (R)	Relative motion with relative trails
*SCAN TO SCAN	SC/SC	Scan to scan correlation. A number may be added to indicate the number of correlation scans
SECONDS	s	Time in seconds
SELECT	SEL	Select, e.g. menu, data, target
SET	SET	The resultant direction towards which current, tidal stream and surface drift flow
SIMULATION	SIM	Simulation
SLAVE	SLAVE	Slave, e.g. display
SPEED	SPD	Speed, e.g. in knots
*SPEED OVER THE GROUND	SOG	Speed made good over the ground, e.g. from GPS, ECHO REF., dual axis LOG
SPEED THROUGH THE WATER	STW	Speed through the water, e.g. LOG (water track)
STABILIZED	STAB	Stabilized
SYNCHRONISATION PULSE	SYNC	Synchronisation
TARGET	TGT	Target, e.g. any fixed/moving object, detected by radar
TIME TO GO	TTG	Time to go

Standard names	Standard abbreviations	Descriptions
TRAILS	TRAILS	Trails. Synthetic afterglow. True or relative. True trails may be sea or ground stabilized
TRANSCEIVER	Tx/Rx	Transceiver, e.g. X or S Tx/Rx, Tx/Rx 1 or 2, etc.
TRANSMITTER	Tx	Transmitter
TRANSPONDER	TPR	Transponder
Transmitting Heading Device	THD	Transmitting Heading Device
TRIGGER PULSE	TRIG	Trigger or timing pulse, e.g. trigger error
TRUE	TRUE	True, e.g. true data, true heading
TRUE COURSE	T CRS	True course
TRUE BEARING	T BRG	True bearing. Relative to true north. Compass bearing corrected for compass error
TRUE MOTION	TM	True motion
TRUE SPEED	T SPD	True speed
UNINTERRUPTED POWER SUPPLY	UPS	Uninterrupted power supply
UNSTABILIZED	UNSTAB	Unstabilized
VIDEO	VID	Video
VISUAL DISPLAY UNIT	VDU	Visual display unit
VIDEO NORMAL	VID NORM	Video normal
*X-BAND	X	X-band (3 cm wavelength), e.g. transceiver
*S-BAND	S	S-band (10 cm wavelength), e.g. transceiver

B.6 ARPA, ATA, EPA, ATD and EPD

Standard names	Standard abbreviations	Descriptions
ACQUIRE	ACQ	Acquisition. The process of selecting a target and initiating tracking or plotting
ACQUISITION ZONE	AZ	Acquisition zone. A zone where targets will be automatically acquired, e.g. footprint-FAZ, sector-SECT AZ and inclusion zone-INC AZ
ANCHOR WATCH	ANCH	Anchor watch
AUTOMATIC RADAR PLOTTING AID	ARPA	Automatic radar plotting aid
AUTOMATIC TRACKING DEVICE	ATD	Automatic Tracking Device
BOW CROSSING RANGE	BCR	The range at which a target will cross own ship's bow
BOW CROSSING TIME	BCT	The time to BCR
CLOSEST POINT OFAPPROACH	CPA	The closest point of approach, e.g. limit (CPA LIM), Trial (CPA T)
DELAY	DELAY	Delay, e.g. setting time to start of manoeuvre
ECHO REFERENCE	REF	Echo reference, e.g. a tracked target used as a reference for ground stabilization
ECHO REFERENCE SPEED	REF SOG	Speed derived from a stationary tracked target
ELECTRONIC PLOTTING DEVICE	EPD	Electronic Plotting Device
EXCLUSION ZONE	EZ	Exclusion zone. Zone within an acquisition zone where target will not be acquired automatically

Standard names	Standard abbreviations	Descriptions
FULL	FULL	Full, e.g. guard zone, acquisition zone, and tracking has no more capacity
GUARD ZONE	GZ	Guard zone. A zone where an alarm will be given when a target enters it
IDENTIFICATION	ID	Identification, e.g. number of a target in tracking or plotting
LABEL TARGET	LAB TGT	Label target, e.g. display target ID on screen
LOST TARGET	LOST TGT	Lost target, e.g. no longer being tracked having been lost and does not have tracking ability
MANOEUVRE TIME	MVR TIME	Manoeuvre time, e.g. an alarm indicating manoeuvre should be carried out now
PAST POSITIONS	PAST POSN	Past positions, e.g. history dots
PREDICTED AREA OF DANGER	PAD	A graphic showing a PAD around a predicted close quarter situation area
PREDICTED POINT OF COLLISION	PPC	A graphic showing where PPC intercept points lie with respect to own ship and other targets
RELATIVE VECTOR	R VECT	Relative vector
SYMBOLS OFF	SYM OFF	Symbols off, e.g. ARPA, ATD, EPD, NAV, ENC etc.
TEST TARGET	TEST TGT	Test target for integrity checking of tracking
TIME TO CLOSEST POINT OF APPROACH	TCPA	Time to closest point of approach, e.g. limit-TCPA LIM, Trial-TCPA T
TIME TO GO	TTG	Time to go
TRACKING	TRKG	Tracking. The computer process of observing the sequential changes in the position of a target in order to establish its motion
TRIAL MANOEUVRE	TRIAL	Trial manoeuvre, T is the ARPA symbol
TRUE VECTOR	T VECT	True vector
VECTOR	VECT	Vector, e.g. true or relative
VECTOR TIME	VECT TIME	Vector time, e.g. length of vector measured in units of time

B.7 Geographic, mapping and navigation

Standard names	Standard abbreviations	Descriptions
ANTENNA	ANT	Antenna, e.g. radar or GPS
AUTOPILOT	AP	Auto-pilot, an automatic heading control aid to enable a vessel to maintain its heading in an intended direction
BEARING AND DISTANCE TO WAYPOINT	BWC	Bearing and distance to way-point (great circle)
BEARING AND DISTANCE TO WAYPOINT	BWR	Bearing and distance to way-point (rhumb line)
BEARING ORIGIN TO DESTINATION	BOD	Bearing origin to destination
BEARING WAYPOINT TO WAYPOINT	BWW	Bearing way-point to way-point
CO-ORDINATED UNIVERSAL TIME	UTC	Co-ordinated universal time
CROSS TRACK ERROR	XTE	Cross track error
CURVED HEADING LINE	CHL	Curved heading line for showing predicted track

Standard names	Standard abbreviations	Descriptions
DGPS	DGPS	Differential GPS. Local-L or Wide-W area system
DGLONASS	DGLO	Differential Global Navigation Satellite System
DECCA	DEC	Decca navigator
DEPTH	DPTH	Depth, e.g. depth alarm
DESTINATION	DEST	Destination
DISTANCE INTERVAL	DIST INT	Distance interval between tracked positions of targets
ECDIS	ECDIS	Electronic chart display and information system
ELECTRONIC NAVIGATIONAL CHART	ENC	The data base held on board the ship for use with ECDIS
ELECTRONIC POSITION-FIXING SYSTEM	EPFS	Electronic position-fixing systems, e.g. GPS, DECCA, LORAN-C
ESTIMATED TIME OF ARRIVAL	ETA	Estimated time of arrival
EVENT	EVENT	Event on radar or ECDIS
GLOBAL POSITIONING SYSTEM	GPS	GPS
GLONASS	GLO	GLONASS
GEOGRAPHICS	GEOG	Geographic maps and grid elements
GREAT CIRCLE	GC	Great circle
GRID	GRID	Latitude and longitude grid, the lines of which approximate to a Mercator projection
HEADING CONTROL SYSTEM	HCS	Heading control system
INFRARED	INF RED	Infrared, e.g. sensor
INTEGRATED BRIDGE SYSTEM	IBS	Integrated bridge system
INTEGRATED NAVIGATION SYSTEM	INS	Integrated navigation system
INTEGRATED RADIO COMMUNICATION SYSTEM	IRCS	Integrated radio communication system
LATITUDE	LAT	Latitude
LATITUDE/LONGITUDE	L/L	Latitude/longitude
LINE OF POSITION	LOP	Line of position
LONGITUDE	LON	Longitude
LORAN	LOR	Loran-C'
MAN OVERBOARD	MOB	Man overboard
MAP LINES	MAP LINES	Map lines. A navigational facility defining channels or traffic separation schemes which are ground stabilized
MAPS	MAP	Maps generated by the user
NAVIGATION	NAV	Navigation, e.g. “NAV SOG” from an EPFS or navigation equipment
OFF TRACK	OFF TRK	Off track, e.g. off track alarm
Port	Port	Port
POSITION	POSN	Position, e.g. mode select, display
RADAR SYSTEM DATA	RSD	Radar system data
RADIUS	RAD	Radius turn, e.g. NEXT RAD
RATE OF TURN	ROT	Rate of turn
RHUMB LINE	RHL	Sailing on a constant course
ROUTE	RTE	Route. A planned course of travel, usually composed of more than one leg

Standard names	Standard abbreviations	Descriptions
SAFETY CONTOUR	SAF CON	Safety contour for depth, e.g. from ECDIS
SEQUENCE	SEQ	Sequence, e.g. maps
Starboard	Stbd	Starboard
SYSTEM ELECTRONIC NAVIGATIONAL CHART	SENC	System electronic navigational chart
TRACK	TRK	The path followed or to be followed from one position to another
TRACK CONTROL SYSTEM	TCS	Track control system
TRACK MADE GOOD	TMG	Track made good between the point of departure to a point of arrival
TRACK PILOT	TRK P	Track pilot
Velocity Made Good	VMG	Velocity made good
VOYAGE	VOY	Voyage, e.g. voyage
WAYPOINT	WPT	Way-point. A reference point on the track
WAYPOINT CLOSURE VELOCITY	WCV	Way-point closure velocity
WHEEL OVER POINT	WOP	Wheel over point or line
WORLD GEODETIC SYSTEM	WGS	World geodetic system e.g. WGS 84

Annex C
(normative)

Guidelines for the display of navigational information on radar by means of radar maps

C.1 Definitions

C.1.1 Guidelines

This guideline, as far as possible, quantifies solutions for type approval, but does not exclude the application of alternative solutions provided the functional requirements are met. This guideline will be amended when technical developments or operational experience form a basis for a better solution.

C.1.2 Radar map

A radar map is a combination of map lines and symbols whereby the user can define and input the navigation, route planning and monitoring data on the radar equipment.

C.2 Application

a) Radar maps may be displayed in such a way that the primary radar and electronic plotting (ATA and EPA or ATD and EPD) information is clearly visible.

b) Radar maps may be displayed on multi-colour and monochrome displays.

c) Radar maps displayed on multi-colour displays shall conform as far as is practicable to the following principles:

   1) the map information displayed is limited to items in Table C.1;

   2) the map symbols used to display the information in C.2 c) 1) are similar in shape to those defined in appendix 2 of IHO S-52 figure 1- items 1 to 40;

   3) the map colours used to display the information in C.2 c) 1) are listed in Table C.1. Where these are not automatically selected, the operating manual shall clearly show how this is to be achieved.

d) Radar maps displayed on monochrome displays shall conform as far as is practicable to the following principles:

   1) those in clause C.2.c) 1) and clause C.2.c) 2);

   2) other means than colour may be used to differentiate lines.

e) Radar map colour fill may be displayed where appropriate in such a way that the primary radar and electronic plotting information is clearly visible.

C.3 Navigation symbols for use with radar maps

a) Navigational symbols for use with radar maps shall be described in the manufacturer's documentation.

b) The number of types of navigational symbols used shall be limited to provide simple operation.

c) The shape of these navigational symbols used on multi-colour and monochrome displays should be similar to those used for the chart radar.

d) The use and selection of colours for these symbols and other non-standard navigational symbols are optional. For planned routes, red, as used in the ECDIS, is recommended.

Table C.1 – Features and colours to be used for radar maps

Mapping feature	Colour to be used
Coastline (high water)	White
Own ship safety contour	Grey
Indication of isolated underwater dangers of depths less than the safety contour which lie within the safe water defined by the safety contour	Magenta
Indication of isolated dangers which lie within the safe water defined by the safety contour such as bridges, overhead wires etc.	Magenta or grey
Buoys and beacons, whether or not these are being used as aids to navigation.	Red or green
Traffic routing systems	Magenta
Prohibited and restricted areas	Magenta
Boundaries of fairways and channels	Grey
Radar background	Black or blue

When the “own ship safety contour” feature is used, the dangerous side shall be clearly indicated, for example, by colour fill, hatching, double lines, broken line, etc. on the dangerous side.

Annex D
(normative)

Unwanted emissions of radar systems – Methods of measurement and required results

D.1 Introduction

ITU-R has now developed a new recommendation for out-of-band (OOB) emission limits SM.1541) This recommendation is associated with the following recommendations:

a) OOB emissions falling into an adjacent allocated band (OAB) – SM.1540

b) Boundary between OOB and spurious emissions – SM.1539

c) Spurious emissions – SM.329

Spurious emission limits have been incorporated into the Radio Regulations, in terms of level, but not in terms of frequency range. There is no intention at present of a similar treatment for either the OOB or OAB limits.

The purpose of this annex is to define how the requirements of Appendix 3 of the Radio Regulations (see also RR Appendix 3, Table 1, although further studies on this issue are being carried out in the ITU) and these new ITU Recommendations concerned with unwanted emissions are to be implemented with regard to marine radars. This includes the requirements, method of measurement, the results to be obtained and the interpretation of the measurement results.

D.2 Requirements

The requirements are defined in Appendix 3 of the Radio Regulations and the recommend-ations listed above in Clause D.1.

The boundary between the OOB and spurious domains and the OOB mask are defined in the OOB recommendation – ITU-R OOB recommendation ITU-R SM.1541, Annex 8 in the following manner –

a) (Out-of-band mask) – “The mask rolls off at 20 dB per decade from the 40 dB bandwidth to the spurious level specified in Appendix 3 of the Radio Regulations. The B_{-40} dB bandwidth can be offset from the frequency of maximum emission level, but the necessary bandwidth (RR No. 1.152) and preferably, the overall occupied bandwidth (RR No. 1.153), should be contained completely within the allocated band”.

NOTE Appendix 3 of the Radio Regulations specifies a spurious attenuation of 43 + 10 log (*PEP*), or 60 dB whichever is less stringent.

b) (Exclusions) – “the OOB limits are not applicable inside exclusive Radiodetermination and or Earth Exploration Satellite (EES) and Space research service bands, but do apply at the band edges.”

These requirements are illustrated in Figures D.1 and D.2.

The OOB masks shown in Figures D.1 and D.2 are calculated using the transmitted pulse width and rise time.

The necessary bandwidth and the –40 dB bandwidth are generally centred about the operating frequency but may be offset to take account of spectrum asymmetry.

The OOB mask commences at a level of –40 dB and falls off at the rate of –20 dB per decade until it meets the spurious emission limit at the OOB boundary. (See RR Appendix 3-7 Table ii.)

When the calculated –40 dB bandwidth falls within the allocated band the OOB mask commences at the edge of the allocated band.

When the –40 dB bandwidth falls outside the allocated band the OOB mask commences at that point in the adjacent band.

The OOB mask can be offset further into the adjacent band to allow for spectrum asymmetries, but the necessary bandwidth associated with this mask shall be contained completely within the allocated band.

The OOB mask emission limits only apply outside the adjacent bands, i.e. below 2,7 GHz and above 3,3 GHz in the case of radars operating in the 2,9 GHz to 3,1 GHz band, and below 8,5 GHz and above 9,8 GHz in the case of radars operating in the 9,3 GHz to 9,5 GHz band.

Emissions in the spurious domain (Figures D.1 and D.2) shall be at least 43 + 10 log PEP or 60 dB, whichever is the least stringent, below the carrier power, as measured in the far field of the radar. For most current marine radars, the limit will be 60 dB and this means that the spurious domain starts at $5 \times B_{-40}$ from the operating frequency of the radar.

D.3 Methods of measurement

The basic methods of measurement for unwanted emissions are contained in ITU-R Recommendation M.1177. This describes two methods, referred to as the “direct” and “indirect” methods. Either method is admissible.

Measurements are to be made for all frequencies in the measurement frequency bands specified in the Table D.1 below.

Table D.1 – Measurement frequency ranges

Allocated band	**Measurement band** GHz	
	Lower limit	**Upper limit**
2,9 GHz – 3,1 GHz	2	5th harmonic
9,3 GHz – 9,5 GHz	0,7 of the waveguide cut-off	26

D.4 Guidelines for the use and interpretation of ITU-Recommendation M.1177

The recommendation provides some specific techniques for the measurement of the unwanted emissions of radar systems, that in principle can be used for any type of radar system. In practice, the recommendation makes no attempt to provide detailed test methods for each type of system.

This standard provides the additional detail required for the minimum test requirements for the measurement of marine radars as a basis for certification, that the particular marine radar system under test, meets the requirements of the Radio Regulations and ITU-R Recommendations as appropriate.

D.4.1 Selection of pulse widths

The ITU-R Recommendation on OOB (SM.1541) applies to complex and simple radars with user-selectable pulse waveforms. For a particular radar, the pulse length and rise time for a number of representative pulses (including the shortest and longest pulses) shall be measured and the corresponding B_{-40} bandwidths calculated. The widest calculated B_{-40} bandwidth shall then be used to create the OOB mask to be applied to that radar. Emission measurements only need to be carried out for the pulse length setting producing the widest calculated B_{-40} bandwidth.

D.4.2 Measurement in azimuth and elevation – antennas

For marine radars that are essentially surface search radars, there is no requirement to make measurements in the vertical plane.

For measurements in the azimuth plane, the antenna may be either rotating or the measurement system may be aligned to the antenna bore sight and measurements in azimuth taken at appropriate antenna angles where the directions of unwanted emissions are known. Both techniques are admissible and the particular choice shall be made by agreement between the manufacturer and the test authority.

In both cases the maximum value of the emission occurring in the azimuth plane shall be recorded over the frequency range defined in Table D.1.

Provided that all of the antennas to be used with the equipment under test are of the same type, then only the smallest (i.e. that with the largest azimuth beam-width) needs to be used to verify compliance with the unwanted emission requirements.

D.5 Results required

D.5.1 Necessary bandwidth

The necessary bandwidth as calculated from the measured pulse width and rise time shall be within the allocated frequency band.

D.5.2 B_{-40} bandwidth

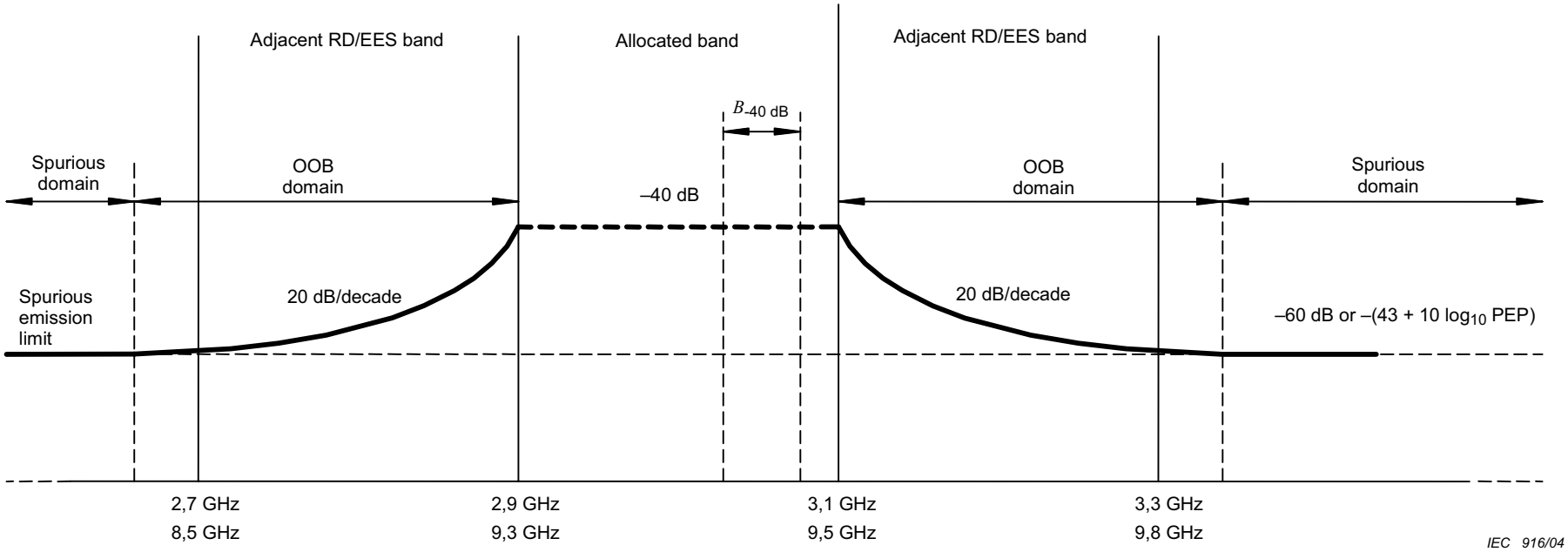
The B_{-40} bandwidth shall be calculated using the methods defined in D.4.1 and in Annex 8 of SM.1541. This bandwidth together with the declared frequency of the pulse transmission are used to determine which of the masks illustrated in Figure D.1 or Figure D.2 shall be used for the purposes of conformity.

D.5.3 Emission spectrum

The emission spectrum shall be below the calculated mask, as determined by D.5.2 above, in both the OOB and spurious domains, for all appropriate frequencies in the ranges specified in Table D.1. As previously indicated in Clause D.2, the OOB emission masks limits do not apply within the allocated band or the adjacent RD/ESS bands.

The spurious emission limit applies in the spurious domain, regardless of frequency band.

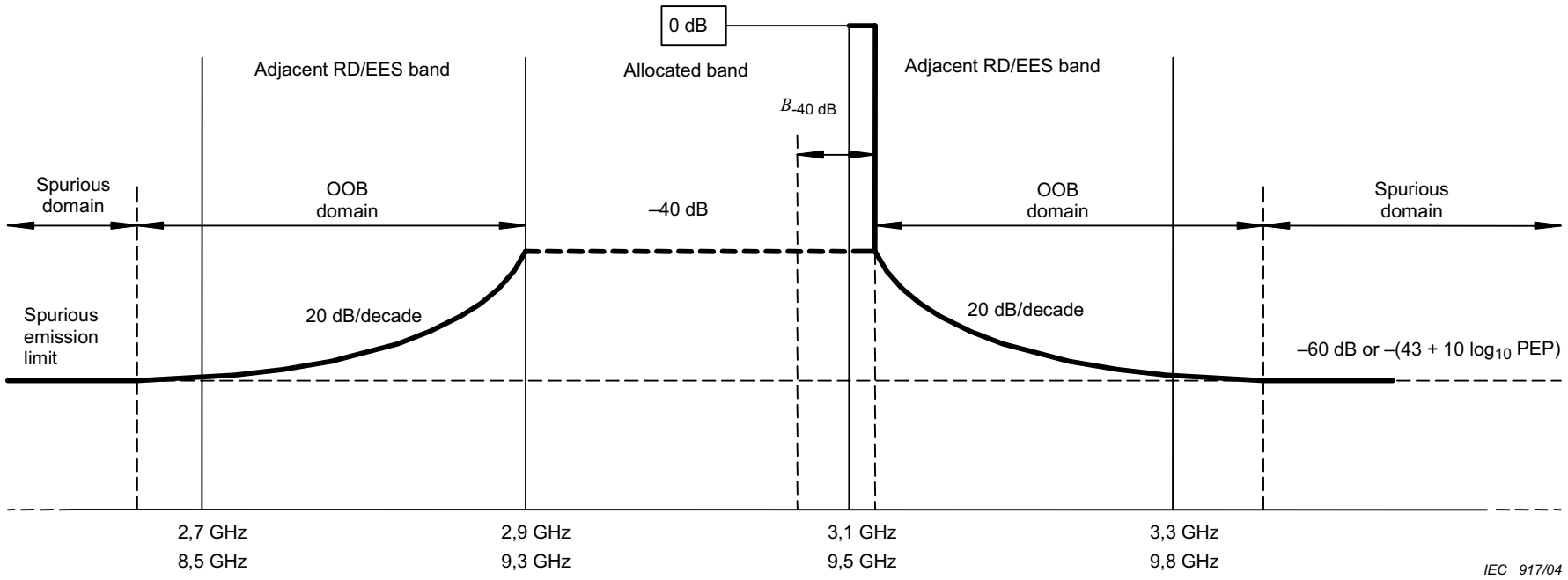
Systems shall be compliant if the OOB mask of Figure D.2 is offset further into the adjacent band to allow for spectrum asymmetries, provided that the necessary bandwidth associated with this mask is completely contained within the allocated band.



NOTE RD/EES – Radiodetermination/Earth Exploration Satellite

NOTE OOB emission mask limits do not apply within the allocated or adjacent RD/EES bands

Figure D.1 – B_{-40} falls within the allocated band



NOTE RD/EES – Radiodetermination/Earth Exploration Satellite

NOTE OOB emission mask limits do not apply within the allocated or adjacent RD/EES bands

Figure D.2 – B_{-40} falls outside the allocated band

Annex E
(normative)

General requirements – Method of test and required results

This annex specifies minimum performance requirements, methods of testing and required test results for general requirements which can be applied to radar display and antenna equipment according to IEC 62252 radar classes A, B and C. This annex is based on IEC 60945.

E.1 Scope

This annex specifies minimum performance requirements, methods of testing and required test results for general requirements, which can be applied to those characteristics common to radar according to this standard.

All classes A, B and C equipment shall be subjected to all the tests specified within this annex unless otherwise specified, 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 annex:

- equipment category (E.4.4);
- performance test (3.1.16);
- performance check (3.1.12);
- pre-conditioning for environmental tests (3.1.17).

The laboratory or test facility conducting technical tests shall conform to appropriate international standards concerning calibration and quality control.

Personnel having appropriate nautical knowledge, particularly those involving subjective judgement, shall conduct operational checks.

E.1.1 General requirements

Where equipment provides a facility, which is additional to the minimum requirements of this standard the operation and, as far as is reasonably practicable, the malfunction of such an additional facility shall not degrade the performance of the equipment.

Equipment shall be installed in such a manner that it is capable of meeting the requirements of this standard.

Guidance on installation of equipment can be found by reference to equipment manuals.

E.2 Normative references

See Clause 2.

E.3 Definitions and abbreviations

E.3.1 Definitions

See 3.1.

E.3.2 Abbreviations used in this standard

See 3.2.

E.3.3 IMO performance standard

Not applicable (NA) to this standard at this time. Any IMO performance standard for radar/radar plotting for small craft that may be adopted in the future will become applicable at that time.

E.4 Minimum performance requirements

E.4.1 General

E.4.1.1 Introduction

This Annex E developed from the fourth edition of 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. The layout of Clause E.4 (Minimum performance requirements) has been changed to give a better grouping of ergonomics, hardware and software requirements.

E.4.1.2 General requirements

Where 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.

Equipment shall be installed according to the manufacturer’s documentation.

E.4.2 Design and operation

E.4.2.1 Ergonomics and HMI

E.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 this standard by a user.

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

E.4.2.1.2 Arrangement

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.

E.4.2.1.3 Operation

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 its related indicator to be obscured 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.

E.4.2.1.4 Identification

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. The local language may be used for (classes B and C).

E.4.2.1.5 Screen displays and indications

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 the English language shall be available to be used. The local language may be used for (classes B and C).

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.

E.4.2.1.6 Voice announcement

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.

It shall be possible to switch off this facility.

Announcements shall be clearly understandable.

Volume of announcements shall not exceed that defined for alarms (see E.4.2.2.2).

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

E.4.2.1.7 Safety of operation

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

When an action causes a detectable error the system shall give clear feedback**.**

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.

E.4.2.1.8 Distress alert

Not applicable to this standard

E.4.2.2 Hardware

E.4.2.2.1 General

Equipment with a safety-related function shall give priority to simplicity in design.

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, which if inadvertently exercised 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.

Where a digital input panel with the digits "0" to "9" is provided and where space permits, the digits shall preferably be arranged to conform to 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 class A only.

E.4.2.2.2 Alarms and indicators

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 a primary colour of the display system.

The sound pressure level of an integrated equipment audible alarm 1 m from the source shall be at least 65 dB(A) but not greater than 85 dB(A).

E.4.2.2.3 Illumination

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.

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

E.4.2.3 Software

E.4.2.3.1 General

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 and be separated from those of control;
– the structure shall support maintenance and up-dates of software by minimising 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 E.4.2.3 for example by block, data flow or status diagram.

E.4.2.3.2 Safety of operation

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

Any software required in the 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 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.

E.4.2.3.3 Monitoring

Means shall be provided for the equipment to provide an alarm or a distinctly obvious indication in the event of a software process failure at any stage during operation including initialisation.

E.4.2.3.4 Operation

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

E.4.2.4 Inter-unit connections

For external communication, equipment shall comply with standard communication protocols and data formats in accordance with IEC 61162 series as applicable (not applicable for class C).

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.

E.4.3 Power supply

E.4.3.1 Extreme power supply

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.

E.4.3.2 Excessive conditions

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.

E.4.3.3 Power supply short-term variation and power supply failure

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.

E.4.4 Durability and resistance to environmental conditions

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

a) protected,

b) exposed to the weather,

c) antenna system.

The equipment manual shall identify the category of the equipment.

E.4.5 Interference

E.4.5.1 Electromagnetic compatibility

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.

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

E.4.5.2 Acoustic noise

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.

E.4.5.3 Compass safe distance (all equipment categories) Class A only

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.

For radars class B and class C the compass safe distance shall be stated on the equipment or in the manufacturer's documentation.

E.4.6 Safety precautions

E.4.6.1 Protection against accidental access to dangerous voltages

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.

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.

E.4.6.2 Electromagnetic radio-frequency radiation

(See 4.32.1.)

E.4.6.3 X ray radiation

Equipment containing elements such as vacuum tubes, for example cathode ray tubes, magnetrons and TR cells, which are likely to cause X-ray radiation, shall comply with the following requirements:

a) external X-radiation from the equipment in its normal working condition shall not exceed the limits set by the administration concerned;

b) 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;

c) 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.

E.4.7 Maintenance

E.4.7.1 Maintenance of hardware

The equipment shall be so designed that the main units can be replaced readily, for on-board repair, without elaborate re-calibration or readjustment.

E.4.8 Equipment manuals

Adequate information shall be provided to enable the equipment to be properly installed and operated.

Operating manual shall:

a) be written in English or in the national language if manufactured for a specific country;

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

c) contain basic user troubleshooting procedures.

E.4.9 Marking and identification

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:

a) identification of the manufacturer;

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

c) 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 the installed software shall be either marked or displayed on command on the equipment.

Marking requirements for compass safe distance are given in E.4.5.3.

E.5 Method of testing and required results

E.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.

Durability tests are designed to test equipment resistance to mechanical deterioration due to exposure to the shipboard environment, or to the rigours of mishandling due to 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.

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.

E.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 frequencies for a.c. supplies) for all variations of load imposed by the EUT, that is, the test power supply's 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.

E.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.

E.5.2.2 Extreme test conditions

Extreme environmental conditions are defined in Clause E.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 E.1 shall be used as appropriate to the EUT.

Table E.1 – Extreme power supplies variation

Power supply	Voltage variation %	Frequency variation %
a.c.	±10	±5
d.c.	+30 –10	NA

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 E.2.

E.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 E.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 misconnection is also regarded as an excessive condition. Where appropriate, the EUT shall be subjected to 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.

NOTE Reset may include the change of a fuse.

E.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 E.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 I.

E.6 Operational checks (all equipment categories)

E.6.1 Ergonomics and HMI

E.6.1.1 General

The EUT shall be checked by inspection for compliance with E.4.2.1.1.

E.6.1.2 Arrangement

The EUT shall be checked by inspection for compliance with E.4.2.1.2.

E.6.1.3 Operation

The EUT shall be checked by inspection for compliance with E.4.2.1.3.

E.6.1.4 Identification

The EUT shall be checked by inspection for compliance with E.4.2.1.4.

E.6.1.5 Screen display and indicators

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 to the standard marine communications phrases (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.

u) Check that no more than two flash rates are used and that they are then time synchronized.

E.6.1.6 Voice announcement

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

b) Check that a switch is provided to activate or deactivate the function.

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

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

E.6.1.7 Safety of operation

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

b) Check that all actions, that may cause irreversible errors, 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.

E.6.1.8 Distress alert

N/A to this standard.

E.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.

E.6.2.1 General

a) Check that provision has been made for the removal of or for blocking off, the position of controls of any optional facility which is 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 to ITU-T Recommendation E.161 (4x3 array). 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 to ISO 3791.

E.6.2.2 Alarms and indicators

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 E.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.

E.6.2.3 Illumination

a) Check that any illumination provided in the EUT is adequate for operation of the equipment under all expected conditions of ambient illumination, without dazzle.

b) Check that means are provided for dimming or extinction of 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 controls, which are not illuminated, such as tracker balls, are locatable easily and unambiguously by tactile means.

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

E.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.

E.6.3.1 General

Check documentation for compliance with E.4.2.3.1.

E.6.3.2 Safety of operation

Check the following:

a) documentation for compliance with E.4.2.3.2;

b) that software defaults, where applicable, are inserted in all modes of operation and that the default value:
   – 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) that the software prevents an operation or warns an operator when attempting an input that leads to an invalid operation of the equipment;

d) that operations not required for normal operation, or which may adversely affect system performance, are not readily accessible.

E.6.3.3 Monitoring

N/A to this standard.

E.6.3.4 Operation

Check documentation for compliance with E.4.2.3.4.

E.6.4 Inter-unit connection

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.

E.7 Power supply – Methods of testing and required results

E.7.1 Extreme power supply

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

Table E.2 – Schedule of performance tests and checks

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

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

E.7.2 Excessive conditions

For the relevant requirements to be met, see E.5.2.3.

E.7.3 Power supply short-term variation

For the relevant test, see the appropriate subclause of IEC 60945 .

E.7.4 Power supply failure

For the relevant test, see the appropriate subclause of IEC 60945.

E.8 Durability and resistance to environmental conditions – Method of testing and required test results

Durability and resistance tests shall be waived where the manufacturer is able to provide evidence that the EUT has been tested and would satisfy these requirements.

E.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 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 E.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 E.4.4 are summarised in Table E.3 below.

Table E.3 – Durability and resistance to environmental conditions

	Protected	Exposed	Antenna system
Dry heat	+55 °C	+55 °C (storage +70 °C)	
Damp heat	+40 °C 93 % relative humidity 1 cycle		
Low temperature	–15 °C	–25 °C	–25 °C
Vibration/shock	**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		**Vibration**: 5 Hz at ±25 mm ± 10 % for 2 h Or **shock**: 3 shocks at 100 m/s^2 for 25 ms pulse duration Vertical axis only
Rain and spray		12,5 mm nozzle 100 l/min at 3 m	
Corrosion	Four periods of seven days at 40 °C with 90 % – 95 % relative humidity after 2 h salt spray		

At the end of each test under extreme environmental conditions, the EUT shall be exposed to normal environmental conditions (E.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 normal temperature air.

E.8.2 Dry heat

E.8.2.1 Storage test (exposed equipment and antenna system)

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.

E.8.2.1.1 Purpose

To simulate the effects of temperature stress on equipment in the non-operating (non-powered) mode.

E.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 6 h to 8 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 E.7.1.

E.8.2.1.3 Required result

The requirements of the performance check shall be met.

E.8.2.2 Functional test (protected, exposed equipment and antenna system)

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.

E.8.2.2.1 Purpose

To determine the ability of equipment to be operated at high ambient temperatures and to operate through temperature changes.

E.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 6 h to 8 h at +55 °C ± 3 °C, the EUT shall be subjected to a performance test and check as specified in E.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.

E.8.2.2.3 Required result

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

E.8.3 Damp heat

E.8.3.1 Functional test (protected, exposed equipment and antenna system)

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 %.

E.8.3.1.1 Purpose

To determine the ability of equipment to be operated under conditions of high humidity.

E.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 6 h to 8 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 a period as agreed by the manufacturer, and shall be kept operational for at least 1 h during which period the EUT shall be subjected to a performance check as specified.

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.

E.8.3.1.3 Required results

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

E.8.4 Low temperature

E.8.4.1 Storage test (portable equipment)

N/A to this standard.

E.8.4.2 Functional test

E.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 temperatures.

E.8.4.2.2 Method of test (portable equipment)

N/A to this standard.

E.8.4.2.3 Required result

N/A to this standard.

E.8.4.2.4 Method of test (protected 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 between –15 °C ± 3 °C for a period of 6 h to 8 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 a period as agreed by the manufacturer, and shall be kept operational for at least 1 h, during which period the EUT shall be subjected to a performance test and check as specified E.7.1

The temperature of the chamber shall be maintained at –15 °C ± 3 °C during the whole test period.

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

E.8.4.2.5 Required result

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

E.8.4.2.6 Method of test (antenna system and exposed equipment)

The EUT shall be subject to the same conditions and procedures specified for protected equipment (see E.8.4.2.4), except that the temperature of the chamber shall be reduced to and maintained at –25 °C ± 3 °C.

E.8.4.2.7 Required result

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

E.8.5 Thermal shock (portable equipment)

N/A to this standard.

E.8.6 Drop (portable equipment)

N/A to this standard.

E.8.7 Vibration/shock (protected and exposed equipment)

E.8.7.1 Purpose

To determine the ability of equipment to withstand vibration/shock without resulting in mechanical weakness or degradation in performance.

E.8.7.2 Method of test (protected and exposed equipment)

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 the 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, commencing the test at between 2 Hz and 5 Hz, at all frequencies :

– 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 resonance 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.

E.8.7.3 Required result

The requirements of the performance check shall be met.

E.8.7.4 Method of test (antenna system)

Two methods of measurement are acceptable, either by vibration or shock. The manufacturer shall state which method shall be used.

E.8.7.4.1 Vibration

The antenna shall be subjected to a sinusoidal vibration in the vertical plane at 5 Hz with an excursion of ±25 mm ±10 % (equivalent to 2,5 *g*) for a 2 h duration.

E.8.7.4.2 Results required

A successful performance check shall be carried out at the end of the test period.

E.8.7.4.3 Shock

The test provides a method by which responses of components and equipment comparable with those likely to be experienced in practice in the operational environment can be produced in the test laboratory. The antenna is to be designed to withstand the test without external indications of damage or subsequent degradation in performance. A performance check is to be carried out before and after the test.

E.8.7.4.4 Method of measurement

The antenna shall be so mounted that the shock can be applied to the antenna-mounting base to simulate an upward vertical impulsive force. The antenna shall be mechanically connected to the shock machine by its normal means of attachment. The procedure shall be carried out in normal laboratory environmental conditions. The severity of the test is specified by the peak acceleration, pulse shape and duration given in Table E.4.

Table E.4 – Test severity – half-sine pulse

Peak acceleration m/s^2	**Duration of pulse** ms
100	25

The shock pulse shall be measured by an accelerometer, placed at the antenna fixing point nearest to the centre of the table surface.

a) Carry out a performance check.

b) Switch off the power supply and apply three successive upward shocks of the required test severity and pulse shape.

c) Check for external indications of damage.

d) Carry out a second performance check.

E.8.7.4.5 Results required

There shall be no external indications of damage and there shall be no detectable degradation in performance.

E.8.8 Rain and spray (exposed equipment and antenna systems)

E.8.8.1 Purpose

To simulate the effects of rain, sea-spray and light breaking seas on equipment.

E.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 that 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.

E.8.8.3 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.

E.8.9 Immersion

N/A to this standard.

E.8.10 Solar radiation (portable equipment)

N/A to this standard.

E.8.11 Oil resistance (portable equipment)

N/A to this standard.

E.8.12 Corrosion (salt mist) (all equipment categories)

E.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.

E.8.12.2 Purpose

To determine 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.

E.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 de-mineralised 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.

E.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.

E.9 Electromagnetic emission – Methods of testing and required test results

(See E.4.5.1)

E.9.1 General

The equipment shall be tested in accordance with IEC 60945, current edition Clause 9, for electromagnetic emission. The EUT shall achieve the results stated therein.

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

E.10.1 General

The equipment shall be tested in accordance with IEC 60945, current edition Clause 10, for immunity to electromagnetic environment. The EUT shall achieve the results stated therein.

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

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

E.11.1.1 Purpose

To ensure 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 equipment, when applicable.

E.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 61672. 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.

E.11.1.3 Required result

The acoustic noise 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 pressure of an alarm shall be at least 65 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.

E.11.2 Compass safe distance (all equipment categories) class A only

(See E.4.5.3)

E.11.2.1 Purpose

To determine 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.

E.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 not powered;

b) after normalising with the EUT not powered; and

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

Normalising means a procedure to maximise 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.

E.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 E.4.5.3.

For radars class B and class C the compass safe distance shall be stated on the equipment or in the manufacturer’s documentation.

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

E.12.1 Protection against accidental access to dangerous voltages

(See E.4.6.1)

E.12.1.1 Purpose

To ensure safety when installed equipment is accessible.

E.12.1.2 Method of test

The EUT shall be subjected to the test corresponding to IEC 60529, Table 1, 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 6 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.

E.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.

E.12.2 Electromagnetic radio-frequency radiation

(See E.4.6.2 and 5.32.1)

E.12.2.1 Purpose

To enable safety rules to be applied in the vicinity of radiating equipment.

E.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.

E.12.2.3 Required result

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

E.12.3 Emission from visual display unit (VDU)

(See E.4.6.2)

E.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.

E.12.3.2 Purpose

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 DC potential of less than 500 V.

E.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 intervals of 90° for the electric field and at intervals of 45° 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.

NOTE For guidance, see IEC 60945, 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 address-ability.

E.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.

E.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.

E.12.3.4 Required result

The emissions shall be within the following limits:

Table E.5 – Emission 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 round 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 round and at 300 mm in-front	≤ 250 nT r.m.s.	*
2 kHz to 400 kHz	≤ 25 nT r.m.s.	at 500 mm in-front	≤ 150 nT r.m.s.	*
* Measurement distance at the limit value to be recorded in the test report.				

E.12.4 X-radiation

(See E. 4.6.3)

E.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.

E.12.4.2 Purpose

To ascertain that emissions of the EUT are within safe limits.

E.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.

E.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.

E.13 Maintenance (all equipment categories)

The EUT shall be ckecked by inspection for compliance with E.4.7.1.

E.14 Equipment manuals (all equipment categories)

The EUT shall be ckecked by inspection for compliance with E.4.8.

E.15 Marking and identification (all equipment categories)

The EUT shall be ckecked by inspection for compliance with E.4.9.

Annex F
(normative)

Automatic tracking device (ATD) – Methods of testing and required test results – Class A only

F.1 Performance requirements

F.1.1 "Automatic tracking device" (ATD)

F.1.1.1 Collision avoidance

In order to improve the standard of collision avoidance at sea, ATD shall:

a) reduce the workload of observers by enabling them to obtain information about automatically plotted targets so that they can perform as well with several separate targets as they can by manually plotting a single target;

b) provide continuous, accurate and rapid situation evaluation.

F.1.1.2 Minimum requirements

The ATD shall comply with the following minimum requirements.

F.1.1.3 Master display

Where an ATD display is intended for use as the master display of a complete radar system, the system shall comply with IEC 62252.

F.1.1.4 Slave display

Where an ATD display is intended for use as a slave display of a complete radar system it shall comply with the relevant clauses of IEC 62252, where applicable to such a display. In addition, the ATD display shall be capable of presenting readily the signals shown on the master display without significant degradation.

F.1.2 Performance standards

F.1.2.1 Detection

Where a separate facility is provided for detection of targets, other than by the radar observer, it shall have a performance not inferior to that, which could be obtained by the use of the radar display.

F.1.2.2 Acquisition

F.1.2.2.1 Manual acquisition

There shall be a facility to provide for manual acquisition with the relevant symbol (see symbol 1 of Annex H) and cancellation for relative speeds up to 100 knots.

F.1.2.2.2 Manual acquisition use

Manual acquisition shall have a performance not inferior to that, which could be obtained by the user of the radar display.

F.1.2.3 Tracking

F.1.2.3.1 Automatic tracking and display

The "automatic tracking device" shall be able to automatically track, process, simultaneously display and continuously update the information of targets. A target being acquired and tracked during the initial stage shall be shown by a symbol (see symbol 3 of Annex H) within 3 s. Targets being tracked when tracking is in steady state shall be shown by symbols 4A or 4B and 5 of Annex H within 20 scans.

F.1.2.3.2 Acquired track continuation

The "automatic tracking device" shall continue to track an acquired target, which is clearly distinguishable on the display for any 5 out of 10 consecutive scans, provided the target is not subject to target swap.

F.1.2.3.3 Track error minimisation

The possibility of tracking errors, including target swap, shall be minimised by "automatic tracking device" design. A qualitative description of the effects of error sources on the automatic tracking and corresponding errors shall be provided to the user, including the effects of low signal-to-noise and low signal-to-clutter ratios caused by sea returns, rain, snow, low clouds and non-synchronous emissions. Such descriptions shall be in the operating manual.

F.1.2.3.4 Target identifiers

Automatically applied "target identities" shall not be re-used until, as a minimum, the number assigned equals the maximum number of tracked targets.

F.1.2.3.5 Tracking of a manoeuvring target

The ATD shall continuously track a manoeuvring target.

F.1.2.4 Display

The display may be a separate or integral part of the ship's radar. However, the "automatic tracking device" display shall include all the data required to be provided by a radar display in accordance with the performance standards for navigational radar equipment.

F.1.2.4.1 Integrity

The design shall be such that any malfunction of "automatic tracking device" parts producing data additional to information to be produced by the radar as required by the performance standards for navigational equipment shall not affect the integrity of the basic radar presentation.

The equipment shall be regarded as complying with the above if the design is such that, where practicable, normal performance of the radar system in accordance with IEC 62252 will not be affected by malfunction of any ATD subsystem that is not an essential part of the radar.

F.1.2.4.2 Range availability

The "automatic tracking device" facilities shall be available on at least 3, 6 and 12 nautical mile range scales and there shall be a positive indication of the range scale in use.

F.1.2.4.3 Additional range availability

"Automatic tracking device" facilities may also be provided on other range scales. The methods of operation, which are provided, shall be clearly described in the manufacturer's manual.

F.1.2.4.4 Display mode capability

The "automatic tracking device" shall be capable of operating with a relative motion display with "north-up" and "course-up" azimuth stabilization. In addition, the "automatic tracking device" may also provide for a true motion display. If true motion is provided, the operator shall be able to select for his display either true or relative motion. There shall be a positive indication of the display mode and orientation in use.

F.1.2.4.5 Course and speed information

The course and speed information generated by the "automatic tracking device" for acquired targets shall be displayed in a vector or graphic form, which clearly indicates the target's predicted motion with the relevant symbols (see symbols 4A or 4B or 5 of Annex H). In this regard:

a) an "automatic tracking device" presenting predicted information in vector form only, shall have the option of both true and relative vectors. There shall be an indication of the vector mode selected and if "true" is selected, there shall be a display of whether it is stabilized with reference to sea or ground;

b) an "Automatic tracking device" which is capable of presenting target course and speed information in graphic form shall also, on request, provide the target's true and/or relative vector;

c) vectors displayed shall be time-adjustable;

d) a positive indication of the time-scale of the vector in use shall be given. For class B and class C a positive or an indirect indication of the time-scale of the vector in use shall be given; and

e) if stationary targets are being used for ground referencing then this shall be indicated with the relevant symbols (see symbol 13 of Annex H). In this mode, relative vectors including those of the targets used for ground referencing shall be displayed when requested.

F.1.2.4.6 Visibility of radar targets

The "automatic tracking device" information shall not obscure the visibility of radar targets. The display of "automatic tracking device" data (vector, graphic and associated symbol) shall be under the control of the radar observer. It shall be possible to cancel the display of unwanted "automatic tracking device" data within 3 s of command.

F.1.2.4.7 ATD information display

It shall be possible to remove the ATD information completely from the display.

F.1.2.4.8 Visibility of information

The method of presentation shall ensure that the "automatic tracking device" information is clearly visible in general to more than one observer in the conditions of light normally experienced on the bridge of a ship by day and by night. Screening may be provided to shade the display from sunlight but not to the extent that it will impair the observer's ability to maintain a proper lookout. Facilities to adjust the brightness shall be provided.

F.1.2.4.9 Range and bearing accessibility

Provisions shall be made to obtain quickly the range and bearing of any object which appears on the "automatic tracking device" display. The accuracy for this data shall be as stated within this standard.

F.1.2.4.10 Target motion indication

The "automatic tracking device" shall present in a period of not more than 1 min an indication of the target's motion trend and display within 3 min the targets predicted motion in accordance with F.1.2.4.5, F 1.2.6, F.1.2.7.1 and F.1.2.7.2.

F.1.2.4.11 Availability of ATD information

After changing range scales on which the "automatic tracking device" facilities are available or on resetting the display, full plotting information shall be displayed within a period of time not exceeding one scan of 360°.

F.1.2.5 Operational warnings

A simple guard zone (F.1.2.5.1) may be provided.

If provided the "automatic tracking device" shall have the capability to warn the observer with a visual and audible signal of any distinguishable target that closes to a range or transits a zone chosen by the observer. The target causing the warning shall be clearly indicated with the relevant symbols (see Annex H) on the display.

F.1.2.5.1 Guard zone

A target entering the zone shall initiate an audible and visual alarm. The visual alarm shall be symbol 7 of Annex H. After acknowledgement the symbol may cease to flash and shall remain until outside the zone.

F.1.2.5.2 Methods of operation provided

The methods of operation that are provided shall be clearly described in the manufacturer's operation manual.

F.1.2.5.3 Closing target indication

The "automatic tracking device" shall have the capability to warn the observer with a visual and audible signal of any tracked target that is predicted to close within a minimum range and time chosen by the observer. The target causing the warning shall be clearly indicated with the relevant symbols (see symbol 8 of Annex H) on the display.

F.1.2.5.4 Lost target indication

The "automatic tracking device "shall clearly indicate if a tracked target is lost, other than out of range and the target's last tracked position shall be clearly indicated on the display (see symbol 9 of Annex H).

F.1.2.5.5 Warning capability activation or de-activation

It shall be possible for the observer to activate or de-activate the audible warning capability.

F.1.2.6 Alphanumeric data requirements

F.1.2.6.1 Target selection

The observer shall be able to select any tracked target to obtain data. Targets selected shall be marked with the relevant symbol (see symbol 12 of Annex H) on the radar display. If data is required for more than one target at the same time, each symbol shall be separately identified, for example with a number adjacent to the symbol.

F.1.2.6.2 Target selection information

The following information for each selected target shall be clearly and unambiguously identified and displayed immediately and simultaneously in alphanumeric form outside the radar area:

a) present range of the target;

b) present bearing of the target;

c) predicted target range at the closest point of approach (CPA);

d) predicted time to CPA (TCPA);

NOTE If the CPA has passed, it shall be indicated by a TCPA with a negative (–) sign.

e) calculated true course of the target;

f) calculated true speed of the target.

F.1.2.6.3 Identification of sea or ground reference

The display of F.1.2.6.2 e) and f) shall include an identification of whether the data uses sea or ground reference.

F.1.2.6.4 Simultaneous display of target information

When information for several targets is displayed, not less than two items shall be displayed simultaneously for each target selected. If the items of information are displayed in pairs for each target, the groupings shall be F.1.2.6.2 a) with b); c) with d); and e) with f).

F.1.2.7 Accuracy

The "automatic tracking device" shall provide at least the accuracies that are given in F.1.2.7.1 and F.1.2.7.2 for the four scenarios defined in Clause F.3 and with the sensor errors specified in Clause F.4. The values given relate to the best possible manual plotting performance under environmental conditions of ±10° of roll.

F.1.2.7.1 Steady state tracking presentation

An "automatic tracking device" shall present within 1 min of steady state tracking the relative motion trend of a target with the following accuracy values (95 % probability values).

Table F.1 – Accuracy values

Scenario	Data		
	Relative course degrees	**Relative speed** knots	**CPA** nautical miles
1	11	2,8	1,6
2	7	0,6	–
3	14	2,2	1,8
4	15	1,5	2,0
NOTE 1 In steady state tracking both own and target ship follow a straight-line course at constant speed.			
NOTE 2 Probability values are the same as confidence levels.			
NOTE 3 The values are plus (+) and minus (–).			

F.1.2.7.2 Presentation of steady state tracking within 3 min

An "automatic tracking device" shall present within 3 min of steady state tracking the motion of a target with the following accuracy values (95 % probability values).

Table F.2 – Accuracy values

Scenario	Data					
	Relative course degrees	**Relative speed** knots	**CPA** nautical miles	**TCPA** min	**True course** degrees	**True speed** knots
1	3,0	0,8	0,5	1,0	7,4	1,2
2	2,3	0,3	–	–	2,8	0,8
3	4,4	0,9	0,7	1,0	3,3	1,0
4	4,6	0,6	0,7	1,0	2,6	1,2
NOTE The values are plus (+) and minus (–).						

F.1.2.7.3 Presentation of target motion trend

When a tracked target or own ship, has completed a manoeuvre, the system shall present in a period of not more than 1 min an indication of the target's motion trend and display within 3 min the target's predicted motion in accordance with F.1.2.4.5, F.1.2.6, F.1.2.7.1 and F.1.2.7.2. In this context, a "manoeuvre of own ship" shall be deemed to consist of an alteration of course of ±45° in 1 min.

F.1.2.7.4 Own ship movement error contribution

The "automatic tracking device" shall be designed in such a manner that under the most favourable conditions of own ship motion the error contribution from the "automatic tracking device" shall remain insignificant, compared to the errors associated with the input sensors, for the included scenarios (see Clause F.3).

F.1.2.8 Connections with other equipment

The "automatic tracking device" shall not degrade the performance of any equipment providing sensor inputs. The connection of the "automatic tracking device" to any other equipment shall not degrade the performance of that equipment. This requirement shall be met whether the "automatic tracking device" is operating or not. Additionally, the "automatic tracking device "shall be designed to comply with this requirement under fault conditions as far as is practicable.

F.1.2.8.1 External sensor connection sensing and status

The ATD shall provide an indication when any input from an external sensor is absent. The ATD shall also repeat any alarm or status messages concerning the quality or source of the input data from its external sensors that may influence its operation.

F.1.2.8.2 Data exchange

Data exchange between the ATD and other equipment shall be in accordance with IEC 61162. As far as possible, such an interface shall not degrade the ATD performance by normal or abnormal behaviour of the interface nor of the signals on it.

F.1.2.8.3 Alternative data exchange

If no suitable IEC 61162 interface is available, another appropriate interface may be used.

F.1.2.9 Warnings

The "automatic tracking device" shall provide suitable warnings of "automatic tracking device" malfunction to enable the observer to monitor the proper operation of the system.

F.1.2.10 Sea and ground stabilization

F.1.2.10.1 Sea stabilization

Log and speed indicators providing inputs to "automatic tracking device" equipment shall be capable of providing the ship's speed through the water in the fore and aft direction.

F.1.2.10.2 Ground stabilization

If a ground stabilized input is also available from

a) a dual axis log;

b) an electronic position-fixing system (if the speed measurement accuracy is in accordance with the requirements of IEC 61108);

c) tracked stationary targets,

then

– the source of the input in use shall be displayed;

– the type of the input in use shall be displayed (F.1.2.10.1 and F.1.2.10.2).

F.1.2.11 Equipment connected to the "automatic tracking device"

Speed and heading measuring equipment shall be connected to the "automatic tracking device". The type and capability of the sensor equipment shall be detailed in the manufacturer’s documentation.

The speed input shall provide speed through the water and may, in addition, provide speed over ground.

The type of measuring equipment in use shall be indicated on the display.

F.2 Methods of testing and required test results

F.2.1 General

Tests shall be conducted normally by operating the ATD under test covering the adjacent sea area and using simulated target echoes from a synthetic target generator (see F.4.10) whose characteristics are similar to target echoes produced by the radar. Means shall be provided for setting the effective amplitude of one or more simulated targets to 10 dB above peak noise level, such a target being referred to in the test data as a "test reference" target.

Unless otherwise stated, simulated targets shall follow constant courses at constant speeds and tests shall be carried out on each range scale on which ATD facilities are provided, up to a maximum of 24 nautical miles.

Subclause F.4.10 shall be consulted for more details on using simulated targets.

Before these tests are conducted, the equipment under test (EUT) shall be subjected to and shall satisfy, the relevant parts of this standard handling the environmental and EMC testing (see Annex E).

F.2.2 Detection, acquisition, tracking and general facilities

F.2.2.1 Confidence

Before implementing these tests, the test operator shall carry out a confidence check, by non-quantitative means, to ensure that the basic functions of F.1.2.1, F.1.2.2 and F.1.2.3 are available.

F.2.2.2 Detection

There is no additional test for this function as it is covered by other tests.

F.2.2.3 Manual acquisition

F.2.2.3.1 Method of measurement

Ten simulated radar targets superimposed on radar receiver generated noise or equivalent shall be fed into the ATD. One or more of these targets shall be a reference target. The targets shall be positioned with an approximately uniform distribution at ranges between 1 nautical mile and the maximum of the range scale in use or the maximum acquisition range provided and over an arc of not less than 120°.

Two or more of the simulated targets shall have a speed relative to the test radar of not less than 5 knots and one of these shall start at a range of approximately 5 nautical miles with a relative speed of 100 knots. The operation of the manual acquisition and tracking cancellation controls shall be tested on all range scales on which acquisition facilities are provided and the target symbols of those acquired shall be observed on the display.

Acquisition shall be tested in the following cases:

a) each of a pair of targets on the same bearing, at a mean range of approximately 10 nautical miles and separated by 0,5 nautical miles;

b) as a) above but at a mean range of approximately 2,5 nautical miles;

c) each of a pair of targets at a common range of approximately 10 nautical miles and on bearings so that the adjacent edges of their targets are separated by 4°;

d) as c) above but at a common range of approximately 2,5 nautical miles.

F.2.2.4 Tracking

F.2.2.4.1 Method of measurement

Following the acquisition phases of F.2.2.3, the system shall be required to continue to track the acquired targets for a period of not less than 12 min or until they exceed the maximum tracking range or fall below the reference target level.

At the end of the 12 min period the range scale shall be changed and the presentation of full plotting information shall be checked for those acquired targets which shall be displayed on the new range scale.

F.2.2.4.2 Results required

a) It shall be possible in all cases specified in F.2.2.3 to acquire each target within not more than five scans after the initiation of acquisition, i.e. from the time of the completion of the manual acquisition procedure.

   Proportionately longer time up to a maximum of 1 min shall be allowed where the target to be acquired is within 6° of other targets that are being or have been acquired.

b) In all cases, it shall be possible to acquire not less than 10 targets by manual means.

c) In all cases, a clearly identifiable relevant symbol (see Annex H) shall appear on the display at each acquired target.

d) It shall be possible, by suitable means provided, including manual means, to cancel any chosen acquired target.

e) Within 20 scans of the initiation of acquisition of each target the appropriate symbol in Annex H shall indicate the general trend of the target motion.

f) Within 60 scans of the initiation of acquisition, data as required by F.1.2.4.5 and F.1.2.6.2 shall be available on all tracked targets.

g) All symbols shall correlate with the relevant targets unambiguously.

h) The provision of suitable means of complying with F.1.2.4.6 and F.1.2.4.7 shall be verified.

i) Compliance with F.1.2.4.11 shall be verified.

F.2.3 Tracking reliability

F.2.3.1 Fading target

F.2.3.1.1 Method of measurement

The echo due to a test reference target with a relative speed of 20 knots and on a constant course shall be fed into the ATD and shall be acquired. To avoid the possibility of target swap, no other target shall come within 1 nautical mile of the test target.

Starting not less than 60 scans after the initiation of acquisition, the echo shall be caused to miss 50 % of any 10 consecutive paints in various patterns which shall include missing alternate paints and missing five consecutive paints. The test shall be repeated with test target relative speeds of 5 knots and 100 knots.

F.2.3.2 Lost target warning

F.2.3.2.1 Method of measurement

At the conclusion of each test of F.2.3.1, the test target echo shall be suppressed at its source.

F.2.3.3 Target manoeuvre

F.2.3.3.1 Method of measurement

The echo due to a test reference target with a relative speed of 20 knots and on a collision course with own ship shall be fed into the ATD and be acquired at a range of not less than 5 nautical miles. When the target reaches a range of 3 nautical miles, it shall be caused to turn to starboard at a rate 5°/s through an angle of 90° and shall then follow a constant course at constant speed for not less than 3 min.

F.2.3.4 Target swap

F.2.3.4.1 Method of measurement

The echo due to a test reference target with a relative speed of 20 knots and on a collision course with own ship shall be fed into the ATD and shall be acquired at a range of not less than 10 nautical miles.

When the target reaches a range of 5 nautical miles it shall be caused to pass a non-acquired, stationary, reference target displaced in bearing so that the adjacent edges of their echoes are separated by 4° and shall continue on the same course for not less than 1 min.

F.2.3.4.2 Results required

a) The ATD shall continue to track the test target throughout the test of F.2.3.1 and shall not initiate the lost target warning.

b) The lost target warning shall be initiated automatically not more than 20 scans after the start of test of F.2.3.2. Observe that the indication appears initially at the track position at which the alarm was initiated.

c) The ATD shall continue to track the target throughout the test of F.2.3.3.

d) The ATD shall continue to track the acquired target throughout the test of F.2.3.4.

F.2.4 Tracking accuracy

F.2.4.1 Method of measurement

a) The ATD shall be set to the 12 nautical mile range scale and shall be fed with compass and log inputs corresponding to scenario 1 of Clause F.3. A test reference target, whose course, speed and initial position are such that 3 min after acquisition they shall correspond to those given in scenario 1 of Clause F.3 shall be fed into the ATD. The target echo signal and own ship inputs shall be generated by means which take account of the sensor errors listed in Clause F.4 including those due to own ship roll of ±10°.

   The target shall be acquired and the time of acquisition, t_0, as defined in F.2.2.4.2.a) shall be noted.

   At t_0 + 1 min, the motion trend of the target as indicated on the ATD display in vector or graphic form shall be observed.

   At t_0 + 3 min, the true course and speed and the CPA and TCPA of the tracked test target shall be obtained from the ATD alphanumeric read-out facility and recorded. The motion of the target as indicated on the ATD display in vector or graphic form shall be observed. The target echo generator shall be reset and the test repeated until a total of 20 tests has been recorded. If the target echo generator utilises pseudo-random number generators then arrangements shall be made for a different sequence to be used for each test.

b) The observed indications in vector or graphic form shall be compared with the requirements of F.1.2.7.1 or F.1.2.7.2 as appropriate.

c) The error in each recorded value shall be determined by subtracting from each recorded result the correct value for that parameter as derived from this scenario.

d) The above test procedure shall be repeated successively for scenarios 2, 3 and 4 of Clause F.3.

e) The operating manual shall be checked for the inclusion of information relating to the requirements of F.1.2.3.3.

F.2.4.2 Results required

If the results of all 20 tests are within the limits given in the tables of F.1.2.7.1 or F.1.2.7.2 as appropriate, the equipment shall be considered as complying with the requirements for the particular scenario under test.

If the result of any test is outside the limits, a statistical analysis shall be applied to all the results and if necessary, additional tests shall be carried out.

F.2.5 Closing target warning

F.2.5.1 Method of measurement

a) The echo of a test reference target with a relative speed of 20 knots and on a collision course with own ship shall be fed into the ATD. The guard zones shall be previously adjusted to be at a range of 10 nautical miles encompassing the bearing of the target and shall not include a clutter area. The target shall be initially at a range of not less than 11 nautical miles. The target shall follow a constant course until it reaches a range of 8 nautical miles. The test shall be repeated with the zone adjusted to a range of 2,5 nautical miles with initial and final ranges of the target of approximately 3 nautical miles and 1,5 nautical miles respectively.

b) The operation of the zone shall be observed for an extended period.

c) The operating manual shall be checked for the inclusion of information relating to the requirements of F.1.2.5.

F.2.5.2 Results required

a) The guard zone shall be clearly indicated on the display with the relevant symbol. In each test of F.2.5.1, the closing target warning shall be initiated automatically, not more than 1 min after the target crosses the outer boundary of the guard zone as indicated on the display. The position of the target shall be clearly indicated on the display with the relevant symbol.

b) The false alarm rate shall not be excessive.

c) The operating manual shall be satisfactory.

F.2.6 Collision risk (CPA/TCPA) warning

F.2.6.1 Method of measurement

a) Using the 12 nautical mile range scale, the CPA warning limit shall be set to a range of approximately 1,5 nautical miles and the TCPA warning limit shall be set to a convenient time between 10 min and 20 min, inclusive. The echoes due to two reference targets, each with a relative speed of 20 knots and on a collision course with own ship shall be fed into the ATD at ranges so that their TCPAs differ by 3 min. Each target shall be acquired at a range so that its TCPA is at least 4 min greater than the limit set for the TCPA warning. The alphanumeric read-out of TCPA for the nearer target shall be monitored and its value when the warning is initiated shall be recorded.

   The minimum value observed before the warning is initiated shall be recorded.

   Any audible warning initiated by this target shall be cancelled within 30 s of its initiation. The farther target shall then be similarly monitored and recorded.

b) The test shall be repeated using the same warning limit settings but with a single test target on a succession of courses giving CPA ranges just less than and just greater than the limit set for the CPA warning, the target being tracked until it reaches its CPA.

The alphanumeric read-outs of CPA and TCPA shall be monitored and shall be recorded when the warning is initiated. Additionally, prior to the initiation of the warning, the indicated CPA and TCPA shall be recorded if at any time both of them are less than 0,9 times their respective set limit values.

F.2.6.2 Results required

a) For each target in the test of F.2.6.1 a), the recorded TCPA at which the warning is initiated shall be not greater than 1,1 times the limit set for the TCPA warning. The minimum TCPA recorded before the warning is initiated shall be not less than 0,9 times the limit set for the TCPA warning.

b) For each test of F.2.6.1 b), the recorded CPA and TCPA at which the warning was initialised shall be not greater than 1,1 times their respective set limit values.

There shall be no recorded instance of the CPA and TCPA indications when both are less than 0,9 times their set limit values before the warning is initiated.

F.2.7 Display

Check by inspection of the equipment that the requirements of F.1.2.4 are complied with, except that in F.1.2.4.10, 1 min and 3 min shall be replaced by 20 scans and 60 scans respectively.

F.2.8 Audible warnings

Check by inspection of the EUT.

F.2.9 Data requirements

Check by inspection of the EUT.

F.2.10 Interfaces

By practical demonstration and inspection of the documentation.

F.2.11 Performance test and warnings

By practical demonstration and inspection of the documentation.

F.2.12 Sea and ground stabilization

Methods provided shall be tested by practical demonstration and inspection of the documentation.

F.2.13 Equipment connected to "Automatic tracking device"

By practical demonstration and inspection of the documentation.

F.2.14 System configuration and quality assurance

By practical demonstration and inspection of the relevant documentation.

F.3 Operational scenarios

For each of the following scenarios, predictions are made at the target position defined after previously tracking for the appropriate time of 1 min or 3 min:

Table F.3 – ATD scenarios

Scenario 1	Own ship course	000°
	Own ship speed	10 knots
	Target range	8 nautical miles
	Bearing of target	000°
	Relative course of target	180°
	Relative speed of target	20 knots
Scenario 2	Own ship course	000°
	Own ship speed	10 knots
	Target range	1 nautical mile
	Bearing of target	000°
	Relative course of target	090°
	Relative speed of target	10 knots
Scenario 3	Own ship course	000°
	Own ship speed	5 knots
	Target range	8 nautical miles
	Bearing of target	045°
	Relative course of target	225°
	Relative speed of target	20 knots
Scenario 4	Own ship course	000°
	Own ship speed	25 knots
	Target range	8 nautical miles
	Bearing of target	045°
	Relative course of target	225°
	Relative speed of target	20 knots

F.4 Sensor errors

For the accuracy figures quoted in F.1.2.7, the error model is based upon the following sensor errors.

NOTE σ means 'standard deviation'.

F.4.1 Radar

F.4.2 Target glint (scintillation) (for 200 m length target)

Along length of target σ = 30 m (normal distribution)

Across beam of target σ = 1 m (normal distribution)

F.4.3 Roll-pitch bearing

The bearing error will peak in each of the four quadrants around own ship for targets on relative bearings of 045°, 135°, 225° and 315° and will be zero at relative bearings of 0°, 90°, 180° and 270°. This error has a sinusoidal variation at twice the roll frequency.

For a 10° roll the mean error is 0,22° with a 0,22° peak sine wave superimposed.

F.4.4 Beam shape

Assumed normal distribution giving bearing error with σ = 0,05°.

F.4.5 Pulse shape

Assumed normal distribution giving range error with σ = 20 m.

F.4.6 Antenna backlash

Assumed rectangular distribution giving bearing error ±0,05° maximum.

F.4.7 Quantization

Bearing – rectangular distribution ±0,1°.

Maximum range – rectangular distribution ±0,01 nautical miles maximum.

Bearing encoder assumed to be running from a remote synchro giving bearing errors with a normal distribution σ = 0,03°.

F.4.8 Gyro-compass

Calibration error 0,5° with a normal distribution about this with σ = 0,12°.

F.4.9 Log

Calibration error 0,5 knots with a normal distribution about this with 3 σ = 0,2 knots.

The above (Clause F.4) values shall be used for the testing of the ATD.

The bearing error resulting from the combination of all sensor errors including target glint shall be limited to ±0,6°.

F.4.10 ATD testing using simulated targets

This standard specifies the accuracy requirements and various other aspects of performance with which an ATD shall comply. These requirements are contained in Clause F.1.

One method of determining whether an ATD satisfies the accuracy requirements is to simulate the radar return from a target by injecting signals into the ATD at video frequency and causing the simulated target to move in accordance with each of the scenarios of Clause F.3. This can be achieved by passing antenna bearing, trigger and video signals from the radar to a synthetic echo generator (SEG), which then feeds the trigger and video signals to the ATD having mixed a synthetic echo, representing a target, with the radar video. This synthetic echo can, if required, be controlled in size and intensity.

In normal operation at sea, the data fed to the ATD by the radar suffers from errors due to several factors. The principal ones are identified and quantified in Clause F.4. When simulated targets are used to determine the accuracy of an ATD, it is necessary to

superimpose the effects of these errors onto the simulated target signal. This can be done by random sampling of the distributions of the various errors, using different (randomly selected) values for each successive revolution of the radar antenna.

Most errors can be expressed as simple relative range and bearing deviations of the track of a target. However, one error source identified in Clause F.4, which has to be simplified for purposes of the simulation, is the target glint, because real target glint is a very complex physical phenomenon, being a characteristic of the target's structure and instantaneous aspect relative to the radar. A simple and reasonably realistic method of simulating the effect of target glint is to generate a synthetic echo of fixed size and intensity and cause the position of this echo to move in accordance with the distributions identified for target glint in Clause F.4.

It is necessary to simulate each scenario at least 20 times using different random samples of the errors in order to assess whether or not an ATD satisfies the accuracy requirements. All the random numbers required can be computer generated.

Preferably a Sensor Error Generator (SEG), which has the capability of generating up to 20 targets for some of the tests, shall be used to carry out many of the performance tests specified in this standard.

This method of testing an ATD has certain advantages over the use of real targets. For example, each test is carried out under controlled conditions that can be set up accurately and can be repeated exactly.

Annex G
(normative)

Electronic plotting device (EPD) Class A only

G.1 Performance requirements

G.1.1 Introduction

"Electronic plotting device" (EPD) shall, in order to improve the standard of collision avoidance at sea:

a) reduce the workload of observers by enabling them to obtain information about plotted targets so that they can perform as well with several separate targets as they can by manually plotting a single target;

b) provide continuous, accurate and rapid situation evaluation.

G.1.1.1 Facilities

The radar facilities provided by an EPD display shall comply with the relevant clauses of this standard appropriate to its mode of use.

In addition to the general requirements contained within this standard, the EPD shall comply with the following minimum requirements.

G.1.2 Definitions

See Clause 3 of this standard.

G.1.2.1 Means to plot

The electronic plotting device shall provide a means to plot targets on a radar display.

See Clause G.4 for a description of how manual plotting shall be implemented.

G.1.2.2 Range scales

G.1.2.2.1 Plotting

It shall be possible to plot targets on the 3, 6 and 12 nautical mile range scales. The facility may be provided on additional range scales. There shall be a positive indication of the range scale in use. Plots shall be maintained when switching between range scales. The methods of operation that are provided shall be clearly described in the manufacturer's manual.

G.1.2.2.2 Time to plot after change of range

After changing range scales on which the "electronic plotting device" facilities are available or on resetting the display, full plotting information shall be displayed within a period of time not exceeding one scan of 360°.

G.1.2.3 Target plotting speed

It shall be possible to plot targets with a relative speed up to 75 knots.

G.1.2.4 CPA/TCPA limits adjustment

It shall be possible for the operator to adjust the CPA/TCPA limits and the vector time.

G.1.2.5 Plot positions and identification

G.1.2.5.1 Identification of plot position

Plot positions shall be identified by an approved symbol (see Annex H, symbols 1, 4 or 6) and an associated plot number. It shall be possible to switch off the plot number.

G.1.2.5.2 Automatic target identity

Automatically applied 'target identities' shall not be re-used until, as a minimum the number assigned, equals the maximum number of plotted targets.

G.1.2.6 Lapsed time between plots

The minimum lapsed time between any two plots shall be greater than 30 s.

G.1.2.7 Vectors

After the second plot, a vector shall be displayed on the target, It shall be possible to select a true or relative vector. There shall be a positive indication of vector mode, including an indication of sea or ground stabilization:

a) vectors displayed shall be time-adjustable;

b) a positive indication of the time-scale of the vector in use shall be given.

G.1.2.8 Vector origin

The vector origin shall move across the screen at a rate and direction defined by the calculated true course and speed.

G.1.2.9 Plot correction

It shall be possible to correct the position of a plot.

G.1.2.10 Target data on demand

It shall be possible, on demand, to display the following data on a selected target:

a) plot number and time since last plot (min); (format xx:mm)

b) present range of the target;

c) present true bearing of the target:

d) predicted target range at the closest point of approach (CPA);

e) predicted time to CPA (TCPA);

NOTE If the CPA has passed, it shall be indicated by a TCPA with a negative (–) sign.

f) calculated true/relative course of target;

g) calculated true/relative speed of target.

The selected plot shall be clearly identified with an approved symbol (see Annex H, symbol 12) and the plot data shall be displayed outside of the screen radar area. If data is required for more than one target at the same time each symbol shall be separately identified, for example, with a number adjacent to the symbol.

G.1.2.11 Plot identity/lapsed time drop-out

There shall be an indication by a text message including the plot number of any plot that is not updated for 10 min. The plot shall be dropped if the time between consecutive plots exceeds 15 min.

G.1.2.12 Display

The display may be a separate or an integral part of the ship's radar. However, the "electronic plotting device" display shall include all the data required to be provided by a radar display in accordance with the performance standards for navigational radar equipment.

G.1.2.12.1 Integrity of information

The design shall be such that any malfunction of "electronic plotting device" parts producing data additional to information to be produced by the radar as required by the performance standards for navigational equipment, shall not affect the integrity of the basic radar presentation.

The equipment shall be regarded as being in compliance if the design is such that, where practicable, correct operation of the radar system in accordance with this standard will not be affected by a malfunction of any EPD sub-system that is not an essential part of the radar.

G.1.2.12.2 Display mode capability

The "electronic plotting device" shall be capable of operating with a relative or true motion display with "north-up" azimuth stabilization. There shall be a positive indication of the display mode and orientation in use.

G.1.2.12.3 Radar target visibility

The "electronic plotting device" information shall not obscure the visibility of radar targets. The display of EPD information (vector and associated symbol) shall be under the control of the radar observer. It shall be possible to cancel the display of unwanted "electronic plotting device" information within 3 s of command.

G.1.2.12.4 Plot information

It shall be possible to remove the EPD information completely from the display.

G.1.2.12.5 EPD information presentation

The method of presentation shall ensure that the EPD information is clearly visible in general to more than one observer in the conditions of light normally experienced on the bridge of a ship by day and by night. Screening may be provided to shade the display from sunlight but not to the extent that it will impair the observer's ability to maintain a proper lookout.

G.1.2.13 Operational alarms and indications

G.1.2.13.1 Minimum range alarm

The "electronic plotting device" shall have the capability to alarm the observer with a visual and audible signal of any tracked target that is predicted to close within a minimum range and time, chosen by the observer. The target causing the alarm shall be clearly indicated with the relevant symbols (see Annex H, symbol 8) on the display.

G.1.2.13.2 Audible alarm control

It shall be possible for the observer to activate or de-activate the audible alarm capability.

G.1.2.14 Connections with other equipment

The connection of the "electronic plotting device" to any other equipment shall not degrade the performance of that equipment. This requirement shall be met whether the "electronic plotting device" is operating or not. Additionally, the EPD shall be designed to comply with this requirement under fault conditions as far as is practicable.

G.1.2.14.1 Serial interfaces

Provided serial interfaces shall comply with the IEC 61162 series, as applicable.

G.2 Methods of testing and required test results

G.2.1 General

Before these tests, the equipment under test (EUT) shall be subjected to and satisfy the relevant parts of this standard regarding the environment and EMC testing (see Annex E).

G.2.2 Description of manual plotting tests

G.2.2.1 General principle

Comparing target data (CPA, TCPA, speed and course) gained simultaneously from the EUT of the EPD device and from evaluation of plot-positions (range and bearing) while plotting a cursor position simulating a target position.

G.2.2.2 Operational conditions

The tests shall be carried out by entering plots to pre-defined positions (range and bearing) and own ship data according to 'test scenarios' covering the most relevant sources of potential error. The 'test scenarios' to be used are given in Table G.1 and are detailed in Clause G.3. Faults of sensors and precision of positioning the cursor over a real radar target have no effects on these tests – only the accuracy of the EPD calculations is tested.

Table G.1 – Test scenarios

Scenario 1	Target with nearly the same course and a risk of collision (CPA = 0); after 9 min change of own course 45° starboard (CPA > 0).
Scenario 2	Own ship at anchor (SPD = 0) at time = t_o; target approaches from 135° exactly towards own position (CPA = 0); own ship gets underway at t_o + 9 min. and speed increases to 5 knots.
Scenario 3	Target with exactly the same course and speed; after 6 min reduction of own speed to 5 knots; after 12 min change of target course so that CPA = 0.
Scenario 4	Target with exactly opposite course; after 10 min change of own course 10° starboard to CPA > 0.
Scenario 5	Target with crossing course and a risk of collision (CPA = 0); after 6 min a reduction of own speed, target reduces accordingly (CPA = 0); after 12 min own course is changed 90° to port so that CPA > 0.
Scenario 6	Target with opposite course manoeuvres to a collision course (CPA = 0); after 9 min, own speed and course are changed; target changes its course accordingly (CPA = 0).

G.2.2.3 Method of measurement

With the gain reduced to a minimum or off, own ship data course and speed shall be set to the required values by using "manual settings" in steps.

Placing the cursor to the range and bearing values given by the scenario shall set plot marks.

The test scenarios shall be performed in plot intervals of 3 min. Target data CPA, TCPA, course and speed obtained by the EUT and the range and bearing values used by the EUT are read out and recorded.

G.2.2.4 Results required

All data sets shall be evaluated by using these valid values for range and bearing, compared with the target data obtained by the EUT (thus target data are not compared with the original scenario data; the scenario is only a means of making the tests comparable). Acceptable tolerances for evaluation of scenarios shall be:

a) CPA ± 0,1 nautical miles for CPA < 1 nautical mile and range < 6 nautical miles. In other cases ± 5 % of the range scale in use;

b) TCPA ± 2 min for TCPA < 10 min and range < 6 nautical miles. In other cases ± 20 % of the calculated TCPA;

c) course: ± 5°;

d) speed: ± 1 knot.

G.2.3 Display

Check for compliance with the requirements of G.1.2.4 by inspection of the equipment.

G.2.4 Audible alarms

Check by inspection of the EUT.

G.2.5 Connections with other equipment

Check by practical demonstration and inspection of the documentation.

G.3 Operational scenarios

NOTE In all scenarios, the following abbreviations are used:

T	true
R	relative
NM	nautical miles
kn	knots
SPD	speed
CPA	closest point of approach
TCPA	time to closest point of approach
CRS	course
RNG	range
BRG	bearing

G.3.1 Scenarios

All scenarios show speed and course changes of own ship, a momentarily change of speed or CRS after plotting.

Scenario 1:

Target with nearly same course and risk of collision (CPA = 0).

After 9 min change of own course 45° starboard (CPA > 0) to avoid collision.

Table G.2 – Scenario 1 data

Plot No.	Time (min)	Own ship		Marker		Target data					
		SPD (kn)	CRS (°)	RNG (NM)	T BRG (°)	R SPD (kn)	R CRS (°)	T SPD (kn)	T CRS (°)	CPA (NM)	TCPA (min)
1	0,00	25	270	5,00	315,00						
2	3,00	25	270	4,85	315,00	3,0	135,0	22,98	264,70	0,0	97,0
3	6,00	25	270	4,70	315,00	3,0	135,0	22,98	264,70	0,0	94,0
4	9,00	25	270	4,55	315,00	3,0	135,0	22,98	264,70	0,0	91,0
5	12,00	25	315	4,13	302,64	20,47	194,74	22,98	264,71	3,93	3,72
6	15,00	25	315	3,94	288,32	20,47	194,86	23,02	264,76	3,93	0,70
7	18,00	25	315	4,01	273,54	20,50	194,81	23,02	264,67	3,93	–2,29
8	21,00	25	315	4,32	260,11	20,43	194,37	22,84	264,69	3,94	–5,21

Scenario 2:

Own ship at anchor (SPD = 0) at time t_0; target approaches on a course 135° exactly towards own position (CPA = 0); after 9 min own ship get underway and speed increases to 5 knots.

Plot 1 to 3 shows CRS 0° HDG 0°

Table G.3 – Scenario 2 data

Plot No.	Time (min)	Own Ship		Marker		Target Data					
		SPD (kn)	CRS (°)	RNG (NM)	T BRG (°)	R SPD (kn)	R CRS (°)	T SPD (kn)	T CRS (°)	CPA (NM)	TCPA (min)
1	0,00	0	0	5,00	135,00						
2	3,00	0	0	4,50	135,00	10,0	315,00	10,0	315,0	0,0	27,0
3	6,00	0	0	4,00	135,00	10,0	315,00	10,0	315,0	0,0	24,0
4	9,00	5	90	3,50	135,00	10,0	315,00	10,0	315,0	0,0	21,0
5	12,00	5	90	2,83	138,58	13,97	300,34	9,97	315,01	0,89	11,55
6	15,00	5	90	2,18	144,35	13,93	300,24	9,93	314,92	0,89	8,57
7	18,00	5	90	1,56	154,84	14,11	300,62	10,14	315,17	0,88	5,48
8	21,00	5	90	1,06	176,73	13,98	300,41	9,99	315,08	0,88	2,52

Scenario 3:

Target with exactly the same course and speed; after 6 min reduction of own speed to 5 knots; after 12 min change of target course so that CPA = 0.

Table G.4 – Scenario 3 data

Plot No.	Time (min)	Own ship		Marker		Target data					
		SPD (kn)	CRS (°)	RNG (NM)	T BRG (°)	R SPD (kn)	R CRS (°)	T SPD (kn)	T CRS (°)	CPA (NM)	TCPA (min)
1	0,00	10	180	3,00	135,00						
2	3,00	10	180	3,00	135,00	0,0	0,0	10,0	180,0	3,0	**
3	6,00	10	180	3,00	135,00	0,0	0,0	10,0	180,0	3,0	**
4	9,00	5	180	3,18	138,19	4,98	179,69	9,98	180,15	2,13	–28,43
5	12,00	5	180	3,37	141,02	4,99	180,02	9,99	180,01	2,12	–31,49
6	15,00	5	180	2,70	141,02	13,40	321,02	10,0	302,73	0,0	12,09
7	18,00	5	180	2,03	141,02	13,40	321,02	10,0	302,73	0,0	9,09
8	21,00	5	180	1,37	141,02	13,20	321,02	9,83	302,36	0,0	6,23
** TCPA > 99 or undefined											

Scenario 4:

Target with exactly opposite course; after 10 min change of own course 10° starboard to CPA > 0.

Table G.5 – Scenario 4 data

Plot No.	Time (min)	Own ship		Marker		Target data					
		SPD (kn)	CRS (°)	RNG (NM)	T BRG (°)	R SPD (kn)	R CRS (°)	T SPD (kn)	T CRS (°)	CPA (NM)	TCPA (min)
1	0,00	10	90	5,00	90,00						
2	3,00	10	90	4,00	90,00	20,0	270,00	10,00	270,00	0,0	12,0
3	6,00	10	90	3,00	90,00	20,0	270,00	10,00	270,00	0,0	9,00
4	9,00	10	100	2,00	90,00	20,0	270,00	10,00	270,00	0,0	6,00
5	12,00	10	100	1,01	85,08	19,95	274,98	10,03	269,98	0,17	2,99
6	15,00	10	100	0,17	5,00	19,90	274,77	9,98	269,53	0,17	0,00
7	18,00	10	100	1,01	284,92	19,90	275,23	9,97	270,44	0,17	–3,00
8	21,00	10	100	2,00	280,00	19,95	275,02	10,03	270,05	0,17	–5,99

Scenario 5:

Target with crossing course and a risk of collision (CPA = 0);

After 6 min a reduction of own speed, target reduces accordingly (CPA = 0); after 12 min own course is changed 90° to port so that CPA > 0.

Table G.6 – Scenario 5 data

Plot No.	Time (min)	Own ship		Marker		Target data					
		SPD (kn)	CRS (°)	RNG (NM)	T BRG (°)	R SPD (kn)	R CRS (°)	T SPD (kn)	T CRS (°)	CPA (NM)	TCPA (min)
1	0,00	25	45	5,00	30,00						
2	3,00	25	45	4,50	30,00	10,00	210,0	15,56	54,58	0,0	27,00
3	6,00	15	45	4,00	30,00	10,00	210,0	15,56	54,58	0,0	24,00
4	9,00	15	45	3,75	30,00	5,00	210,0	10,25	52,25	0,0	45,00
5	12,00	15	315	3,50	30,00	5,00	210,0	10,25	52,25	0,0	42,00
6	15,00	15	315	3,89	43,66	19,21	103,05	10,25	52,28	3,35	–6,19
7	18,00	15	315	4,46	54,34	19,25	102,86	10,32	52,21	3,34	–9,21
8	21,00	15	315	5,14	62,41	19,15	103,26	10,15	52,25	3,36	–12,18

Scenario 6:

Target with opposite course manoeuvres to a collision course (CPA = 0); after 9 min own speed and course are changed; target changes its course accordingly (CPA = 0).

Table G.7 – Scenario 6 data

Plot No.	Time (min)	Own ship		Marker		Target data					
		SPD (kn)	CRS (°)	RNG (NM)	T BRG (°)	R SPD (kn)	R CRS (°)	T SPD (kn)	T CRS (°)	CPA (NM)	TCPA (min)
1	0,00	25	180	5,50	213,00						
2	3,00	25	180	4,00	229,00	39,77	359,33	14,78	358,19	3,05	3,91
3	6,00	25	180	3,50	229,00	10,00	49,00	19,92	157,74	0,00	21,00
4	9,00	25	200	3,00	229,00	10,00	49,00	19,92	157,74	0,00	18,00
5	12,00	25	200	2,75	229,00	5,00	49,00	20,77	193,30	0,00	33,00
6	15,00	5	200	2,50	229,00	5,00	49,00	20,77	193,30	0,00	30,00
7	18,00	5	290	3,33	214,64	22,05	180,41	26,81	184,00	1,87	–7,50
8	21,00	5	290	4,28	206,31	21,98	180,12	20,72	193,23	1,89	–10,53

G.4 Implementation of manual plotting

The following clauses (G.4.1 to G.4.3) describe how manual plotting shall be implemented.

G.4.1 Set up

The operator positions a first plot over the centre of the target video at position p_1 and time t_1 After an appropriate period of time a second plot (plot 2) is positioned over the current centre of the target video at position p_2 and time t_2. These positions are stored on a conceptual grid that models the earth's surface or the surface of the water, depending on the method of stabilization being used (ground or water). After the second plot has been added the target's velocity is calculated using:

$$\vec{v}_1 = (p_2 - p_1)/(t_2 - t_1)$$

A vector is then drawn at the position of the second plot with its length related to the velocity of the target. The vector is periodically updated in the video circle using the assumption that the target has constant velocity. It can show the target's true or relative motion and the operator can alter its length (in min).

G.4.2 Discrepancies

Over a period of time discrepancies between the position of the target video and the origin of the vector can build up. These can be as a result of errors in the original plot positions or as the result of a change in velocity of the target. If the operator considers that the discrepancy is significantly large, a new plot (plot 3) can be made on the current centre of the video. The velocity is then recalculated using the last two plots made:

$$\vec{v}_2 = (p_3 - p_2)/(t_3 - t_2)$$

The vector origin is reset to the position of the latest plot (plot 3) and the target's velocity is set to v_2.

G.4.3 Corrective measures

With reference to figure G.1 below, it can be seen that after the third plot the target's position and velocity are set to the best available estimates. Additionally, the operation is intuitive to the operator as small positional errors between the position of the target video and the vector origin are translated to small changes in position and velocity of the target after a corrective plot is added. Larger positional errors translate to larger changes in the position and velocity of the target. The target vector will then continue to be updated without the addition of a fourth plot until the errors grow again.

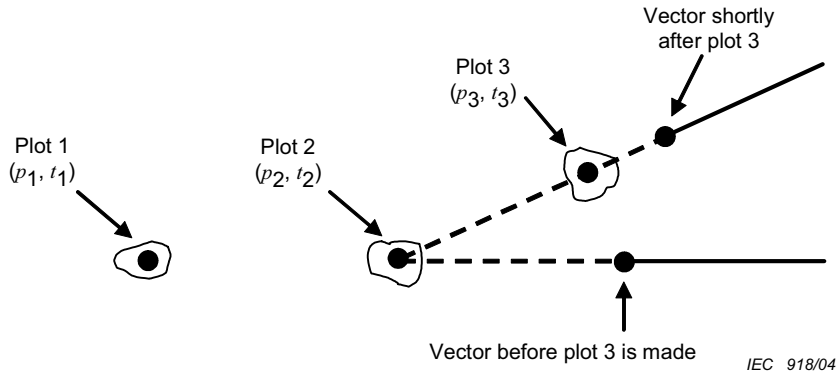


Figure G.1 – Diagram of three plots

Annex H
(normative)

Electronic plotting video symbols (EPVS) – Class A only

H.1 General

Video symbols 1, 3, 4, 5, 7, 8, 9, 11, 12 and 13 shall be used on ATD.

Video symbols 1, 4, 6, 8 and 12 shall be used on EPD. Symbol 7 may be used optionally where this facility is provided.

The size of the video symbols in the text assumes a 340 mm effective diameter display. Where the sizes of alphanumeric characters are not specified, they shall be 6 mm high. For smaller diameter displays the size shall be proportionally smaller. (See E.4.2.1.5)

Other symbols may be used for other anti-collision functions provided they do not conflict with symbols 1 to 14 and navigational symbols for radar (Annex C of the IEC 60936 series) and IHO chart symbols (IHO S-52). The use of these other anti-collision symbols shall be limited to ensure that they do not obscure the anti-collision requirements of the EPD/ATD.

If two or more symbols simultaneously apply to a target, then the symbols may be displayed together, provided that they are clearly distinguishable.

For the three warning and alarm symbols (symbols 7, 8 and 9), the following priorities shall be used:

– An unacknowledged alarm (symbol 7 flashing) is always a higher priority than an acknowledged alarm (symbol 7 steady);
– CPA/TCPA warning (symbol 8) has a higher priority than a target entering a guard zone (symbol 7);
– Guard zone warning (symbol 7) has a higher priority than a lost target warning (symbol 9).

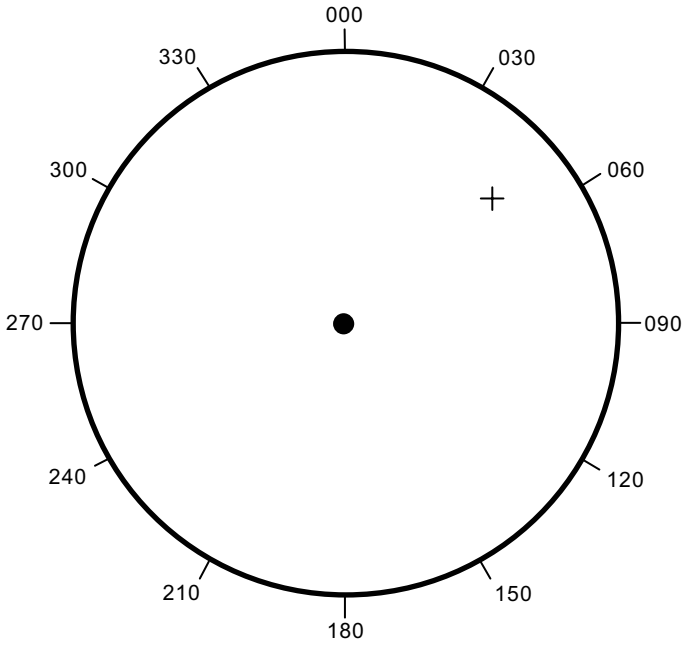
H.2 Symbols

The following symbols are graphically presented within a representation of a radar plotting display.

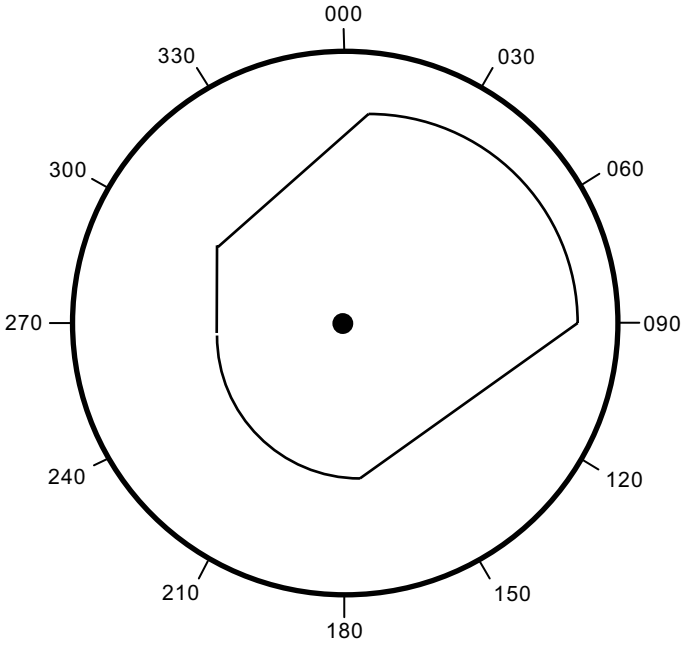
The following diagrams are intended to illustrate only the form of the symbols.

NOTE These symbols are taken from IEC 60872-1 for compatibility; symbol 10 for trial manoeuvre is not used.

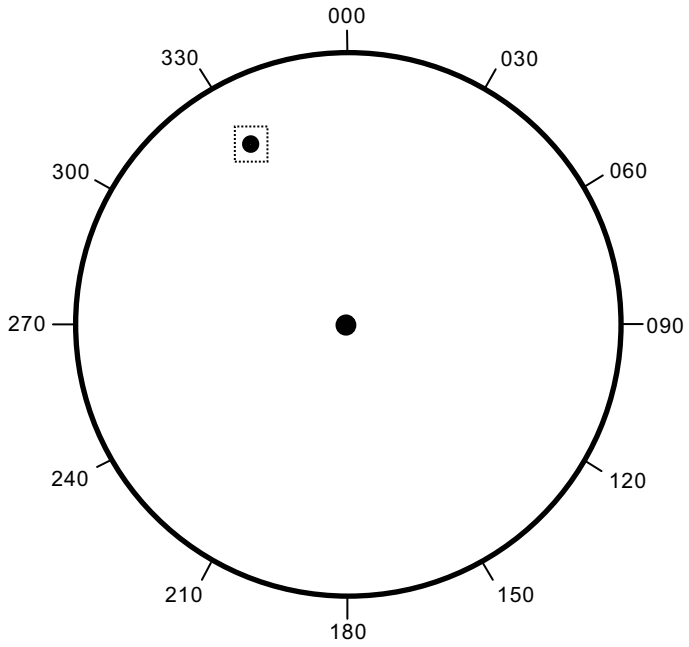
H.2.1 Symbol 1

	EPVS symbol number	Detail	Description of symbol
	1 ATD EPD	Manual acquisition and plotting	A cross shall be used as the cursor for manual acquisition on an ATD and for plotting on an EPD.
			NOTE 1 The cross shall be at least double the size of any other video symbol's maximum dimension, to avoid confusion. NOTE 2 The cursor is also used for other radar purposes. NOTE 3 The cross may have an open centre so that it does not obscure an echo.

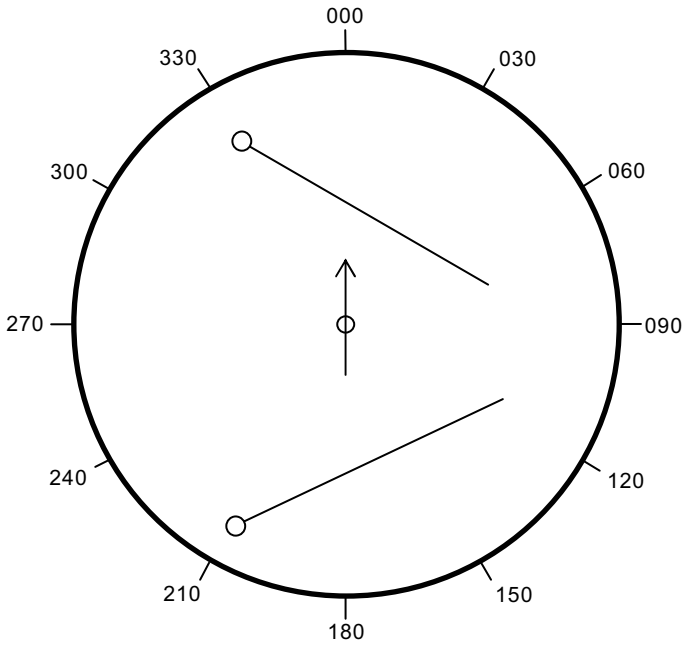
H.2.2 Symbol 2

	EPVS symbol number	Detail	Description of symbol
	2	Area of auto acquisition. On any range scale where acquisition is suppressed over a certain area, the area of acquisition shall be indicated on the display.	If facilities are provided for suppression of acquisition, continuous lines shall be used to define the limits outside of which auto acquisition is suppressed.
			NOTE 1 No restriction is placed on the number and shapes of auto acquisition zones. NOTE 2 The acquisition zone can also serve as a guard zone (see symbol 7).

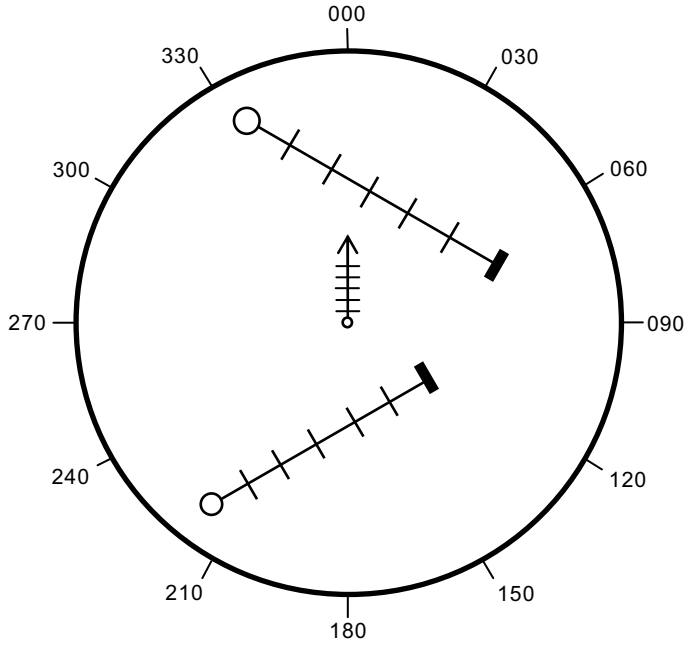
H.2.3 Symbol 3

	EPVS symbol number	Detail	Description of symbol
	3 ATD	Target being tracked during the initial stage.	A broken square around the echo indicates the targets under acquisition and initial stage of tracking before steady-state tracking.
			

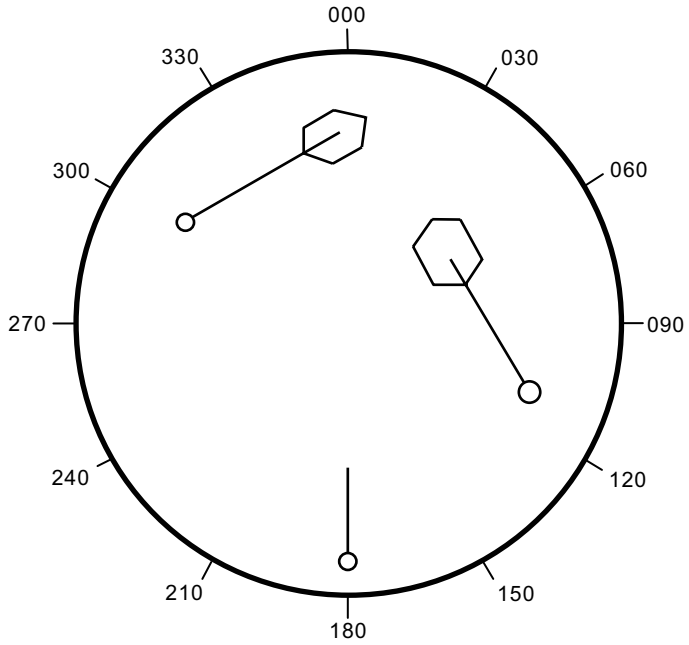
H.2.4 Symbol 4A

	EPVS symbol number	Detail	Description of symbol
	4A ATD EPD	Course and speed vector. Target being tracked when tracking is in steady state. *The course and speed information generated by the* ATD/EPD *for acquired targets* shall *be displayed in a vector or graphic form.*	A vector indicating the target's predicted true or relative motion, which may have a fixed time scale or time-adjusted scale. The vector origin is to be defined by a small dot or the centre of a circle. The circle shall be at least 2 mm in diameter. The position of own ship shall always be indicated by a dot.
			NOTE Optionally an open arrow or a double arrow may be added, if chosen by the user, to the end of own ship true vector. This is to indicate that all the vectors are sea stabilized to show course and speed through water (single arrow) or ground stabilized to show course and speed over the ground (double arrow) respectively.

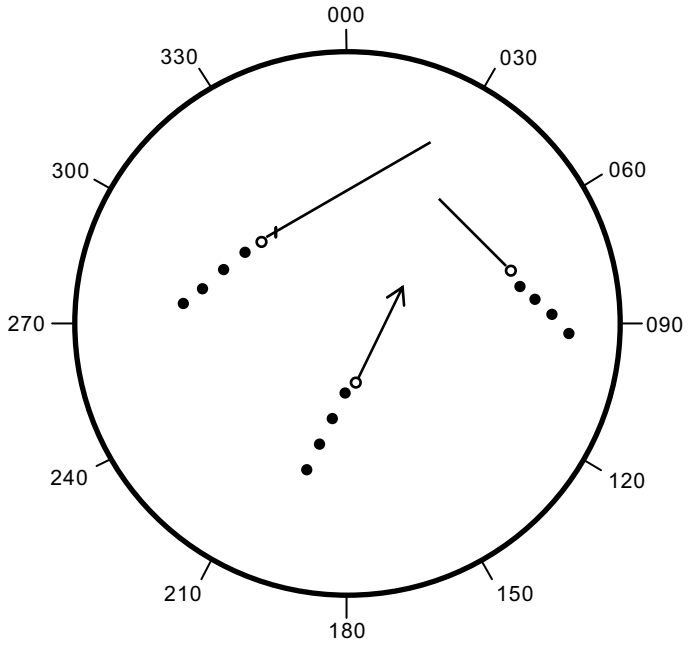
H.2.5 Symbol 4B

	EPVS symbol number	Detail	Description of symbol
	4B ARPA ATD EPD	Course and speed vector. Target being tracked when tracking is in steady state. *The course and speed information generated by the* ATD/EPD *for acquired targets* shall *be displayed in a vector or graphic form.*	A vector indicating the target's predicted true or relative motion, which may have a fixed time scale or time-adjusted scale. The vector origin is to be defined by a small dot or the centre of a circle. The circle shall be at least 2 mm in diameter.
			NOTE 1 Optionally an open arrow or a double arrow may be added, if chosen by the user, to the end of own ship true vector. This is to indicate that all vectors are sea stabilized to show course and speed through the water (single arrow) or ground stabilized to show course and speed over the ground (double arrow) respectively. NOTE 2 Marks at 1 min intervals. Bold mark at 6 min intervals. Length represents user-selectable period applied to ALL vectors.

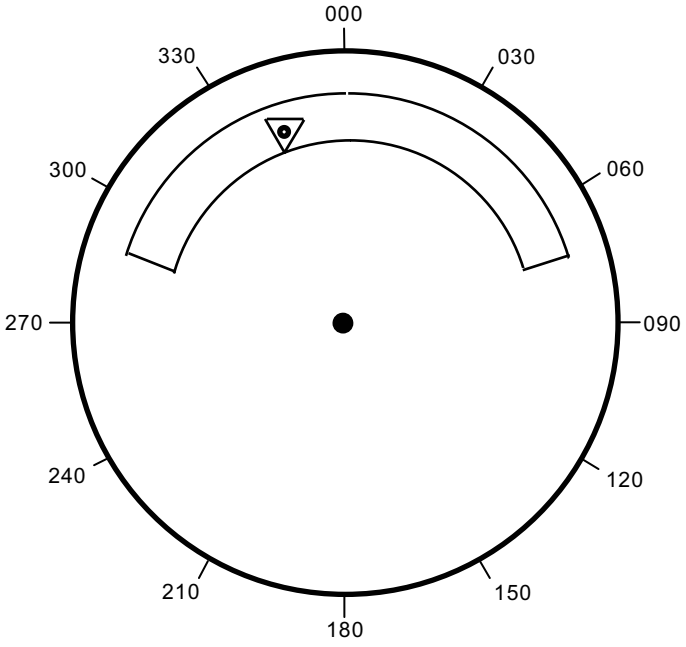
H.2.6 Symbol 5

	EPVS symbol number	Detail	Description of symbol
	5 ATD	Course and speed graphics. Target being tracked when tracking is in steady state. *The course and speed information generated by the* ATD *for acquired targets* shall *be displayed in a vector or graphic form.*	The graphics can take the form of a shape such as a hexagon (see example) or ellipse. The vector origin is to be defined by a small dot or the centre of a circle. The circle shall be at least 2 mm in diameter.
			NOTE 1 The form of the graphics shall avoid shapes that are being used for other RP symbols. NOTE 2 The meaning of the graphics shall be fully explained in the manufacturer's handbook, and shall specifically include how the graphics represent target speed.

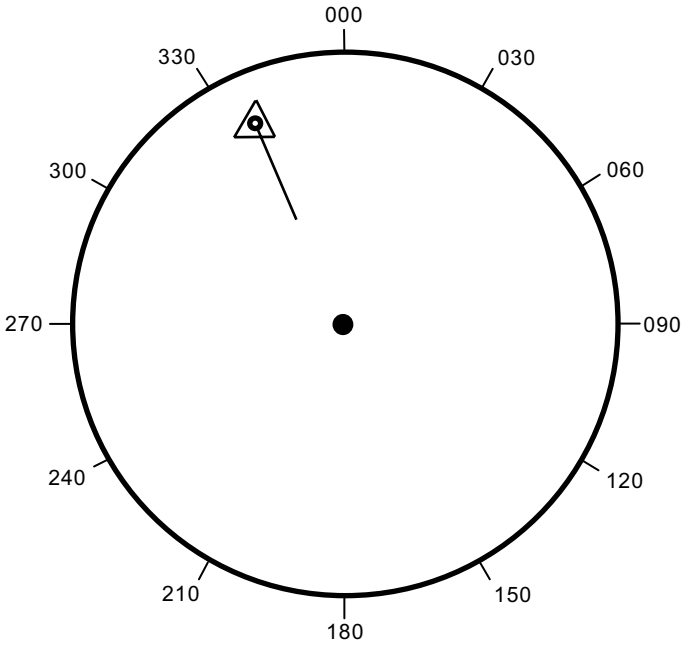
H.2.7 Symbol 6

	EPVS symbol number	Detail	Description of symbol
	6	Past position of target on RP	Plot positions shall be identified by an associated, plot number, placed adjacent to the initial plot and subsequently placed adjacent to the vector origin.
	EPD	Plot position of targets on EPD.	On EPD, the past plot positions may not be equally time-spaced, and are not shown astern of own ship.
			This diagram applies to RP only.

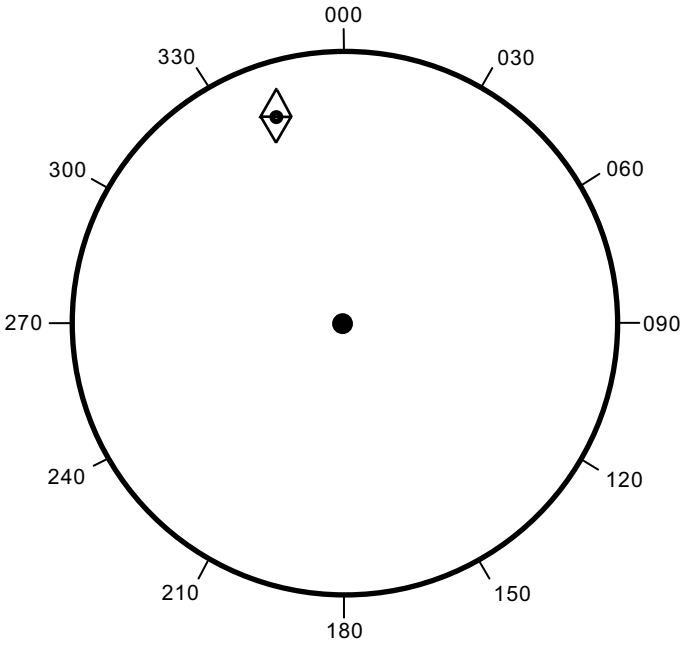
H.2.8 Symbol 7

	EPVS symbol number	Detail	Description of symbol
	7 ATD	Target entering guard zone. The ATD shall, and the EPD may, have the capability to warn the observer with a visual and audible signal of any distinguishable target, which closes to a range or transits a zone chosen, by the observer. The target causing the warning shall be clearly indicated on the display.	A flashing equilateral triangle, apex down, shall be used to mark the target. A guard zone shall consist of continuous lines bounding the area chosen by the operator.
			NOTE 1 Flashing is at a frequency of about 0,5 Hz to 1 Hz. NOTE 2 After acknowledgement it is permissible to cease flashing. NOTE 3 The area chosen by the operator shall be limited in range depth. NOTE 4 It is permissible to show symbols 4A or 4B together with this symbol.

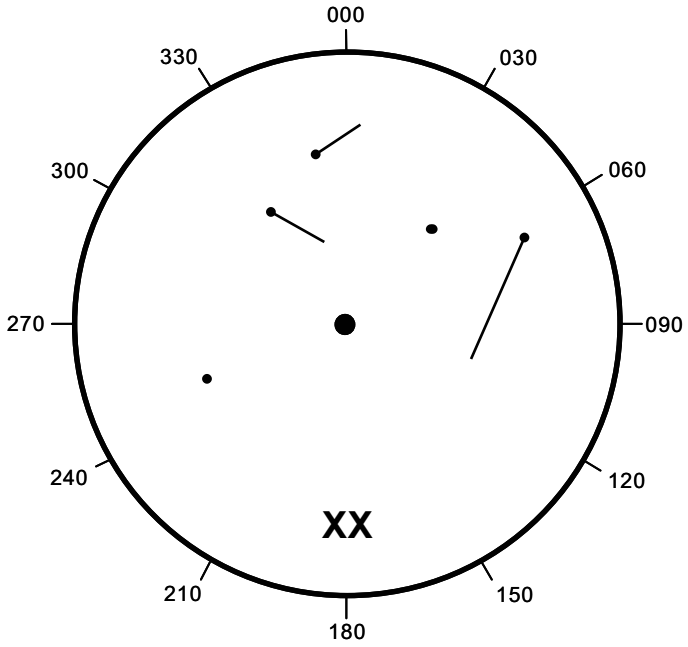
H.2.9 Symbol 8

	EPVS symbol number	Detail	Description of symbol
	8 ATD EPD	CPA/TCPA warning The ATD shall, and the EPD may, have the capability to warn the observer with a visual and audible signal of any tracked target, which is predicted to close within a minimum range and time chosen, by the observer. The target causing the warning shall be clearly indicated on the display.	A flashing equilateral triangle, apex top, shall be used to mark the target. In addition, the target vector may be flashed.
			NOTE 1 Flashing is at a frequency of about 0,5 Hz to 4 Hz. NOTE 2 After acknowledgement it is permissible to cease flashing.

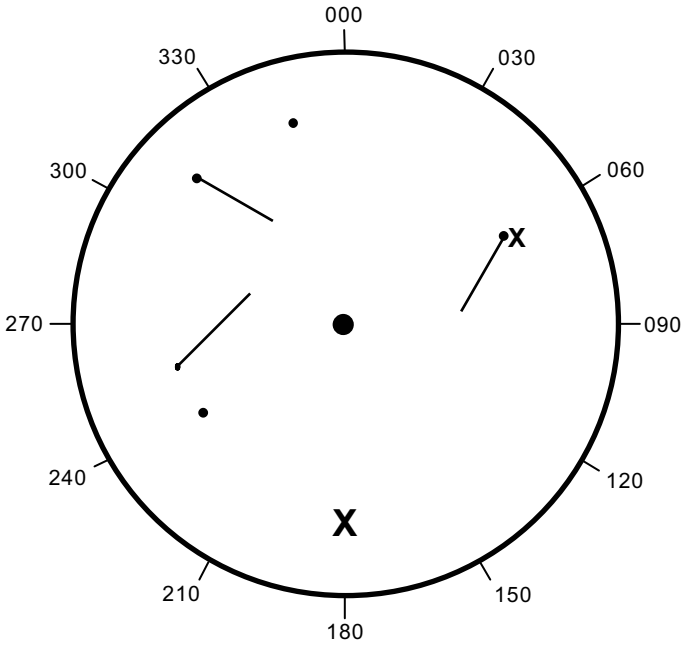
H.2.10 Symbol 9

	EPVS symbol number	Detail	Description of symbol
	9 ATD	Lost target warning The ATD shall clearly indicate that if a tracked target is lost, other than out of range, and the target's last tracked position shall be clearly indicated on the display.	A diamond shall flash. The diamond shall be formed from two equal triangles (one apex up, the other apex down).
			NOTE 1 The form of the diamond consists of two equilateral triangles which, are used as warning symbols. NOTE 2 Flashing is at a frequency of about 0,5 Hz to 1 Hz. NOTE 3 After acknowledgement it is permissible to cease flashing. NOTE 4 This is to be used in conjunction with symbols 4, 5 and 14.

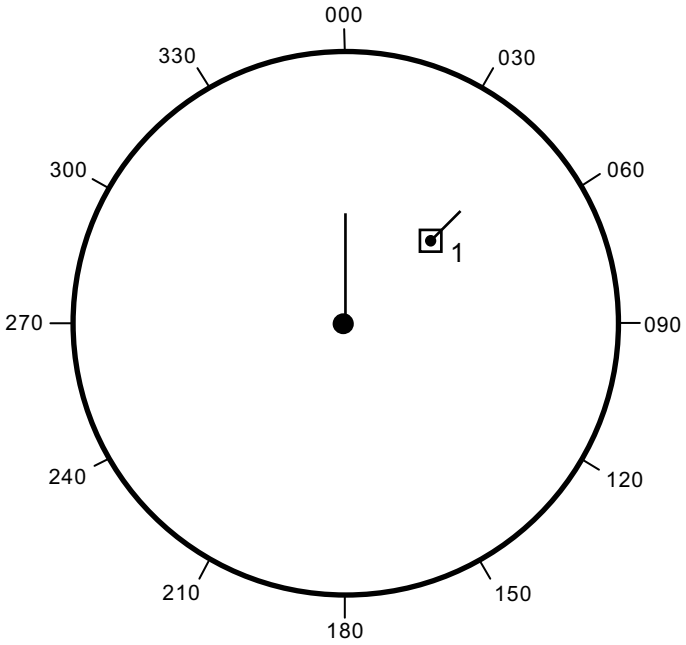
H.2.11 Symbol 11A

	EPVS symbol number	Detail	Description of symbol
	11A ATD	Test targets on a synthetic picture Test programmes shall be available so that the overall performance of ATD can be assured periodically against a known solution.	The letters **XX** at the bottom of the display shall flash.
			NOTE 1 The letters **XX** at the bottom shall be shall be at least double the size of any other video symbol. NOTE 2 If an automatic test programme is incorporated, the indication of an ATD system failure shall be given. NOTE 3 Flashing is at a frequency of about 0,5 Hz to 1 Hz.

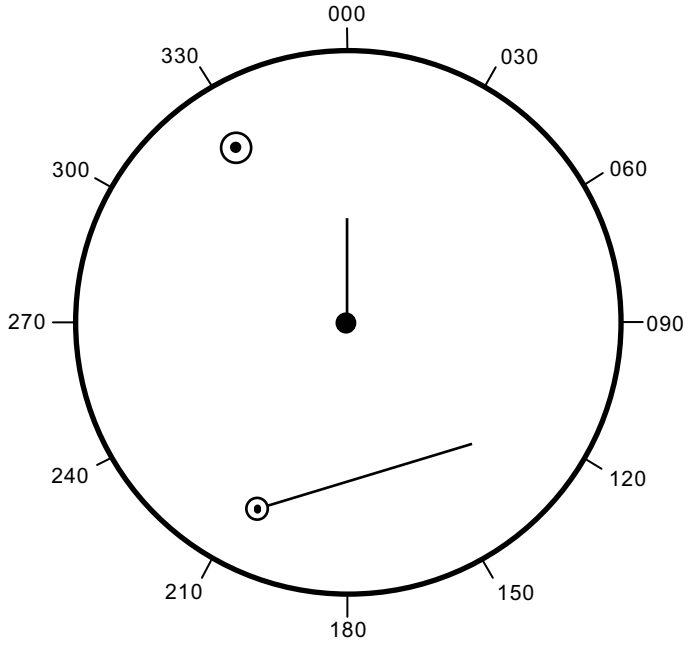
H.2.12 Symbol 11B

	EPVS symbol number	Detail	Description of symbol
	11B ATD	Test target superimposed on a live picture Test programmes shall be available so that the overall performance of ATD can be assured periodically against a known solution.	The letter **X** at the bottom of the display and on the test target shall flash.
			NOTE 1 The letters **X** at the bottom shall be at least double the size of any other video symbol. NOTE 2 A flashing **x** adjacent to the test target shall indicate test targets superimposed on a live picture. The size of the **x** shall be as specified in E.4.2.1.5. NOTE 3 If an automatic test programme is incorporated, the indication of an ATD system failure shall be given. NOTE 4 Flashing is at a frequency of about 0,5 Hz to 1 Hz.

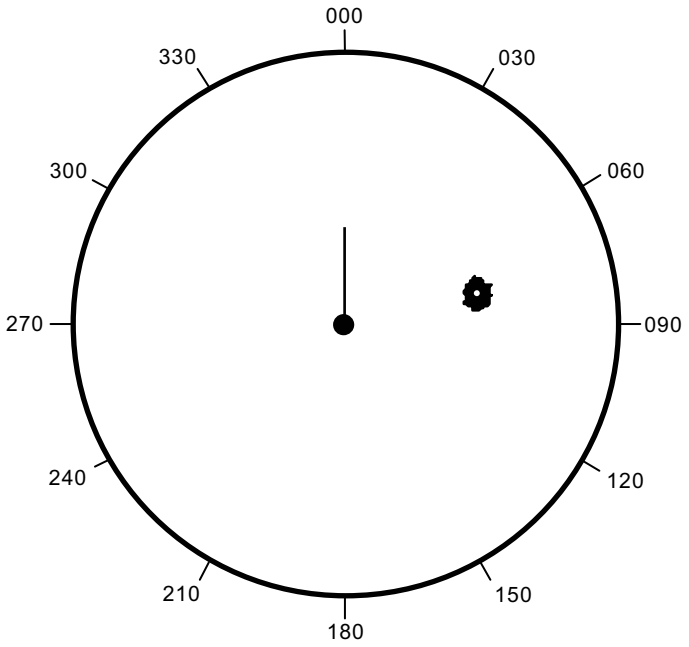
H.2.13 Symbol 12

	EPVS symbol number	Detail	Description of symbol
	12 ATD EPD	Data requirements Targets selected shall be marked with the relevant symbol on the radar display. If data is required for more than one target at the same time each symbol shall be separately identified, for example with a number adjacent to the symbol.	A square is to be used as a symbol to mark the data reading target.
			

H.2.14 Symbol 13

	EPVS symbol number	Detail	Description of symbol
	13 ATD	Ground referencing If stationary targets are being used for ground referencing, this fact shall be indicated by the relevant symbol. In this mode, relative vectors including those of the targets used for ground referencing shall be displayed when requested.	Symbols 3, 4 and 9 annotated with the letter R and if more than one target is used, with R1, R2, R3, etc.
			

H.2.15 Symbol 14

	EPVS symbol number	Detail	Description of symbol
	14	Tracked target without vector or graphic Targets being tracked on which the operator does not require a vector (symbol 4) or graphic (symbol 5), because it is outside operator interest limits (range, CPA, TCPA)	A clearly visible dot (such as negative video or different colour) over the target which is distinguishable from symbols 4A, 4B and 5.
			NOTE If the tracked target is lost, symbol 9 shall be shown.

NOTE Later developed symbols as affected by the introduction of AIS symbology are permitted as replacements to the above symbols where applicable.

Annex I
(informative)

Performance checks during environmental testing

Company/applicant .....

Equipment name .....

Equipment type/class .....

Testing laboratory .....

File reference .....

Test specification IEC 62252 Ed 1 Annex E.....Clause

I.1 Equipment identity

The equipment listed below has been supplied for testing.

Antenna/turning unit(s)			
Type			
Frequency band			
Array length			
Transmitter/receiver			
Type			
Masthead/bulkhead			
Frequency band			
Output power			
RF connection – waveguide/coaxial			
Display unit			
Type			
Single or multi-unit			
Monochrome/colour			

Remarks/comments:

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.....
.....

Accepted for test

Signature ..... Date .....

I.2 Performance checks for radar functions

Date of test .....

The following controls/functions should be exercised as appropriate. Normal operation should be confirmed by a tick in the pass box or measurement.

Functions	Pass	Fail	N/A[1]
Power (on/off switch) time (s) (4.15)	On Standby		
Range selection			
Fixed range rings			
VRM (operation and data display)			
EBL (operation and data display)			
Cursor (operation and data display			
Heading line			
Display – diameter (mm) **Mode** – Head up---------- Course up---------- North up----------			
True motion and true motion reset[2]			
Gain			
Tuning			
Echo trails (wakes)			
Antenna turning – regular rotation speed ± 10 % of nominal rotation			
[1] A comment is required if a test is considered not applicable (N/A) [2] With IEC 61162 speed log input of 30 knots forward speed			

Remarks/comments:

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I.3 Performance tests for plotting functions

Date of test .....

The following performance tests are to be conducted.

Functions ATD	Pass	Fail	N/A[1]
Manual acquisition of targets			
Automatic acquisition of targets			
Target cancel			
Target vectors True/relative Direction and length of vector Vector movement tracking echo			
Target data (alphanumeric) Course Speed CPA TCPA			
Display of past positions (history)			
[1] A comment is required if a test is considered not applicable (N/A)			

Remarks/comments:

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Functions EPD	Pass	Fail	N/A[1]
Plot 2 points – Vector appears			
Plot cancel			
Vector: True/relative Direction and length of vector Vector movement constant			
Plot data (alphanumeric) Course Speed CPA/TCPA			
[1] A comment is required if a test is considered not applicable (N/A)			

Remarks/comments:

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I.4 Performance tests for interface functions

The following tests are to be conducted as appropriate.

Functions	Pass	Fail	N/A[1]
Compass data			
Position information (IEC 61162)			
Speed information Single axis log (200 pulse/nautical mile) Dual axis log (IEC 61162)			
[1] A comment is required if a test is considered not applicable (N/A)			

Remarks/comments:

……
……

I.5 Performance tests for interswitch functions

If interswitch facilities are provided then the following performance tests are to be conducted as appropriate.

Functions	Pass	Fail	N/A[1]
Display/transceiver selection			
Cross connection			
Mimic display/indication of selection			
[1] A comment is required if a test is considered not applicable (N/A)			

Remarks/comments:

……
……

Test complete

Test engineer name ……

Signature …… Date ……

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International Electrotechnical Commission
3, rue de Varembé
1211 Genève 20
Switzerland

or

Fax to: **IEC**/CSC at +41 22 919 03 00

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Non affrancare
No stamp required

A Prioritaire

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Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: *(e.g. 60601-1-1)*

.....

Q2 Please tell us in what capacity(ies) you bought the standard *(tick all that apply).* I am the/a:

purchasing agent ❑
librarian ❑
researcher ❑
design engineer ❑
safety engineer ❑
testing engineer ❑
marketing specialist ❑
other.....

Q3 I work for/in/as a: *(tick all that apply)*

manufacturing ❑
consultant ❑
government ❑
test/certification facility ❑
public utility ❑
education ❑
military ❑
other.....

Q4 This standard will be used for: *(tick all that apply)*

general reference ❑
product research ❑
product design/development ❑
specifications ❑
tenders ❑
quality assessment ❑
certification ❑
technical documentation ❑
thesis ❑
manufacturing ❑
other.....

Q5 This standard meets my needs: *(tick one)*

not at all ❑
nearly ❑
fairly well ❑
exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

standard is out of date ❑
standard is incomplete ❑
standard is too academic ❑
standard is too superficial ❑
title is misleading ❑
I made the wrong choice ❑
other .....

Q7 Please assess the standard in the following categories, using the numbers:
(1) unacceptable,
(2) below average,
(3) average,
(4) above average,
(5) exceptional,
(6) not applicable

timeliness.....
quality of writing.....
technical contents.....
logic of arrangement of contents .....
tables, charts, graphs, figures.....
other .....

Q8 I read/use the: *(tick one)*

French text only ❑
English text only ❑
both English and French texts ❑

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

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