

Maritime navigation and radiocommunication equipment and systems — Shipborne radar — Performance requirements, methods of testing and required test results

ICS 47.020.70

National foreword

This British Standard is the UK implementation of EN 62388:2008. It is identical to IEC 62388:2007. It supersedes BS EN 60872-1:1999, BS EN 60872-2:1999, BS EN 60872-3:2001, BS EN 60936-1:2000, BS EN 60936-2:1999, BS EN 60936-3:2002 and PD IEC/PAS 60936-5:2003, which are withdrawn.

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

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

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**Maritime navigation and radiocommunication equipment and systems -
Shipborne radar -
Performance requirements, methods of testing and required test results
(IEC 62388:2007)**

Equipements et systèmes de navigation
et de radio-communications maritimes -
Radars embarqués -
Exigences de performance,
méthodes de test et résultats attendus
(CEI 62388:2007)

Navigations- und
Funkkommunikationsgeräte und -systeme
für die Seeschifffahrt -
Radar für Schiffe -
Leistungsanforderungen, Prüfverfahren
und geforderte Prüfergebnisse
(IEC 62388:2007)

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

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This European Standard supersedes EN 60936 series (radar) and EN 60872 series (plotting).

Contents from the previous radar series (EN 60936-1, EN 60936-2 and EN 60936-3) and plotting series (EN 60872-1, EN 60872-2 and EN 60872-3) of standards have been included, as appropriate.

EN 62388:2008 supports the new IMO performance standards for shipborne radar, Resolution MSC.192(79) adopted by the IMO in December 2004. Resolution MSC.192(79) supersedes all previous IMO resolutions relating to radar and plotting, including IMO Resolutions A.278(VIII), A.477(XII) and MSC 64(67) Annex 4.

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Endorsement notice

The text of the International Standard IEC 62388:2007 was approved by CENELEC as a European Standard without any modification.

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS –

Shipborne radar – Performance requirements, methods of testing and required test results

1 Scope

This International Standard specifies the minimum operational and performance requirements, methods of testing and required test results conforming to performance standards not inferior to those adopted by the IMO in Resolution MSC.192(79).

(MSC.192/2) *The radar installation, in addition to meeting the general requirements as set out in resolution A.694(17) and the related general standard, IEC 60945, should comply with the performance standards of MSC.192(79). When a requirement of this standard is different from IEC 60945 the requirement in this standard takes precedence.*

All text in this standard with wording identical to that in IMO resolution MSC.192(79) is printed in italics. Reference to MSC.192(79) is by the relevant requirement clause as indicated in brackets, for example (MSC.192/4.2.3). Some clauses from Resolution MSC.192(79) may be split and the requirements in this case are addressed separately.

(MSC.192/5) *The design and performance of the radar should be based on user requirements and up-to-date navigational technology. It should provide effective target detection within the safety-relevant environment surrounding own ship and should permit fast and easy situation evaluation.*

(MSC.192/1) *The radar equipment should assist in safe navigation and in avoiding collision by providing an indication, in relation to own ship, of the position of other surface craft, obstructions and hazards, navigation objects and shorelines. For this purpose, radar should provide the integration and display of radar video, target tracking information, positional data derived from own ship's position (EPFS) and geo referenced data.*

The integration and display of AIS information should be provided to complement radar. The capability of displaying selected parts of Electronic Navigation Charts (ENC) and other vector chart information may also be provided to aid navigation and for position monitoring. Radar is a technology that should be applied together with other sensor information applicable for the task in hand.

NOTE Radar is a system and its performance is a factor of all of its component parts. The type test should include the radar sensor, ancillary units and display, complete with its processing and presentation display. All of these component parts contribute to the requirements and approval to these radar standards. Other navigational systems and equipment that provide radar and/or target tracking functions, should comply with the relevant clauses of this standard according to the guidelines in Annex A. A navigation display or INS may be approved as part of a radar system when tested with the specific radar sensor and relevant ancillary units. Where the intended application for a navigation system is for collision avoidance, as a minimum requirement, the radar image should always be presented, together with the relevant functionality and performance as described in Annex A.

1.1 Purpose

(MSC.192/1) *The radar, when combined with other sensor, or reported information (for example AIS), should improve the safety of navigation by assisting in the efficient navigation of ships and protection of the environment by satisfying the following functional requirements:*

- *in coastal navigation and harbour approaches, by giving a clear indication of land and other fixed hazards;*

- as a means to provide an enhanced traffic image and improved situation awareness;
- in a ship-to-ship mode for aiding collision avoidance of both detected and reported hazards;
- in the detection of small floating and fixed hazards, for collision avoidance and the safety of own ship; and
- in the detection of floating and fixed aids to navigation.

1.2 Application of these standards

(MSC.192/2) *The Performance Standards defined by MSC.192(79) shall apply to all shipborne radar installations used in any configuration mandated by SOLAS independent of the type of ship, frequency band in use and the type of display, providing that no special requirements are specified in Table 1 and that additional requirements for specific classes of ship (in accordance with SOLAS Chapters V and X) are met.*

(MSC.192/2) *Close interaction between different navigation equipment and systems makes it essential to consider this standard in association with other relevant IMO and IEC standards.*

This standard applies to radar systems, navigation systems and navigation equipment which have the task of target detection and collision avoidance. Any equipment which combines these tasks and meets all of the requirements in this standard is regarded as a radar system. In support of the Collision Regulations, all available means shall be used to enhance the role of radar for safe navigation and collision avoidance. The usage of other sensors shall, where practical, observe the requirements of the standards associated with those sensors. This standard also provides guidelines and requirements for radar functionality on all navigational displays supporting the tasks of target detection, collision avoidance, general navigation and position referencing on the bridge of a ship.

The successful integration of radar with AIS, charts, databases and other sensors demands that the radar equipment is correctly set up with special attention to the critical alignment of heading(s), system index delay(s), CCRP offsets and gyro. Failure to align these parameters may cause unacceptable registration with other information and may detract from the purpose of integration. This standard has mandated requirements to provide for these alignments.

NOTE While X-band radar systems remain compatible with radar beacons, SARTs and radar enhancers, S-band systems are permitted to harness new radar technology which may not be compatible with those devices. All tests (or their equivalent) in this standard apply to both non-coherent (for example conventional-based radar) and coherent radar systems (for example pulse compression radar).

1.3 Equipment categories

This standard covers the testing of all SOLAS shipborne radar equipment. Individual equipment may be tested for a specific category of vessel. Table 1 provides a summary of the categories and basic differential capabilities for each category. The category should be indicated on the type label of the main radar electronics unit and on the related Certification of Test. Equipment approved for high speed applications should include a suffix H (for example CAT 1H) and equipment approved with a chart option should include a suffix C (for example CAT 1HC).

(MSC.192/5.3.1.1) *Recognising the high relative speeds possible between own ship and target, the equipment should be specified and approved as being suitable for classes of ship having normal (≤ 30 kn) or high (> 30 kn) own ship speeds (100 kn and 140 kn relative speeds respectively).*

The additional characteristics for equipment qualified to be approved for HSC and/or for chart radar are identified in this standard. For example, HSC equipment should be compatible with own ship speeds of up to 70 kn, should be capable of tracking targets with a 140 kn relative speed and should operate between latitudes of 70° N and 70° S.

A chart radar should conform to all the requirements of Clause 11 in this standard. References are made to IEC 61174 (ECDIS) for specific and standalone chart functionality.

Table 1 – Performance requirements for categories of ship/craft for SOLAS V

	Category of ship/craft		
	CAT 3	CAT 2	CAT 1
Size of ship/craft	<500 gt	500 gt to <10 000 gt and HSC<10 000 gt	All ships/craft ≥10 000 gt
Minimum operational display area diameter	180 mm	250 mm	320 mm
Minimum display area	195 mm x 195 mm	270 mm x 270 mm	340 mm x 340 mm
Auto acquisition of targets	-	-	Yes
Minimum <u>acquired</u> radar target capacity	20	30	40
Minimum <u>activated</u> AIS target capacity	20	30	40
Minimum <u>sleeping</u> AIS target capacity	100	150	200
Trial manoeuvre	-	-	Yes
NOTE The processing capacity of AIS information should be in accordance with 10.5.2.			

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

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

IEC 61174, *Maritime navigation and radiocommunication equipment and systems – Electronic chart display and information systems (ECDIS) – Operational and performance requirements, methods of testing and required test results*

IEC 61966-4, *Multimedia systems and equipment – Colour measurement and management – Part 4: Equipment using liquid crystal display panels*

IEC 61996 (all parts), *Maritime navigation and radiocommunication equipment and systems – Shipborne voyage data recorder (VDR) – Performance requirements – Methods of testing and required test results*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

ISO 9241-8, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 8: Requirements for displayed colours*

ISO 9241-12, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 12: Presentation of information*

ISO 13406-2, *Ergonomic requirements for work with visual displays based on flat panels – Part 2: Ergonomic requirements for flat panel displays*

ISO 80416-4, *Basic principles for graphical symbols for use on equipment – Part 4: Guidelines for the adaptation of graphical symbols for use on screens and displays (icons)*

ITU-R Recommendation M.628-4:2006, *Technical characteristics for search and rescue radar transponders*

ITU-R Recommendation M.824-3:2007, *Technical parameters of radar beacons (racons)*

ITU-R Recommendation M.1176:1995, *Technical parameters of radar target enhancers*

IHO S-52:1996, *Specifications for chart content and display aspects of ECDIS*

IHO S-52 Appendix 1:1996, *Guidance on updating the ENC*

IHO S-52 Appendix 2:2004, *Colour and symbol specifications for ECDIS*

IMO SOLAS:1974, *International Convention for the Safety of Life at Sea, as amended*

IMO Resolution A.694(17):1991, *General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids*

IMO Resolution A.817(19):1995, *Performance standards for electronic chart display and information systems (ECDIS)* (as amended by MSC.64(67) Annex 5 and MSC.86(70) Annex 4)

IMO Resolution MSC.96(72), *Amendments to IMO Resolution A.824(19), Performance standards for devices to indicate speed and distance*

IMO Resolution MSC.112(73), *Revised performance standards for shipborne global positioning system (GPS) receiver equipment*

IMO Resolution MSC.191(79):2004, *Performance standards for the presentation of navigation-related information on shipborne navigational displays*

IMO Resolution MSC.192(72):2004, *Revised performance standards for radar equipment*

IMO SN/Circ.243:2004, *Guidelines for the presentation of navigation related symbols, terms and abbreviations*

CIE 15:2004, *Colorimetry*

VESA-2001-6:2001, *Flat Panel Display Measurements (FPDM)*

3 Terms and definitions

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

3.1

activated AIS target

target representing the automatic or manual activation of a sleeping target for the display of additional graphically presented information. The target is displayed by an “activated target” symbol including a vector; the heading; and the ROT or direction of turn indication (if available) to indicate initiated course changes

3.2

acquisition of a radar target

process of acquiring a target and initiating its tracking

3.3**activation of an AIS target**

activation of a sleeping AIS target for the display of additional graphical and alphanumerical information

3.4**acquired radar target**

automatic or manual acquisition initiates radar tracking. Vectors and past positions (if provided) are displayed when data has achieved a steady state condition (after 1 min)

3.5**automatic identification system****AIS**

Automatic Identification System which complies with the requirements of IMO resolution MSC.74(69) Annex 3 and IEC 61993-2

3.6**AIS target**

target generated from an AIS message

3.7**associated target**

target simultaneously representing a tracked target and a reported AIS target having similar parameters (for example position, course, speed) which comply with an association algorithm

3.8**acquisition/activation zone**

zone set up by the operator in which the system should automatically acquire radar targets and activate reported AIS targets when entering the zone

3.9**azimuth-stabilised**

heading reference input, for example own ship's gyro, is used to orientate the heading line on the radar display so that it points from the CCRP to own ship's referenced heading on the bearing scale

3.10**bow crossing range/bow crossing time****BCR/BCT**

measurements presented as from the bow of the ship as opposed to the CCRP

3.11**cardinal points (compass)**

0, 090, 180, 270 compass points

3.12**consistent common reference point****CCRP**

location on own ship, to which all horizontal measurements such as target range, bearing, relative course, relative speed, closest point of approach (CPA) or time to closest point of approach (TCPA) are referenced, typically the conning position of the bridge

3.13**closest point of approach/time to the closest point of approach****CPA/TCPA**

distance to the closest point of approach (CPA) and time to the closest point of approach (TCPA). Limits are set by the operator and are related to own ship

3.14

course

direction in which the ship is moving or intended to move, expressed in degrees from North, usually from 000° at north, then in a clockwise direction through 360°

3.15

course over ground

COG

direction of the ship's movement relative to the earth, measured on board the ship, expressed in angular units from true north

3.16

course through water

CTW

direction of the ship's movement through the water, defined by the angle between the meridian through its position and the direction of the ship's movement through the water, expressed in angular units from true north

3.17

course-up

C-up

azimuth-stabilised display in which the bearing scale can be orientated so that own ship's course on the bearing scale is vertically above the CCRP. The heading line will continue to point from the CCRP to own ship's referenced heading on the bearing scale. If own ship's heading differs from the course, then the heading line will not point vertically upwards from the CCRP until the bearing scale is reset (manually or automatically) to reflect the course alteration

3.18

dangerous target

target whose predicted CPA and TCPA are violating the values as preset by the operator. The respective target is marked by a "dangerous target" symbol

3.19

default

predefined condition set either by the user or the equipment manufacturer

3.20

ECDIS

Electronic Chart Display and Information System, which complies with IMO resolution A.817(19) amended by MSC.64(67) Annex 5 and MSC.86(70) Annex 4, and IEC 61174

3.21

ECDIS display base

level of information which cannot be removed from the ECDIS display, consisting of information which is required at all times in all geographic areas and all circumstances. It is not intended to be sufficient for safe navigation

3.22

ECDIS standard display

level of information that should be shown when a chart is first displayed on ECDIS. The level of the information it provides for route planning or route monitoring may be modified by the mariner according to the mariner's needs

3.23

electronic navigational chart

ENC

database standardised as to content, structure and format according to relevant IHO standards and issued by, or on the authority of, a Government

3.24**electronic position fixing system****EPFS**

position fixing system using electronic means

3.25**electronic range and bearing line****ERBL**

electronic bearing line carrying a marker, which is combined with the variable range marker, used to measure range and bearing from own ship or between two objects

3.26**EUT**

equipment under test

3.27**evaporation duct**

low lying duct (a change in air density) that traps the radar energy so that it propagates close to the sea surface. Ducting may enhance or reduce radar target detection ranges

3.28**exclusion zone**

area which may exclude the automatic acquisition for target tracking and/or may suppress the automatic activation of sleeping AIS targets

3.29**ground stabilisation**

display mode in which speed and course information are referred to the ground, using ground track input data, or EPFS as reference

3.30**heading**

horizontal direction that the bow of a ship is pointing at any instant, expressed in angular units from a reference direction

3.31**heading line**

graphic line on a radar presentation drawn from the consistent common reference point to the bearing scale to indicate the heading of the ship

3.32**head-up****H-up**

presentation mode which is orientated “up” toward the top of the bearing scale. Radar echoes and tracked targets are shown at their measured distances and moving in a direction relative to own ship’s heading. In head-up, the top of the bearing scale shows 000 degrees. Target trails are relative. It is possible to have an azimuth stabilised head-up mode where the top of the bearing scale shows own ship’s heading. In this case, target trails may be true or relative

3.33**high speed craft****HSC**

vessels which comply with the definition in SOLAS for high speed craft

3.34**icon**

graphic that provides or signifies a control function capability

3.35

integrated navigation system

INS

navigation system which complies with the requirements of Annex 3 to IMO resolution MSC.86(70) and IEC 61924

3.36

latency

delay between actual data received by the equipment and the presentation or use of that data

3.37

lost AIS target

target symbol representing the last valid position of an AIS target before the reception of its data was lost, or its last dead-reckoned (DR) position. The target is displayed by a “lost AIS target” symbol

3.38

lost tracked target

one for which target information is no longer available due to poor, lost or obscured signals. The target is displayed by a “lost tracked radar target” symbol at its last known or dead-reckoned position

3.39

maps/navigation lines

operator defined or created lines to indicate channels, traffic separation schemes or borders of any area important for navigation

3.40

menu

area of display that is allocated to the interactive display and operation of a structured menu for the selection and entry of operational parameters, data and commands. The menu display, when selected, is typically replacing parts of, or the whole, data display

3.41

navigation situation

broad and general description of the type of navigation that is planned or being conducted, for example open ocean, coastal, approach, confined waters, restricted, docking/manoeuvring

3.42

non-volatile and transferable memory

memory which retains its data when it is not provided with power and removed from one equipment or module, and fitted to another equipment or module

3.43

north-up

N-up

azimuth-stabilised presentation in which north on the bearing scale remains fixed vertically above the CCRP. The heading line points from the CCRP to own ship's referenced heading on the bearing scale, and the bearing of any target on the display is measured from north. Such a bearing is commonly referred to as a true bearing when the heading reference input comes from a gyro aligned with true north

3.44

operational display area

area of the display used to graphically present chart and radar information, excluding the user dialogue area. On the chart display this is the area of the chart presentation. On the radar display this is the area encompassing the radar image

3.45**operational mode**

primary function of the presentation selected by the user, for the task at hand or navigation situation, for example radar, chart, conning

3.46**past positions**

equally time-spaced past position marks of a tracked or reported target and own ship. The past positions' track may be either relative or true, and may apply to tracked radar targets or AIS targets

3.47**presentation mode**

result of the combination of user selected parameters that affect the display of information, for example azimuth orientation, motion, stabilisation, chart projection

3.48**protected menu**

one which is not easily accessed by the user and access may be, for example by a password or a switch

3.49**radar**

abbreviation for *radio direction and ranging*. It is a radio frequency system that allows the determination of distance and direction of reflecting objects and of transmitting devices

3.50**radar beacon**

navigation aid which responds to the radar transmission by generating a radar signal to identify its position and identity

3.51**radar cross-section****RCS**

determines the power density returned to the radar for a particular power density incident on a target

3.52**radar detection false alarm**

probability of a radar false alarm represents the probability that noise will cross the detection threshold and be called a target when only noise is present

3.53**radar display**

module of a radar system, consisting of the presentation hardware

3.54**radar echo**

signal reflected by a target to a radar antenna that appears in the radar video signal and radar image

3.55**radar image**

plan view of the radar video in range and bearing

3.56**radar presentation**

display of a radar image together with related alpha-numeric and graphical information

3.57

radar system

entire content and functionality of a system necessary to meet the requirements of this test standard

3.58

radar target

object, fixed or moving, which is detected or detectable by a radar system and has a motion determined by successive radar measurements of range and bearing. A radar target is derived from video signals provided by the radar sensor (transceiver) and which appears in the radar image

3.59

radar video

signal produced by a radar receiver as a result of radar echoes returned

3.60

radar target enhancer

electronic radar reflector, the output of which is an amplified version of the received radar pulse without any form of processing except limiting

3.61

range index delay

delay provided at the start of a radar presentation causing the near range radar signal contents to effectively be suppressed and distorting the linear plan presentation

3.62

rate of turn

ROT

change of heading per time unit

3.63

reference target

symbol indicating that the associated tracked stationary target (for example a navigational mark) is used as a speed reference for the ground stabilisation

3.64

relative bearing

direction of a target's position from own ship's CCRP expressed as an angular displacement from own ship's heading

3.65

relative course

direction of motion of a target relative to own ship's direction (bearing)

3.66

relative motion

RM

display on which the position of own ship remains fixed, and all targets move relative to own ship. *It is the combination of relative course and relative speed*

3.67

relative speed

speed of a target relative to own ship's speed data

3.68

relative vector

predicted movement of a target relative to own ship's motion

3.69**search and rescue transponder****SART**

radar transponder capable of operating in the 9 GHz band

3.70**speed and distance measuring equipment****SDME**

Speed and Distance Measuring Equipment which complies with IMO Resolution MSC.96(72)

3.71**sea state**

status of the sea condition due to the weather environment, expressed as a sea state 0 for flat conditions with minimal wind, to sea state 8 for very rough sea conditions

3.72**selected target**

manually selected target for the display of detailed alphanumeric information in a separate data display area. The target is identified by a “selected target” symbol

3.73**sleeping AIS target**

target indicating the presence and orientation of a vessel equipped with AIS in a certain location. The target is displayed by a “sleeping target” symbol. No additional information is presented until the target is activated

3.74**sea stabilisation**

display mode in which speed and course information are referred to the sea, using gyro or equivalent and water speed log input as reference

3.75**safety of life at sea****SOLAS**

International Convention for the Safety of Life at Sea adopted by the International Conference on Safety of Life at Sea convened by the International Maritime Organization (IMO) in 1974

3.76**speed over ground****SOG**

speed of the ship relative to the earth, measured on board of the ship

3.77**speed through water****STW**

speed of the ship relative to the water surface

3.78**standard display**

level of information that should be shown when a chart is first displayed on ECDIS or ECS. The level of the information it provides for route planning or route monitoring may be modified by the mariner according to the mariner's needs

3.79**steady state tracking**

tracking a target, proceeding at steady motion:

- *after completion of the acquisition process, or*

- *without a manoeuvre of target or own ship, or*
- *without target swap or any disturbance*

3.80

stern line

graphic line drawn from the consistent common reference point to the bearing scale, on a reciprocal bearing to the heading line

3.81

target swap

situation in which the incoming radar data for a tracked target becomes incorrectly associated with another tracked target or a non-tracked radar echo

3.82

target's predicted motion

prediction of a target's future course and speed based on its present motion as determined by past measurements of its range and bearing on the radar

3.83

target tracking

TT

computer process of observing the sequential changes in the position of a radar target in order to establish its motion. Such a target is a Tracked Target

3.84

task at hand

specific activity being performed by the user, for example collision avoidance, route planning, route monitoring, grounding avoidance

3.85

test target

radar target of known characteristics used for test requirement

3.86

trails

tracks displayed by the radar echoes of targets in the form of an afterglow. Trails may be true or relative. Relative trails are as they would be presented in relative motion. True trails are as they would be presented in true motion

3.87

trial manoeuvre

graphical simulation facility used to assist the operator to perform a proposed manoeuvre for navigation and collision avoidance purposes, by displaying the predicted future status of at least all acquired or activated targets as a result of own ship's simulated manoeuvres

3.88

true bearing

direction of a target from own ship's CCRP or from another target's position, expressed as an angular displacement from true north

3.89

true course

direction of motion relative to ground or to sea, of a target expressed as an angular displacement from north

3.90**true motion****TM**

display across which own ship moves with its own true motion. *It is the combination of true course and true speed*

3.91**true speed**

speed of a target relative to ground, or to sea

3.92**true vector**

vector representing the predicted true motion of a target, showing course and speed with reference to the ground or sea

3.93**user configured presentation**

display presentation configured by the user for a specific task at hand. The presentation may include radar and/or chart information, in combination with other navigation or ship related data

3.94**user-defined**

result of a function or parameter selected or defined by the user within the confines of specific equipment

3.95**user dialogue area**

area of the display consisting of data fields and/or menus that is allocated to the interactive presentation and entry or selection of operational parameters, data and commands mainly in alphanumeric form

3.96**VDR**

voyage data recorder

3.97**waypoint****wpt**

position at which a turn is executed

4 General**4.1 Establishing equipment type and status**

The manufacturer shall state the intended system content and the category of equipment under test (EUT). Specific requirements, which shall include intended equipment category, are listed below:

- high speed or normal speed. (MSC.192/5.3.1.1) *Recognising the high relative speeds possible between own ship and target, the equipment shall be specified and approved as being suitable for classes of ship having normal (≤ 30 kn) or high (> 30 kn) own ship speed (100 kn and 140 kn relative speeds respectively);*
- frequency band (X-band and/or S-band) and operational frequency limits;
- declaration of any novel processing, new technology or additional functionality which requires alternative testing or claims equivalency to the requirements;
- list all variants (up-mast/down-mast, split processor/displays, chart option, etc.)

- identification of all antennas available with the radar. The smallest antenna (or its properties) shall be used for all relevant performance testing. Environmental testing (vibration and shock) shall use the largest antenna available;
- all ancillary units (inter-switching, buffer amplifiers, etc);
- units intended for protected (from the weather) or exposed (to the weather) application;
- the intended separation (cable, network or transmission line/feeder) between units. When equipment with separate transmitter and antenna is tested in accordance with this standard, the transmitter/receiver shall be connected to the antenna by a 20 m (minimum) of feeder. The display shall be connected to other units by 65 m of cable. Where equipment is type tested, in which the transmitter and receiver are always installed within the antenna/pedestal combination, the 20 m of antenna feeder shall be omitted. Where necessary, the manufacturer shall supply the appropriate cable and antenna feeder. The manufacturer, or its representative, may propose to the test authority for consideration, a greater distance by which units of the equipment may be separated and still comply with the requirements of this standard. The actual distance requested and tested shall be recorded;
- power supply requirements and declared nominal voltage/frequency of operation. The supply voltage applied to the equipment during the tests shall be the nominal voltage, and alternating current (a.c.) supplies shall be at nominal frequency unless specified otherwise;
- intended equipment configuration(s), either as standalone or as part of a system;
- the manufacturer's code numbers for each piece of equipment and its ancillaries;
- familiarisation documentation or media;
- evidence of sea trials as required by 5.9.3.

4.2 Conditions of measurement and related definitions

All the general requirements of IEC 60945 shall be carried out on the same type of equipment under test (EUT) to verify whether the EUT meets these technical requirements. The equipment shall comply with those requirements of IEC 60945 appropriate to its category, i.e. 'protected' (from the weather) or 'exposed' (to the weather). Accordingly, the manufacturer shall declare which equipment or units are intended to be 'protected' or 'exposed'. The manufacturer shall declare any 'preconditioning' required before environmental checks.

4.3 Test sites and simulation

4.3.1 Environmental and RF testing

Testing for general, environmental and radio frequency measurements shall be conducted in a test house, or location, accepted by the test authority and by competent persons familiar with the radar application.

4.3.2 Over-sea radar performance tests

Many of the tests may be conducted on land at a test site accepted by the test authority. Specific testing shall be required over sea and these may be shore based or at sea on a test ship.

Radar performance tests will normally be carried out at test sites selected by the type test authority. These test sites shall provide an over water test range with test targets and the features required for specified tests. The operational performance testing in this standard shall be conducted with a nominal antenna height of 15 m.

The manufacturer shall, unless otherwise agreed, set up the equipment and ensure that it is operating normally before type testing commences.

4.3.3 Test targets and target simulation for performance tests

Standard targets used for the radar performance measurement and assessment are described in the relevant tests.

The target scenario simulator provides test scenarios to assess the tracking performance of the EUT, in accordance with Annex F.

The reported target simulator provides the test scenario for testing the AIS target functions and for target association, in accordance with Annex F.

Simulators used for testing shall be suitably calibrated or verified before use for measurement.

4.4 Quality requirements

The equipment and documentation shall be developed, produced and written in accordance with a recognised quality procedure, for example ISO 9000 or an equivalent recognised quality standard.

4.5 Test terminology and format

4.5.1 General

For each test subject, there is a requirement subclause (for example referenced to (MSC.192/clause)) and a corresponding compliance subclause, which includes a test method and the required result.

4.5.2 Test requirement terminology

For the purposes of this standard, the following test terminology shall apply:

performance check – reconfiguration of the EUT and checking by non-quantitative visual checks that the system is still operative for the purposes of IEC 60945. This shall include the operation of basic functionality to confirm normal operation;

performance test – for the radar EUT, shall be of an identical standard to that used in the performance check for the purposes of IEC 60945, with the addition of a specified test as described in Clause 16;

clear indication or visibility of test targets – visible for at least 8 out of 10 of the antenna scans, or indication 5 out of 10 with past positions, synthetic afterglow and trails facility switched off;

single operator action – the use of a single hardware key or, the use of the cursor to select a single display icon or window followed by the operation of a key;

dedicated control function – the use of a dedicated single hardware key or, the use of the cursor to select a single dedicated display icon or window followed by the operation of a key;

momentary control function – the use of a dedicated single hardware key or, the use of the cursor to select a single dedicated display icon or window followed by the operation of a key. The control function shall only operate while the key is pushed;

readily available – applies to information or to a function for the selected application, which is available in a top level menu and accessed directly from a screen function or icon, or by a dedicated control;

permanent indication – applies to a status indication permanently or persistently available (as appropriate) and visible at any time that the equipment is operational;

protected menu – is one which is not easily accessed by the user and protected for example, by a password, internal switch or hardware link;

means – “a means to” do something is equivalent to “a method of” something, for example “a means to measure between two points” is the same as “a method of measuring”.

4.5.3 Testing method terminology

Testing method terminology is derived from ISO 9241-12 and for application to this radar standard, terms are defined as:

measurement – refers to measurement or calculation of a variable concerning the presentation of information, accuracy, or the equipment performance;

observation – means to examine or inspect the equipment to confirm that a particular observable condition has been met. Observations can be made by anyone who has the necessary skill to systematically check the presentation of information and make the determination;

document inspection – means to confirm by inspection that any relevant documented information, facility or function is compliant with the requirement;

analytical evaluation – requires the informed judgement of equipment performance from a study of observations or measurements by an expert, a suitably qualified person who has the necessary skill and experience to judge the relevant property in the relevant subject. The method is typically used for the evaluation of properties which can be judged only in the context of other information or knowledge.

5 Radar performance

5.1 General

The performance test shall include measurement of the transmission frequency spectrum, familiarisation of the controls and signal processing functions, followed by minimum range, discrimination and accuracy measurements. The performance assessment in an over-sea environment shall exercise the signal processing and associated control functions. During this assessment, the test authority shall familiarise themselves with the gain and anti-clutter functions. Detection performance testing is provided in 5.9.

NOTE Radar provides the primary means to detect surface hazards for safe navigation and therefore the detection of surface hazards is a primary element in the task of collision avoidance. The performance requirements should address the fundamental radar transmission, detection and signal processing capability of the radar system.

5.2 Transmission and interference

Transmission frequency parameters are measured and the reduction of radiated interference from other sources is assessed.

5.2.1 Transmission frequency

5.2.1.1 Requirement

(MSC.192/5.1.1) *The radar shall transmit within the confines of the ITU allocated bands for maritime radar and meet the requirements of the radio regulations and applicable ITU-R recommendations.*

(MSC.192/5.1.2) *Radar systems of both X-band and S-band are covered in these performance standards:*

- *X-band (9,2-9,5 GHz) for high discrimination, good sensitivity and tracking performance; and*
- *S-band (2,9-3,1 GHz) to ensure that target detection and tracking capabilities are maintained in varying and adverse conditions of fog, rain and sea clutter.*

The frequency band selected shall be indicated.

5.2.1.2 Methods of test and required results

The methods of test and required results are as follows:

- a) confirm by measurement and analytical evaluation that the EUT meets the results required by the method described in Annex B of this standard. The test authority shall record the transmitted frequency or frequencies;
- b) confirm by observation that there is an indication of the selected frequency band in use.

5.2.2 Interference

5.2.2.1 Requirement

(MSC.192/5.1.3) *The radar shall be capable of operating satisfactorily in typical interference conditions as encountered in a normal marine radar environment.*

5.2.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by analytical evaluation that the radar system has a method to substantially reduce interference from other approved marine radar transmitting in the frequency bands allocated to marine radar;
- b) confirm by analytical evaluation that the radar system can transmit in the vicinity of other approved marine radar systems without causing significant interference or significant degradation in performance.

NOTE Radar detection performance specified in this standard may be degraded by third party interference, possibly by equipment other than marine radar, radiated within the bands assigned to marine applications.

5.3 Performance optimisation and monitoring

5.3.1 General

The radar system shall provide the means to optimise detection performance and to identify a significant drop in performance, as tested in 5.3.2.

5.3.2 Optimum performance

5.3.2.1 Requirement

(MSC.192/5.7.1) *Means shall be available to ensure that the radar system is operating at the best performance. Where applicable to the radar technology, manual tuning shall be provided and additionally, automatic tuning may be provided.*

(MSC.192/5.7.2) *An indication shall be provided, in the absence of targets, to ensure that the system is operating at the optimum performance.*

(MSC.192/5.7.3) *Means shall be available (automatically or by manual operation) and while the equipment is operational, to determine a significant drop in system performance relative to a calibrated standard established at the time of installation.*

5.3.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that the operation of the tuning function (or equivalent as applicable to the technology) is effective. The user manual shall describe how optimum performance is maintained;
- b) confirm by observation there is a manual or automatic means to indicate that the radar system is operating at the optimum performance, even in the absence of targets, for example with the provision of a tuning indicator;
- c) if automatic tuning is provided, confirm by analytical evaluation that it is not inferior to the performance achieved with manual tuning;
- d) confirm by observation that when the overall radar performance is reduced by using an attenuator or equivalent means, an overall 10 dB performance reduction or more is identified by an indication to the operator. An up-mast system may be accepted by analogy with a down-mast system, given an equivalent implementation and equipment design.

5.4 Gain and anti-clutter functions

5.4.1 General

This standard specifies control functions associated with processing or controlling the radar signals. If alternative means to achieve equivalent functionality is provided, the manufacturer shall identify the means and shall demonstrate equivalence, supported by the relevant user documentation and to the satisfaction of the test authority.

(MSC.192/5.3.2) *Means shall be provided, as far as is possible for the adequate reduction of unwanted echoes, including sea clutter, rain and other forms of precipitation, clouds, sandstorms and interference from other radars.*

Conformance with these requirements is addressed in 5.4.2 to 5.5.8 and the operation of functions is assessed in 5.9.

5.4.2 Gain function

5.4.2.1 Requirement

(MSC.192/5.3.2.2) *A gain control function shall be provided to set the system gain or signal threshold level.* A permanent indication of the gain level or setting of the signal threshold shall be given.

5.4.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that there is a permanent indication of the gain level;
- b) confirm by observation that the control function is directly accessible;
- c) confirm by evaluation and observation that the gain control coverage varies from a maximum level, providing a full noise speckle on a 24 NM range scale, to a minimum level where only the highest signal levels are presented;
- d) confirm by observation that, if a preset gain adjustment is provided, it is located in a protected set-up menu.

5.4.3 Manual and automatic sea anti-clutter

5.4.3.1 Requirement

(MSC.192/5.3.2.3) *Effective manual and automatic anti-clutter sea functions shall be provided.*

(MSC.192/5.3.2.4) *A combination of automatic and manual anti-clutter sea functions is permitted.*

(MSC.192/5.3.2.5) *There shall be a clear and permanent indication of the status for gain and all anti-clutter sea control functions.*

5.4.3.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that both “manual sea” and “automatic sea” functions are provided;
- b) confirm by document inspection that the user manual describes any installation and operational adjustments associated with these functions and any performance limitations associated with their use;
- c) confirm by document inspection that the user manual describes the operation of the manual and automatic anti-clutter sea control functions, including any advantages and limitations;
- d) confirm by observation that the status and level of the functions are permanently indicated.

5.4.4 Rain anti-clutter

5.4.4.1 Requirement

An effective manual means of suppressing rain clutter shall be provided. Automatic rejection of rain clutter may also be provided. There shall be a clear and permanent indication of the status of the anti-clutter rain function.

5.4.4.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation the availability and operation of the rain anti-clutter control functions;
- b) confirm by observation that the status and level of the rain anti-clutter function is permanently indicated;
- c) confirm by document inspection that the user manual describes the use of the manual rain anti-clutter control (and automatic where provided), together with any performance limitations associated with its use.

5.5 Signal processing

5.5.1 General

Signal processing functions serve to improve target visibility and detection performance.

5.5.2 Target enhancement

5.5.2.1 Requirement

(MSC.192/5.3.1.3.2) *The radar system shall provide the means to enhance the visibility of targets in adverse clutter conditions at close range.*

(MSC.192/5.3.3.1) *Means shall be available to enhance target visibility on the display. If selectable, the target enhance status shall be indicated and the user manual shall describe the operation and principles of the target enhance functions.*

NOTE The function to enhance the visibility of targets in close ranges may use other processing techniques than those for standard navigation purposes.

5.5.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that there are means to enhance target visibility in the clutter environment. The target enhancement functions may be selectable or permanent. If any associated functions are provided, for example to reduce a high false alarm rate, they may be enabled to reduce degradation of target visibility;
- b) confirm by document inspection that the user manual describes the enhancement function(s) and principles, including any associated functions and their use;
- c) confirm by observation that the target-enhance status is indicated.

5.5.3 Radar signal correlation

5.5.3.1 Requirement

Correlation of consecutive transmissions shall be provided to reduce unwanted interference from other radar systems. Scan to scan correlation may be used to reduce echoes from clutter.

5.5.3.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by document inspection and observation that a means is provided for the effective reduction of interference generated by other marine conventional (magnetron) radar;
- b) confirm by document inspection that where correlation techniques are provided, for example to reduce clutter, any advantages and limitations are described in the user manual.

5.5.4 Signal processing and radar image latency

5.5.4.1 Requirement

(MSC.192/5.3.3.2) *The effective signal processing and radar image update period shall be adequate and with minimum latency to ensure that the target detection and associated processing requirements are met.*

5.5.4.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation and measurement that the update of any target information has a latency of not more than the equivalent of one antenna scan. Alternative correlation techniques are permitted to have a latency of multiple scans;
- b) confirm by observation that the status of any correlation function is indicated;
- c) confirm by document inspection that the user manual describes the advantages and limitations of any alternative correlation applied.

5.5.5 Second-time-around echoes

5.5.5.1 Description

These echoes are a reflection of radar energy from a target due to a previous radar transmission which is prevalent in some atmospheric conditions. Second-time-around echoes appear as stable but false targets at any time (range) within the period between consecutive transmissions.

5.5.5.2 Requirement

A means of suppressing these second-time-around echoes may be provided and if provided, shall be tested.

5.5.5.3 Methods of test and required results

If a method for suppressing second time echoes is provided, then

- a) confirm by observation, where conditions permit, during the testing of the radar equipment, that an effective means of reducing second time echoes is provided;
- b) confirm by document inspection that the means provided to suppress second time echoes is described in the user manual.

5.5.6 Transmission format

5.5.6.1 Requirement

To optimise detection performance for the weather conditions, the equipment may provide a means to change the transmission format, for example by providing the ability to increase or to decrease the pulse length.

5.5.6.2 Methods of test and required results

If a means to change the transmission format is provided, then

- a) confirm by document inspection, observation and analytical evaluation that appropriate default transmission formats are provided for each range scale;
- b) confirm by observation that inappropriate transmission formats are inhibited or are indicated to the user, for example the long pulse length should be prohibited on shorter range scales;
- c) confirm by document inspection that the function of changing the transmission format, if provided, is described in the user manual and the basic concept, features, benefits and limitations are stated.

5.5.7 Picture update

5.5.7.1 Requirement

(MSC.192/5.3.3.3) *The picture shall be updated in a smooth and continuous manner.*

5.5.7.2 Methods of test and required results

Confirm by observation that the radar image is updated smoothly and the method of update is not distracting to the user.

5.5.8 Additional processing

5.5.8.1 Requirement

Additional signal processing provided by the equipment shall be evaluated.

5.5.8.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by document inspection what additional signal processing functions are provided;
- b) record top level details of additional signal processing features and any observed impact they have on the radar detection performance.

5.5.9 Signal processing description

5.5.9.1 Requirement

(MSC.192/5.3.3.4) *The equipment manual shall explain the basic concept, features, benefits and limitations of any signal processing functions.*

5.5.9.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that the status of all selectable active signal processing functions is indicated;
- b) confirm by document inspection that the functions are described in the user manual and that basic concepts, features, benefits and limitations are stated.

5.6 Operation with SARTs, target enhancers (RTEs) and beacons

5.6.1 General

X-band radar systems shall be compatible with radar beacons, SARTs and radar enhancers, while S-band radar systems may adopt new technology which may not be compatible with these navigation aids.

5.6.2 Radar beacons, SARTs and enhancers

5.6.2.1 Requirement

(MSC.192/5.3.4.1) *The X-band radar system shall be capable of detecting radar beacons in the relevant frequency band.*

(MSC.192/5.3.4.2) *The X-band radar system shall be capable of detecting SARTs and radar target enhancers.*

(MSC.192/5.3.4.3) *It shall be possible to switch off those signal processing functions, including alternative polarisation modes, which might prevent an X-band radar beacon or SARTs from being detected and displayed. The status of signal processing and polarisation (if selectable) shall be indicated.*

The operation of the equipment with beacons, SARTS and target enhancers shall be described in the user manual.

5.6.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that the X-band equipment operates with a typical radar beacon. The equipment shall be set working overlooking the sea and in the vicinity of known radar beacons, to demonstrate that the EUT is compatible with ITU-R M.824-3 (beacons);
- b) confirm by observation that when the X-band equipment is set working overlooking a sea environment and in the vicinity of known SARTs and radar enhancers, the system detects

SARTs and radar enhancers, as required by ITU-R M.628-4 (SARTs) and ITU-R M.1176 (radar target enhancers);

- c) confirm by observation that the status of signal processing and polarisation (if selectable) is indicated;
- d) confirm by document inspection that the operation of the equipment with beacons, SARTs and target enhancers is described in the user manual.

5.7 Minimum range and range compensation

5.7.1 General

The minimum detection range for the radar system shall be measured after the range index error has been compensated for the selected antenna position.

5.7.2 Range compensation

5.7.2.1 Requirement

(MSC.192/5.4.2) *Compensation for any range index error shall be provided and where multiple antennas are installed, shall be automatically applied for each selected antenna.*

5.7.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by document inspection that the equipment provides the means to compensate for the range index for the position of each antenna and that the settings are protected in a non-volatile memory. Adjust the range compensation for each sensor (as applicable) so that the range of a known target is correct;
- b) confirm by document inspection and observation that the compensation setting for each sensor is retained in a non-volatile memory and that it is automatically applied when each sensor is selected.

5.7.3 Minimum range

5.7.3.1 Requirement

(MSC.192/5.3.1.2) *The short-range detection of the targets under the conditions specified in Table 2 shall be compatible with the requirement.*

(MSC.192/5.4.1) *With own vessel at zero speed (or at a fixed land-based site), an antenna height of 15 m above the sea level and in calm (minimal clutter) conditions, the navigational buoy (with corner reflector) in Table 2 shall be detected at a minimum horizontal range of 40 m from the antenna position and up to a range of 1 NM, without changing the setting of control functions other than the range scale selector.*

Ensure that the range compensation is set correctly (as described in 5.7.2) before measurements are made. A test target, (equivalent to the navigational buoy with corner reflector) having a known RCS of 10 m² at X-band (having a known RCS of 1 m² at S-band) and mounted at a height of 3,5 m, shall be used.

5.7.3.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation and document inspection that if a down-mast transceiver is an option for the radar under test, the test is conducted using a down-mast transceiver, or otherwise the test shall be conducted with an up-mast unit. If the implementation of up-mast and down-mast systems is different, both types of systems shall be tested;

- b) confirm by observation that a reference test target is available having the same properties as the mobile test target. The reference test target shall be stationary and positioned at 1 NM range. Adjust the radar system so that the reference test target at approximately 1 NM is clearly visible;
- c) confirm by measurement that with the radar antenna mounted at the specified height, the separation of a mobile test target (representative of a navigational buoy) and the antenna position can be decreased to the closest point at which the target can be identified within 40 m of the antenna position. Record the result. After adjustment, the mobile test target at the minimum range and the reference target at 1 NM shall be visible with the same setting of the gain and clutter controls;
- d) alternatively a mobile target with an RCS of 10 m^2 at X-band may be used and moved from the closest point at which the target is visible up to 1 NM with the same settings of the gain and clutter controls.

The minimum range is the shortest distance at which, using a mandatory range scale of not more than 1,5 NM, a stationary target is presented separately from the position and image representing the antenna position. The separation distance is measured horizontally from the sea/ground level at the antenna position.

For this measurement, only the range scale selector may be changed and the sea and gain controls may be adjusted before commencing this test. After adjustment, the test target shall be visible at the minimum range and at 1 NM with the same setting of the sea and gain control. An off-centred presentation is permitted for this measurement.

5.8 Range and bearing discrimination

5.8.1 General

Point test targets of the same RCS as those described in 5.7.3 shall be used for the range and bearing discrimination measurements.

5.8.2 Measurement conditions

(MSC.192/5.5) *Range and bearing discrimination shall be measured in calm (minimal clutter) conditions, on a range scale of 1,5 NM or less and at between 50 % and 100 % of the range scale selected.* An off-centred presentation is permitted for this test.

5.8.3 Range discrimination

5.8.3.1 Requirement

(MSC.192/5.5.1) *The radar system shall be capable of displaying two point targets on the same bearing, separated by 40 m in range, as two distinct objects.*

5.8.3.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm the range discrimination by measurement. The radar shall be set to a range scale of 0,75 nautical miles. Two test targets as defined in 5.7.3 shall be placed on the same bearing with respect to the radar antenna, at a distance of between 0,375 nautical miles and 0,75 nautical miles, and separated from each other by a distance of not more than 40 m. The rain control and the effective pulse length of the radar shall be set to their minimum values. The sea and gain controls shall be adjusted to show separation of the two targets on the display;
- b) when the two targets are visibly separated for at least 8 scans out of 10, the linear distance between the two targets shall be measured. Confirm that the distance is not greater than 40 m.

5.8.4 Bearing discrimination

5.8.4.1 Requirement

(MSC.192/5.5.2) *The radar system shall be capable of displaying two point targets at the same range, separated by 2,5° in bearing, as two distinct objects.*

5.8.4.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm the bearing discrimination by measurement. The radar shall be set to the range scale of 1,5 NM or less and the test targets positioned at between 60 % and 100 % of the range scale selected. Two test targets of equal radar cross-section and as defined in 5.7.3, shall be placed at the same distance and shall be separated in bearing with respect to the radar antenna. The measurement may be made at any convenient bearing from the antenna location. The angular separation between the two targets shall be decreased until they cease to be displayed separately. When the two targets are visibly separated for at least 8 scans out of 10 the linear distance between the two targets shall be measured;
- b) confirm by calculation that the angle calculated with respect to the known range of the test targets does not exceed 2,5° and record the calculated angular separation.

5.8.5 Fundamental radar accuracy

5.8.5.1 Requirement

(MSC.192/5.2) *The radar system range and bearing accuracy shall be:*

Range: within 30 m or 1 % of the range scale in use, whichever is greater;

Bearing: within 1°

in typical operational and environmental conditions.

5.8.5.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) bearing: confirm by measurement that when operating on a stationary platform, the overall accuracy of taking bearings by the radar system meets the bearing accuracy required. Measurement shall be by comparing the actual bearings of identifiable point targets with bearings obtained using the radar equipment. The comparison shall be made at sample bearings distributed over 360° and the distance of each target from the radar antenna shall be between 80 % and 100 % of the range scale in use. The bearing measurement can be made either by using a single point target positioned at a series of known bearings relative to the radar antenna pedestal, or by taking the radar bearing of a series of point targets at known surveyed bearings around the radar antenna pedestal;
- b) range: confirm by measurement from a stable platform using actual ranges of identifiable point targets, that when operating on a stationary platform, the overall accuracy of making range measurements by the radar system meets the range accuracy required. Measurement shall use at least two known targets, the first at nominally 1 NM, the second at nominally 10 NM. The range accuracy shall be within 30 m or 1 % of the range scale in use, whichever is the greater, and record the result. The radar transceiver shall operate with the appropriate transmission format for this test.

5.9 Target detection performance assessment

5.9.1 General

This standard specifies the minimum range of first detection performance in clear conditions and in addition, defines clutter conditions in which compliance with the detection performance requirements are tested, measured or assessed, including:

- a) measurement of the range of first detection in minimal clutter conditions. Observations shall be made to confirm the visibility of a test target and in addition, shall be generally consistent with the IMO requirements as in Table 2;
- b) measurement/predictions of the range of first detection in the presence of clutter (between the antenna and the target) and the assessment of the target visibility in clutter conditions by observing test targets within the clutter field and/or rain extent, using sea states and rainfall rates of opportunity.

For all radar performance tests, the radar antenna shall be installed on a platform either at sea or shore-based. The antenna shall be mounted at a height as close as practical at 15 m above mean sea level, recognising that even small deviations in antenna and/or target height can influence target detection performance and will reposition multi-path nulls. To achieve consistency, the tests shall ensure that observations and measurements are made with the test targets positioned for detection at multi-path peaks. The radar antenna height and target parameters shall be documented by the test authority for each test. All test results shall be made available to the equipment manufacturer.

NOTE 1 If a representative radar system is used as a further means to assess detection performance, the antenna of both the test radar and the reference radar should be at the same height and as near as practical, co-located. A reference-radar should be demonstrated to have met the minimum requirements in this standard. It could provide an indication of the relative propagation and clutter conditions at the time of the test measurements. A pass/fail decision should not only rely on comparison with a reference-radar.

NOTE 2 All radar performance documentation requirements are addressed in 5.9.4.

5.9.2 Range of first detection in minimal clutter

5.9.2.1 Requirement

(MSC.192/5.3.1.1) *In the absence of clutter, for long range and small target and shoreline detection, the requirement for the radar system is based on normal propagation conditions, in the absence of significant sea clutter, precipitation and evaporation duct, and with an antenna height of 15 m above sea level.*

Based on:

- *an indication of the target in at least 8 out of 10 scans or equivalent; and*
- *a probability of a radar detection false alarm of 10^{-4} ,*

the requirement contained in Table 2 shall be met as specified for X-band and S-band equipment. The detection performance shall be achieved using the smallest antenna that is supplied with the radar system. A probability of a radar false alarm rate of 10^{-4} can be assumed when a light and even background noise speckle is presented on the display.

NOTE If the set-up of false alarm rate of 10^{-4} visible as a light and even background noise speckle is not applicable for the radar under test, the manufacturer should provide a method to achieve an equivalent set-up.

Table 2 – Range of first detection in clutter-free conditions

Target description ⁵	Target feature height above sea level m	Detection range ⁶	
		X-band NM	S-band NM
Shorelines ⁷	Rising to 60	20	20
Shorelines ⁷	Rising to 6	8	8
Shorelines ⁷	Rising to 3	6	6
SOLAS ships (> 5000 gross tonnage) ⁷	10	11	11
SOLAS ships (> 500 gross tonnage) ⁷	5,0	8	8
Small vessel with radar Reflector meeting IMO P.S. ¹	4,0	5,0	3,7
Navigation buoy with corner reflector ²	3,5	4,9	3,6
Typical navigation buoy ³	3,5	4,6	3,0
Small vessel of length 10 m with no radar reflection ⁴	2,0	3,4	3,0
Channel markers ³	1,0	2,0	1,0

¹ IMO revised performance standards for radar reflectors (resolution MSC.164(78)) – radar cross-section is defined as (RCS) 7,5 m² for X-Band, 0,5 m² for S-Band. The reflector used should not exceed the stated RCS by more than 50 %.

² Target is taken as 10 m² for X-band and 1,0 m² for S-band.

³ The typical navigation buoy is taken as 5,0 m² for X-band and 0,5 m² for S-band. For typical channel markers, with an RCS of 1,0 m² (X-band) and 0,1 m² (S-band) and height of 1 m, a detection range of 2,0 NM and 1,0 NM respectively.

⁴ RCS for 10 m small vessel taken as 2,5 m² for X-band and 1,4 m² for S-band (taken as a distributed target).

⁵ Reflectors are taken as point targets, vessels as complex targets and shorelines as distributed targets (typical values for a rocky shoreline, but are dependent on profile).

⁶ Detection ranges experienced in practice will be affected by various factors, including atmospheric conditions (for example evaporation duct), target speed and aspect, target material and target structure. These and other factors may either enhance or degrade the target detection at all ranges. At ranges between the first detection and own ship, the radar return may be reduced or enhanced by signal multi-paths, which depend on factors such as antenna/target centroid height, target structure, sea state and radar frequency band.

⁷ See Clause D.7.

NOTE RCS values can vary by as much as 30 dB according to target characteristics and aspects, resulting in changes in detection range (see Annex D).

NOTE Detection performance predictions for the range of first detection are derived from CARPET software calculations (CARPET: radar analysis software: Computer Aided Radar Performance Evaluation Tool).

5.9.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation and document inspection that the smallest antenna (at the test frequency band) available for use with the radar system is installed. Adjust the system for best target visibility with a light and even background noise speckle to provide good detection sensitivity. The sea conditions shall be calm for assessing range of first detection (maximum sea state 1, see Table 6 for guidance on sea states). The test may be conducted from a land site overlooking the sea or from a stable platform at sea. All observations shall be conducted in clear conditions;
- b) confirm by observation and evaluation in a test environment approved by the test authority, that using a live radar system positioned to scan over sea and using targets of opportunity, the range of first detection is generally consistent with the examples in Table 2.

In addition and as far as is practical, observations and measurements shall also include:

- established targets at various ranges up to 10 NM;
- known shorelines at various ranges above 3 NM and up to 20 NM;

Shoreline and surface objects shall be clearly visible for at least 16 scans within an observation period of 20 scans (80 % visibility) at ranges generally consistent with those specified in Table 2. Measurements shall be made over at least 4 observation periods and the results shall be assessed. As the same criteria for detection applies to all targets, a sample of targets (not the full content of Table 2) over the observation period shall be sufficient to demonstrate meeting the range of first detection. However, a calibrated test target (as defined in 5.9.3.3.2) may be included as follows. A reflector, with an RCS of 10 m² for X-band (1 m² for S-band) and mounted at a height of 3,5 m, may be used to replicate a navigation buoy with a reflector. Alternatively, this test may be conducted using a reflector with an RCS of 1 m² for X-band (0,1 m² for S-band) and mounted at a height of 1,0 m to replicate a channel marker.

5.9.3 Assessment of target detection with clutter

5.9.3.1 Clutter – general

5.9.3.1.1 Requirement

(MSC.192/5.3.1.3) *Performance limitations caused by typical precipitation and sea clutter conditions will result in a reduction of target detection capabilities relative to those defined in 5.9.2 and Table 2.*

(MSC.192/5.3.1.3.1) *The radar equipment shall be designed to provide the optimum and most consistent detection performance, restricted only by the physical limits of propagation.*

(MSC.192/5.3.1.3.3) *Degradation of detection performance (related to figures in Table 2) at various ranges and target speeds under the following conditions, shall be clearly stated in the user manual:*

- *light rain (4 mm/h) and heavy rain (16 mm/h);*
- *sea state 2 and sea state 5; and*
- *a combination of these.*

(MSC.192/5.3.1.3.4) *The determination of performance in clutter and specifically range of first detection, as defined in the clutter environment in MSC.192/5.3.1.3.3 above, shall be tested and assessed against a benchmark target, as specified in this standard.*

(MSC.192/5.3.1.1 part) *The detection performance shall be achieved using the smallest antenna that is supplied with the radar system.*

NOTE The intended detection performance tests required in MSC.192/5.3.1.3.4 above would ideally be achieved with a radar simulator. This standard provides a performance assessment using known targets and an assessment of the environmental conditions of opportunity. Full simulation of these tests, using a common design of proven test equipment, may be universally adopted by test authorities on further development of this test standard (see IMO NAV52/18 (Report to MSC), agenda item 17, subparagraph 4).

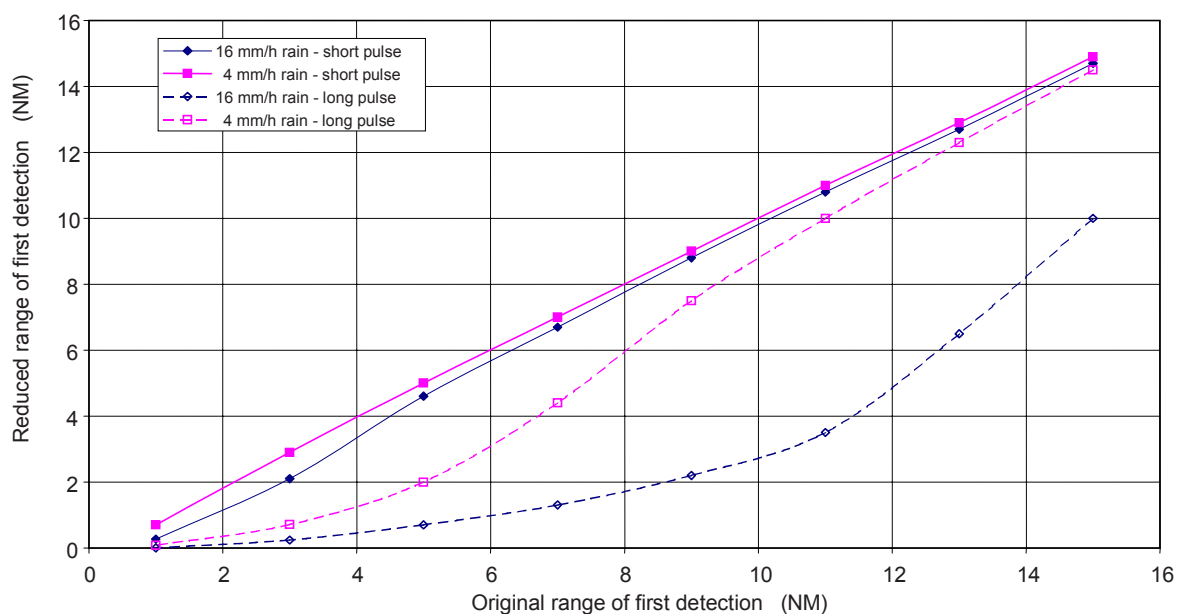
5.9.3.1.2 Methods of test and required results

The manufacturer shall, unless otherwise agreed, set up the radar system to optimise performance and shall confirm that the EUT is operating satisfactorily before tests are conducted. The manufacturer shall provide supporting evidence of the radar performance in various operational weather conditions (within the range specified by IMO) and in various sea areas, for example using fast-sample VDR recordings, video recording of the screen, screen shots or witnessed sea trials. Such evidence shall be submitted prior to performance tests and shall include full technical details of the installed radar system used to gain the results, the location of the recordings and the prevailing environmental conditions. The test authority shall assess such evidence, together with test measurements and observations required in this test section, to determine if the radar performance is satisfactory.

5.9.3.2 Rain clutter

5.9.3.2.1 Requirement

Rain clutter creates a high return of noise-like reflections that effectively decreases the signal to noise levels within the radar receiver. In addition, it creates an attenuation of the radar signal, which also decreases the signal to noise levels. Both these effects reduce the target detection capability of a radar system. Assuming a rain height of 1000 m, and constant rainfall within the detection range, the effect on the range of first detection is as given in Figure 1 for S-Band and Figure 2 for X-Band. As well as frequency of operation, the effect depends on antenna horizontal and vertical beam widths and the pulse length in operation. Radar parameters are assumed to be as described in Clause D.7.



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Figure 1 – Reduction of range to first detection due to rain at S-band

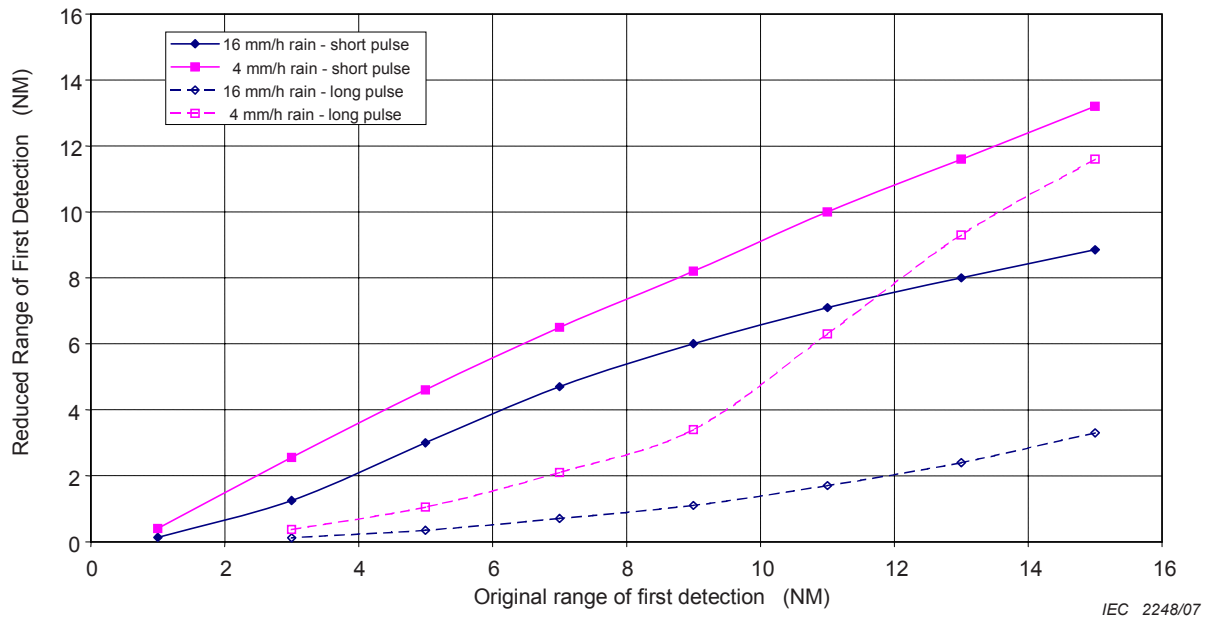


Figure 2 – Reduction of range to first detection due to rain at X-band

The radar manufacturer shall include techniques, such as differential processing and the use of an automatic threshold that allows the radar to optimise its performance in rain. The manufacturer shall provide supporting evidence from sea trials that the system performance in rain is generally consistent with the theoretical data given in Figure 1 and Figure 2.

5.9.3.2.2 Methods of test and required results

For this test, correct use shall be made of the equipment's anti-clutter control functions and the setting of these control functions shall be generally consistent with the guidance provided in the manufacturer's instructions:

- confirm that in rain conditions of opportunity the reduction in target detection from that obtained in clear conditions is generally consistent with, or is less than the performance degradation indicated in Figure 1 and Figure 2, relevant for the system under test. For this test, correct use shall be made of the equipment's anti-clutter controls and the setting of these control functions shall be generally consistent with the guidance provided in the manufacturer's instructions. All manual and automatic rain anti-clutter control functions provided by the radar system shall be evaluated;
- confirm by analytical evaluation of submitted data that the evidence submitted by the manufacturer is generally consistent with the degradation in performance predicted in Figure 1 and Figure 2, as appropriate for the transmission frequency band. The manufacturer shall supply reasonable evidence to the test authority, as far as possible within 4 mm/h to 16 mm/h rainfall rate, for a number of representative targets and ranges and using a similar radar system.

5.9.3.3 Sea clutter

5.9.3.3.1 Requirement

The presence of sea clutter degrades the detection performance of radar. Three main effects cause this degradation:

- a) large waves can obscure targets. There is no generally applicable and reliable way of overcoming this effect;
- b) waves reflect radar energy that competes with the reflection from the target. This increases the noise levels that the target is embedded within. However, the statistical nature of the wave-reflected signal differs from that of the target and various combinations of signal processing techniques can help to make the target more visible;
- c) some waves can exist over several scans and during this time exhibit a target-like behaviour. This causes sea 'spikes' that can obscure or be confused with real targets. Appropriate signal processing can sometimes reduce this effect but not consistently.

As far as possible, tests shall be made when the targets are upwind from the radar antenna position. Crosswinds and downwind will improve target detection; in this case, the test results may exceed the minimum requirement. Deviations from the direction of the wind related to the antenna position shall be noted in the test report.

At longer distances, typically over a mile or two (depending for example on antenna height), the effect of b) above is greatly lessened. At shorter distances, this effect becomes very marked and the radar manufacturer shall include signal processing in order to improve the detection performance of the radar in conditions of sea clutter caused by this effect. This needs to include the provision of a manual control and an automatic anti-clutter control that affect the threshold and the range dependence of the threshold (Sensitivity Time Control).

The manufacturer shall include processing to enable optimisation of the performance of the radar for effects caused by b) and c) above.

Signal processing, for example scan-to-scan correlation, can reduce the effect of c) above. The manufacturer should include a means to apply such techniques in order to reduce the effect. Side effects of this technique such as limitations in the detection of fast targets shall be noted in the user manual.

5.9.3.3.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation and evaluation that the following performance is achieved under the defined test conditions:
 - tests shall be performed in different sea states of opportunity between 2 and 5. At least one test shall be performed in sea state 3 or greater. Tests at the higher level of sea states are more significant and should be used whenever possible. The sea state used when commencing the test shall be noted in the test report. The nominal height of the radar antenna should be set to 15 m above actual sea height. The nominal height of the test radar target should be set to 3,5 m above actual sea level;
 - the nominal range of the test targets shall be at 0,4 NM for S-band and at 0,7 NM for X-band systems. Three radar test targets with characteristics equivalent to an omni-azimuth (horizontal plane) Luneberg lens reflector shall be used. The radar cross-section of the three reflectors at the frequency of measurement shall be 1 m^2 , 5 m^2 and 10 m^2 for X-band and $0,1 \text{ m}^2$, $0,5 \text{ m}^2$ and 1 m^2 for S-band.

NOTE To achieve a consistent target performance, an omni-azimuth (horizontal plane) lens reflector (featuring a metal grid reflector to provide a stable and a consistent RCS) is recommended for the test targets. The design is based on a dielectric sphere with a permittivity varying with the distance from the centre, providing a focal point located at the peripheral of the lens. Alternative reflectors that can maintain the same tolerance of $\pm 2,0 \text{ dB}$ on the radar cross-section, over 360° in azimuth and $\pm 15^\circ$ elevation, may also be used. The reflector gives a wide response, wide bandwidth and compact size. The tight tolerances of this reflector make it suitable as a benchmark target. Standard octahedral radar reflectors and other Luneberg lenses are not suitable.

The test shall be set up to ensure that there is confidence that all measurements will be taken at the peak of the multi-path pattern (see Annex D). Minor adjustments in the antenna height and target range/height figures given above may need to be made for each set of

measurements (observation period) to ensure that the measurements continue to be made at the multi-path peak.

With the radar set at the 6 NM range, with no precipitation within this range and with no sea or rain clutter processing applied, the radar gain control function shall be set so that there is a light noise speckle at longer ranges, outside the range where sea clutter is visible (at this stage there could be significant sea clutter visible at shorter ranges). The range scale shall then be set to 3 NM and the manual sea clutter control function adjusted to make the target optimally visible in a light clutter speckle. Test targets shall be continuously optically visible during these tests.

- b) confirm by observation that the manufacturer has included processing to enable optimisation of the performance of the radar for effects (see 5.9.3.3.1);
- c) confirm by observation that a skilled user can adjust the manual anti-clutter control function to reduce the visible level of sea clutter around the target for the best target visibility. Ensure that the target is visible to a skilled user and is assessed to be generally consistent with Table 3 and Table 4, with visibility for at least 80 % of scans (tabulated as V) or at least 50 % of scans (tabulated as M) as appropriate for the sea state and target radar cross-section.

In these tests, no allowance has been made for wave obscuration. If significant wave obscuration is present, the results will need to be interpreted accordingly.

NOTE Performance predictions are only indicative of the performance achieved in the real world and hence are only provided for guidance.

Each visibility test shall be conducted over at least twenty scans and once set for the observation period the anti-clutter control functions shall not be readjusted. The test shall be repeated for a minimum of three times and the calculated average Pd shall be recorded. For marginal pass/fail results, this procedure shall be repeated for at least 5 times for each sea state measured. To aid a marginal pass/fail decision, results may be assessed by bracketing results gained from two different reflector sizes, for example a 1 m² and a 5 m² target. The target visibility test results, the description of the environment and the test location shall be recorded.

- d) confirm by observation that the automatic anti-clutter control functions are effective in improving target visibility when following the manufacturer's defined procedures;
- e) confirm by analytical evaluation that the radar manufacturer has submitted recorded evidence from trials conducted in a variety of sea clutter conditions and that the supplied sea clutter control functions are effective in improving target visibility;
- f) confirm by observation that limitations such as the detection of fast vessels when scan to scan techniques are used are noted in the user manual.

5.9.3.4 Performance in sea and rain clutter

5.9.3.4.1 Requirement

Control functions supplied by the manufacturer for optimising radar performance in sea and rain clutter shall also be effective in conditions that have a mixture of both types of clutter. In these conditions, detection performance will be further degraded.

5.9.3.4.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that in conditions of opportunity the clutter controls can be set to improve target visibility when there is both rain and sea clutter present. Ensure that the performance is generally consistent with the tests undertaken separately for rain and sea clutter (see 5.9.3.2.2 and 5.9.3.3.2);
- b) confirm by observation that the automatic anti-clutter control functions improve target visibility in general accordance with the manufacturer's documentation and that the

performance is generally consistent with the tests undertaken separately for rain and sea clutter (see 5.9.3.2.2 and 5.9.3.3.2).

NOTE These tests need not be conducted if the manufacturer has provided sufficient evidence of performance in combined sea and rain conditions.

Table 3 – X-band pass/fail assessment criteria

X-band test target RCS:	Target visibility in Douglas sea states			
	SS 1 to 2	SS 2 to 3	SS 3 to 4	SS 4 to 5
1 m ²	V-M	M-NV		
5 m ²	V	V-M	M-NV	
10 m ²	V	V	V	V-M

NOTE Test target range is nominally positioned at 0,7 NM.

Table 4 – S-band pass/fail assessment criteria

S-band test target RCS:	Target visibility in Douglas sea states			
	SS 1 to 2	SS 2 to 3	SS 3 to 4	SS 4 to 5
0,1 m ²	V	V-M	M-NV	
0,5 m ²	V	V	V-M	M-NV
1,0 m ²	V	V	V	V-M

NOTE Test target range is nominally positioned at 0,4 NM.

Table 5 – Pass/fail assessment

Abbreviation	Interpretation
SS	Sea state
V	Target visible for at least 80 %
M	Target visible for at least 50 %
NV	Target visible for less than 50 %

NOTE Results are derived by averaging the Pd for all observations in each condition.

NOTE Detailed numerical data supporting the defined test criteria is shown in Annex D.

NOTE Full detection performance predictions are tabulated in Annex D.

Table 6 – Douglas sea state parameters

Douglas sea state	Mean wind speed kn	Significant wave height m	Sea state description
0	<4	<0,2	Flat, very calm
1	5-7	0,6	Smooth
2	7-11	0,9	Slight
3	12-16	1,2	Moderate
4	17-19	2,0	Rough
5	20-25	3,0	Very rough
6	26-33	4,0	High
NOTE Significant wave height is defined as the average height (crest to trough) of the one-third highest waves. Individual waves and/or swell can combine to significantly increase the wave height and may result in obscuration of the target. This table only applies to waves formed by local wind. NOTE The table values are approximate due to the subjective nature of the sea state assessment. NOTE Sea swell will make assessment of wave height very difficult.			

5.9.4 Radar performance documentation

5.9.4.1 Requirement

(MSC.192/5.3.1.3.5) *Degradation due to a long transmission line, antenna height or any other factors shall be clearly stated in the user manual.*

Relevant factors shall also be included in the installation instructions.

The radar manufacturer shall include in the user manual a description of the effects that reduce the performance of the radar in sea clutter and emphasise that in increasing levels of sea clutter some targets will become difficult or impossible to detect. A description of how the detection of targets in sea clutter can be optimised shall be given.

The user manual shall include the relevant data and operational techniques for optimising performance relating to Figure 1 and Figure 2 (degradation of performance in rain). Documentation shall include a description of the degradation of radar performance in rain in a manner that would be understood by the user.

5.9.4.2 Methods of test and required results

The methods of test and the required results are as follows:

- confirm by document inspection that factors which could degrade radar performance are described in the user manual;
- confirm by document inspection that installation-related factors which could degrade radar performance are described in the installation manual;
- confirm by document inspection that the manufacturer has included techniques for optimising the performance of the radar in rain to achieve, as a minimum, performance generally consistent with Figure 1 and Figure 2, as appropriate;
- confirm by document inspection that the user manual includes relevant data relating to Figure 1 and Figure 2 and that there is a description of the degradation of radar performance in rain in a manner that would be understood by the user;
- confirm by document inspection that the user manual provides a description of the effects that reduce the performance of the radar in sea clutter and emphasises that in increasing levels of sea clutter, some targets will become difficult or impossible to detect. A

description of how the detection of targets in sea clutter can be optimised shall be provided;

- f) confirm by document inspection that the user manual has a description of the effects that sea clutter has on the detection performance of radar (see 5.9.3.3.1) and that a description is given of the equipment control functions and of the recommended user procedures to reduce the effects of clutter. The documentation shall include a warning on the limitation of such controls and that wanted targets may remain or become invisible. In particular, unless the manufacturer can show otherwise, it should be stated that the use of control functions to reduce sea clutter spikes may make some targets invisible, particularly targets with higher speeds;
- g) confirm by document inspection that the user manual explains that further degradation in detection performance will be experienced when the radar is operating in simultaneous conditions of precipitation and sea clutter;
- h) confirm by document inspection that the radar manufacturer has submitted sufficient evidence from tests conducted in a variety of combined sea and rain clutter conditions.

5.10 Radar antenna (including pitch and roll)

5.10.1 General

The radar antenna is fundamental to the radar performance and shall be tested to provide information for specific tests required within this standard.

5.10.2 Vertical radiation pattern/pitch and roll

5.10.2.1 Requirement

(MSC.192/5.6) *The target detection performance of the equipment shall not be substantially impaired when own ship is rolling or pitching up to $\pm 10^\circ$.*

The vertical radiation pattern shall be designed to permit the pitch and roll of a ship without undue loss of performance, while providing a main beam pattern to limit degradation in performance due to nearby structures and to reduce the illumination of precipitation.

5.10.2.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by measurement, the vertical radiation pattern (one way) of the radar antenna, measured either in the far field region or in a region that can be referenced to it. The measurement shall be carried out at the upper and lower frequency band declared by the manufacturer. The vertical plots shall be recorded;
- b) confirm by document inspection of the measured result in a), that the -3 dB beam width encompasses $\pm 10^\circ$ in elevation. Compliance for alternative tests for meeting the above requirements may be demonstrated by measurements of the antenna radiation pattern and submission of processing tests for achieving the required results. Providing that the radar system meets with the roll/pitch requirements of 5.10, alternative processing may be used to permit a broader vertical antenna beam width.

5.10.3 Antenna horizontal pattern

5.10.3.1 Requirement

The X-band radar shall be capable of operating in a horizontally polarised mode. The far field horizontal pattern for an X-band antenna shall be measured at the upper and lower operational frequencies, as specified by the manufacturer. The measurements provide a performance check at the frequency extremes. The limits of the horizontal beam pattern specified in Table 7 shall be met. The figures relate to one way propagation. The limits in Table 7 shall also apply to an S-band antenna.

Table 7 – Main horizontal beam pattern

Power relative to maximum of main beam dB	Maximum total beam width X-band degrees (°)	Maximum total beam width S-band degrees (°)
–3	2	2
–20	10	10

5.10.3.2 Methods of test and required results

The methods of test and the required results are as follows:

- confirm by document inspection that horizontal polarisation is available on X-band systems and record any alternative polarisation(s) that may be selected;
- confirm by measurement in all polarisation modes that the horizontal beam limits given in Table 7 are met at the upper and lower operational frequencies;
- verify that for the smallest radar antenna, including any design using new technology, meets the bearing discrimination requirement in 5.8.4.

Compliance for alternative tests of meeting the above requirements may be demonstrated by measurements of the antenna radiation pattern and submission of processing tests for achieving the required results. Providing it can be demonstrated that the radar system meets the bearing discrimination requirements of 5.8.4, alternative processing may be used to permit a broader horizontal antenna beam width.

5.10.4 Antenna side lobes

5.10.4.1 Requirement

(MSC.192/7.4.3) *The antenna side lobes shall be consistent with satisfying the system performance as defined in this standard.*

As far as is practical, the design shall minimise the antenna side lobes. The measured side lobes shall be within the limits defined in Table 8.

Table 8 – Effective side-lobes

Position relative to maximum of main beam degrees (°)	Maximum power relative to maximum of main beam dB
Within ± 10	– 23
Outside ± 10	– 30

5.10.4.2 Methods of test and required results

The far-field horizontal radiation pattern of the radar antenna shall be determined either by direct measurement in the far field or by transforming an intermediate range measurement in the far field. This test shall be carried out at the upper and lower operating radio frequency limits of the nominal radio frequency declared by the manufacturer:

- confirm by measurement that the far field horizontal radiation pattern conforms to Table 8, noting that the figures relate to one-way propagation only. The measured horizontal pattern (plot) of the antenna shall be recorded in the test report;

- b) confirm by analytical evaluation that no significant side lobes exceed the limits defined in Table 8. The antenna horizontal radiation pattern shows the relative response of the antenna plotted against angular displacement in the horizontal plane. A significant side-lobe is defined as any positive excursion from the monotonically decreasing main beam pattern of more than 2 dB.

5.11 Radar availability

5.11.1 Standby and transmit

5.11.1.1 Requirement

(MSC.192/5.8) *The radar equipment shall be fully operational (run or transmit status) within 4 minutes after switch-on from cold. A standby condition shall be provided, in which there is no operational radar transmission. The radar shall be fully operational within 5 s from the standby condition.*

5.11.1.2 Methods of test and required results

The methods of test and the required results are as follows:

- a) confirm by observation that a standby facility is provided;
- b) confirm by measurement that the 4 min operational requirement from switch-on is met. The radar system shall be pre-conditioned by being disconnected from the power source for at least 1 h, then reconnected to a power source, switched on and a stopwatch started. As soon as the radar system indicates that it is available for operation, it shall be set to transmit mode. When the radar system is fully operational, the stop watch shall be stopped and the time recorded. The time from switch-on shall be within 4 minutes;
- c) confirm by measurement that the 5 s operational requirement from standby is met. The radar system shall be set to the standby mode for at least 2 minutes, after which the radar system shall be set to transmit and the stopwatch started. When the radar system is fully operational (run or transmit status), the stopwatch shall be stopped and the elapsed time recorded.

6 Display presentation

6.1 General

This standard includes the harmonisation requirements of the presentation of navigational information adopted by the IMO in Resolution MSC.191(79). Exceptions to presentation requirements of Resolution MSC.191(79) are identified.

NOTE The manufacturer may submit evidence of physical display measurements and related documentation to the satisfaction of the test authorities to support the physical requirements. In this case and with the agreement of the test authority, additional measurements during the performance test may not be deemed necessary.

6.2 Performance standards

(MSC.192(6.2.1) *The display presentation shall comply with the performance standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays (MSC.191(79)), unless otherwise specified in this standard to maintain the clarity of the radar image.*

Tests in Clause 6 verify compliance with the radar presentation requirements of MSC.191(79).

NOTE A future IEC test standard may further clarify the presentation requirements and methods of test.