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Navigation radar used on inland waterways;
Operational, functional and technical requirements

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Contents

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Foreword

This draft European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document defines the functional and operational requirements for navigational radar installations used in inland waterways as required by CESNI ES-TRIN standard [i.1].

The present document is applicable to radar equipment and its associated primary navigational display intended for the navigation of vessels on inland waterways with the following characteristics:

- Transmitter Peak Envelope Power up to 10 kW.
- The antenna is rotating and passive.
- Unmodulated single carrier frequency only may be utilized.

The applicable frequencies of operation of this type of radio equipment are given in table 1. These frequencies are allocated to the radio navigation service, as defined in article 5 of the ITU Radio Regulations [i.4].

Table 1: Radio navigation service frequencies

	Radio navigation service frequencies
Transmit	9 300 MHz to 9 500 MHz
Receive	9 300 MHz to 9 500 MHz

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] IMCO Resolution A.278 (VIII) (1973): "Symbols for controls on marine navigational radar equipment".

[2] ISO 25862:2019: "Ships and marine technology -- Marine magnetic compasses, binnacles and azimuth reading devices".

[3] IEC EN 60945 (2002): "Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] CESNI: "European Standard laying down Technical Requirements for Inland Navigation vessels, ES-TRIN".

[i.2] Recommendation ITU-R M.824-4 (02/2013): "Technical parameters of radar beacons".

[i.3] Recommendation ITU-R M.628-5 (03/2012): "Technical characteristics for search and rescue radar transponders".

[i.4] ITU Radio Regulations (2020).

[i.5] IEC 62388 (2013): "Maritime navigation and radiocommunication equipment and systems - Shipborne radar - Performance requirements, methods of testing and required test results".

[i.6] IEC 62288 (2014): "Maritime navigation and radiocommunication equipment and systems - Presentation of navigation-related information on shipborne navigational displays - General requirements, methods of testing and required test results".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

conventional radar: radar where the output signal is generated by a magnetron, using pulsed emissions but not using frequency, phase or power modulation

FTC: function to suppress rain clutter

IR: function to suppress interference from other radars

Peak Envelope Power (PEP): average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions

NOTE: This definition is taken from ITU Radio Regulations [i.4].

Radar Cross-Section (RCS): cross-section determining the power density returned to the radar for a particular power density incident on a target

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

radar equipment: equipment and its associated primary navigational display intended for the navigation of vessels on inland waterways

RAIN: function to suppress rain clutter, other term for FTC

SEA: sea clutter suppression, other term for STC

standard reflector: radar reflector with an equivalent Radar Cross Section (RCS) at a frequency of 9 400 MHz equal to 10 m^2

STC: function to suppress sea clutter

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dB	decibel
t	time
λ	wavelength

π	mathematical constant: 3,14159265…
ρ	reflection coefficient
σ	radar cross section

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternating Current
ACP	Azimuth Clock Pulse
AIS	Automatic Identification System
AR	Azimuthal Resolution
ARP	Azimuth Reference Pulse
AtoN	Aids to Navigation
CESNI	European Committee for drawing up standards in the field of inland navigation
COG	Course Over Ground
DC	Direct Current
EBL	Electronic Bearing Line
ECDIS	Electronic Chart Display and Information System
EN	European Norm
ES-TRIN	European Standard laying down Technical Requirements for Inland Navigation vessels
EUT	Equipment Under Test
FTC	Fast Time Constant
GNSS	Global Navigation Satellite System
IEC	International Electrotechnical Committee
IHO	International Hydrographic Organization
IMCO	Inter-Governmental Maritime Consultative Organization
IR	Interference Rejection
ISO	International Organization for Standardization
ITU-R	International Telecommunications Union - Radiocommunications
LED	Light Emitting Diode
MR	Minimum Range
P-Line	Parallel-Line
PRF	Pulse Repetition Frequency
PRT	Pulse Repetition Time
RACON	RAdar beaCON
RCS	Radar Cross-Section
RF	Radio Frequency
ROT	Rate-Of-Turn indicator
RR	Radial Resolution
SART	Search and Rescue Radar Transponder
SHM	Ships Heading Marker
SOG	Speed Over Ground
SOLAS	Safety Of Life At Sea
STC	Sensitivity Time Control
Tr	Trigger
V	Video
VRM	Variable Range Marker
WG	WaveGuide

4 General requirements

4.1 Purpose of the radar equipment

The radar equipment shall facilitate the navigation of vessels on inland waterways by providing an intelligible radar picture of their position in relation to buoys, shorelines and other navigational marks as well as enabling the reliable and timely recognition of other ships and obstructions protruding above the water surface.

4.2 Construction and design

Mechanical and electrical construction and design of the radar equipment shall be suitable for operation on board vessels navigating on inland waterways.

4.3 Operational controls

The equipment shall be designed in such a way that incorrect operation will not cause the equipment to fail.

One person shall be able to operate the radar equipment and watch the display simultaneously.

Control panel shall be provided as a separate unit. It shall contain all controls used directly for radar navigation. The use of cordless remote controls is not permitted.

The equipment shall not have more controls than are necessary for its correct operation. The design, markings and controls of the equipment shall enable simple, unambiguous and fast operation. The arrangement shall be such that the possibility of operating mistakes is minimized.

All controls shall be arranged in such a way that when a control is operated the associated indication remains visible and that the radar navigation can continue without restriction.

The effect of operation of controls shall be such that movements to the right or upwards shall have a positive effect on the manipulated variable, while movements to the left or downwards have a negative effect.

If pushbuttons are used, they shall be designed in such a way that they can also be found by touch. Moreover they shall have a noticeable pressure point (tactile feedback).

Controls to switch off the equipment shall be protected against unintentional operation.

All controls and indicators shall be equipped with a dazzle-free source of lighting suitable for use under all conditions of light which can be adjusted to zero by means of an independent control.

All controls and indicators shall be provided with symbols and/or a description in English and, if possible, switchable to the users language. Symbols shall meet the requirements of IMCO Resolution No. A.278 (VIII) [1].

The height of all indicative markings shall be at least 4 mm unless this is not technically feasible and therefore a reduction to 3 mm will be allowed.

Any functions additional to the minimum functions specified in the present document, as well as any connections for external apparatus, shall not impair the capability to meet the minimum requirements contained in the present document.

The antenna unit shall have a safety switch by means of which the transmitter and the rotator drive can be switched off. After switching the equipment to the STBY or to the ON state, a message shall occur on the display, if the safety switch is activated.

4.4 Interfaces

4.4.1 Fail safe design

All interfaces shall be designed fail safe, so that connecting, disconnecting or a failure of the connected equipment or a short circuit shall not cause any deterioration of the radar equipment performance.

4.4.2 Display of data received via interfaces

Unless otherwise specified, all information received via an interface shall be displayed outside of the radar picture. Existing requirements concerning the presentation of such received data shall be fulfilled.

4.4.3 Operation of equipment connected via interfaces

Unless otherwise specified all operation menus for equipment connected via interfaces shall be placed outside of the radar picture. Existing requirements concerning the presentation and the functionality of such menus shall be fulfilled.

4.4.4 Interpretation and presentation of data delivered via interfaces

If the radar acts as a display for an external device it shall receive and display all information including alarms or status messages concerning the quality of the input data.

4.5 Software

4.5.1 Software performance

Software used in equipment of the present document is assumed to be a safety critical part of a navigation system. Manufacturers of navigation systems shall make sure that all software components allow secure navigation in every situation. Software components have to be clearly designed by means of established software design methods and ergonomic criteria.

4.5.2 Software protection

Manufacturer shall implement provisions to protect all operational software incorporated in the equipment. Any software required in equipment to ensure operation in accordance with its equipment standard, including that for its initial activation or reactivation, shall be permanently installed within the equipment, in such a way that it is not possible for the operator to have access to this software. It shall not be possible for the operator to augment, amend or erase any software in the equipment required for operation in accordance with its equipment standard.

4.6 Equipment labelling

Each unit of the equipment including any external power supply, shall be clearly and indelibly marked on the exterior with the identification of the manufacturer, the type designation of the equipment and the serial number of the unit. All operating controls, indicators and terminals shall be clearly marked in accordance with IEC EN 60945 [3]. The compass safety distance shall be stated on the outdoor unit and on the display unit.

4.7 Operating and service manuals

A detailed operating manual and a summarized operating manual on a durable medium shall be supplied with each equipment in the language(s) of the country(ies) in which it is intended to be placed on the market.

The detailed version of the operating manual shall contain at least the following information:

- activation and operation;
- maintenance and servicing;
- instructions as to the correct technical installation;
- general safety instructions with special reminders of safety risks due to the rotating antenna, and of the power flux density of the microwave radiation compared with the actual limits;
- link to CE declaration by manufacturer; can alternatively be supplied by separate paper document.

Each detailed operating manual shall contain a manufacturer's statement to the effect that the equipment meets the requirements of the present document.

A detailed installation manual shall be provided.

Service manuals may be written in the English language only.

5 Testing requirements specifications

5.1 Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use, but as a minimum, shall be that specified in the test conditions contained in the present document. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the operational environmental profile defined by its intended use.

5.2 Conformance Requirements

5.2.1 Tests under extreme conditions

5.2.1.1 Performance check procedure

5.2.1.1.1 Definition

Where stated in the present document a performance check as described in this clause shall be carried out to ensure proper functionality.

5.2.1.1.2 Required test results

The following results are required:

- the warm up time shall not exceed 4 minutes;
- after switching to ON the antenna shall rotate and the transmitter functions;
- the display shall indicate the regular status of the equipment;
- the display shall be readable without any degradation;
- the operation of GAIN, TUNE, STC, FTC, EBL and VRM controls shall function correctly.

5.2.1.1.3 Conformance

The conformance tests are specified in clause 6.5.1.1.

5.2.1.2 Temperature test of the indoor unit

5.2.1.2.1 Definition

This test determines the ability of the indoor unit to work under extreme temperatures without resulting in mechanical weakness or degradation in performance.

5.2.1.2.2 Required test results

The indoor equipment shall satisfy all requirements of the performance checks as described in clause 5.2.1.1 for ambient temperatures of the indoor unit of 0 ^{o}C and +40 ^{o}C.

5.2.1.2.3 Conformance

The conformance tests are specified in clause 6.5.1.2.

5.2.1.3 Temperature test of the outdoor unit

5.2.1.3.1 Definition

This test determines the ability of the outdoor unit to withstand extreme temperatures without resulting in mechanical weakness or degradation in performance.

5.2.1.3.2 Required test results

The outdoor equipment shall satisfy all requirements of the performance checks as described in clause 5.2.1.1 for ambient temperatures of the outdoor unit between -20 ºC and +55 ºC.

5.2.1.3.3 Conformance

The conformance tests are specified in clause 6.5.1.3.

5.2.1.4 Damp heat test of outdoor unit

5.2.1.4.1 Definition

This test determines the ability of the outdoor unit to be operated under conditions of high humidity.

5.2.1.4.2 Required test results

The equipment shall meet the requirements of the performance checks as described in clause 5.2.1.1.

5.2.1.4.3 Conformance

The conformance tests are specified in clause 6.5.1.4.

5.2.1.5 Extreme power voltage and frequency test

5.2.1.5.1 Definition

This test determines the ability of equipment to withstand extreme power supply conditions without resulting in mechanical weakness or degradation in performance.

5.2.1.5.2 Required test results

In both cases the equipment shall satisfy all requirements of the performance checks as described in clause 5.2.1.1 for all power supply conditions of table 4.

5.2.1.5.3 Conformance

The conformance tests are specified in clause 6.5.1.5.

5.2.1.6 Extreme vibration test

5.2.1.6.1 Definition

This test determines the ability of equipment to withstand vibration without degradation in performance.

5.2.1.6.2 Required test results

The equipment shall meet the requirements of the performance checks as described in clause 5.2.1.1. There shall be no harmful deterioration of the equipment visible.

5.2.1.6.3 Conformance

The conformance tests are specified in clause 6.5.1.6.

5.2.2 Operational and functional requirements

5.2.2.1 Start-up time

5.2.2.1.1 Definition

Start-up time is the time the equipment takes to be operational after setting the relevant main switch from the OFF state to the ON state.

5.2.2.1.2 Required test results

The radar equipment shall take less than four minutes to reach the STBY state. After switching from the STBY to the ON state a delay time of maximally one antenna revolution to reach the full operational state shall be accepted.

5.2.2.1.3 Conformance

The conformance tests are specified in clause 6.5.2.1.

5.2.2.2 System sensitivity

5.2.2.2.1 Definition

The system sensitivity expresses the ability to detect and display a weak target.

5.2.2.2.2 Required test results

The echo blip of the standard reflectors (RCS = 10 m^2) shall be visible in every antenna scan/revolution.

The echo blip of the small reflector (RCS = 1 m^2) shall be visible in at least 8 antenna scans (blip/scan-factor ≥ 0,8).

5.2.2.2.3 Conformance

The conformance tests are specified in clause 6.5.2.2.

5.2.2.3 Gain dynamic range

5.2.2.3.1 Definition

Gain dynamic range is the difference in gain between the highest and the lowest possible gain settings of the gain control.

The gain control shall have a dynamic range that allow noise just to be made visible at ranges where the "sea" clutter suppression (STC) is no longer effective as well as allowing powerful radar echoes with an RCS in the order of 10 000 m^2 in any range.

5.2.2.3.2 Required test results

With zero gain no targets shall be visible on the screen.

With maximum gain the noise floor on the outer range of the picture shall be visible.

With optimal gain all reflectors of the test field shall be visible simultaneously.

5.2.2.3.3 Conformance

The conformance tests are specified in clause 6.5.2.3.

5.2.2.4 Minimum range

5.2.2.4.1 Definition

The minimum range is the shortest distance from which the radar is able to detect and display targets (see clause B.1).

5.2.2.4.2 Required test results

In all low range scales up to and including 1 200 m the nearest reflector (15 m) shall be visible as long as the difference in height between the radar antenna and the nearest reflector is less than 7,50 m.

5.2.2.4.3 Conformance

The conformance tests are specified in clause 6.5.2.4.

5.2.2.5 Radial resolution capability

5.2.2.5.1 Definition

The radial resolution is the shortest distance between two targets on the same bearing that can be discriminated (see clause B.2).

5.2.2.5.2 Required test results

At all distances between 15 and 1 200 m in all range scales up to and including 1 200 m, standard reflectors located 15 m apart on the same bearing shall be shown on the radar picture clearly separated.

5.2.2.5.3 Conformance

The conformance tests are specified in clause 6.5.2.5.

5.2.2.6 Azimuthal resolution capability

5.2.2.6.1 Definition

The azimuthal resolution is the ability of the radar to display and distinguish targets which are close to each other in azimuth and at the same distance from the antenna (see clause B.3). In the present document the azimuthal resolution is understood to be the minimum azimuthal distance between standard reflectors at which they are shown clearly separated on the radar picture. The azimuthal resolution is related to range scale and distance. The required azimuthal resolution capability for the lower range scales up to and including 1 200 m is shown in annex B.

5.2.2.6.2 Required test results

All reflectors positioned at a distance of 85 m (with 5 m azimuthal spacing) and at a distance of 1 200 m (30 m azimuthal spacing) at all range scales up to and including 1 200 m shall be shown on the screen simultaneously as clearly separated targets, regardless of the azimuthal position of the test field in relation to the heading line (see annex B).

All requirements of this test shall be met at each antenna height of 5 m, 7 m and 10 m. Adjustments are allowed only at the operator accessible controls.

5.2.2.6.3 Conformance

The conformance tests are specified in clause 6.5.2.6.

5.2.2.7 Range scales and fixed range rings

5.2.2.7.1 Definition

For the presentation of the radar picture the radar equipment shall be provided with eight sequentially switchable range scales in combination with defined fixed range ring distances.

Further sequentially switchable range scales above and below the specified range scales are permitted.

5.2.2.7.2 Required test results

All above mentioned range scales and rings distances shall be switchable and displayed within the required accuracy of ±5 m or 1,5 % of the range scale in use, whereby the larger value shall apply in each case:

Range 1	500 m	every 100 m one fixed range ring;
Range 2	800 m	every 200 m one fixed range ring;
Range 3	1 200 m	every 200 m one fixed range ring;
Range 4	1 600 m	every 400 m one fixed range ring;
Range 5	2 000 m	every 400 m one fixed range ring;
Range 6	4 000 m	every 1 000 m one fixed range ring;
Range 7	8 000 m	every 2 000 m one fixed range ring;
Range 8	16 000 m	every 4 000 m one fixed range ring.

The width of the range rings shall not exceed 0,5 mm. The display of sub-ranges and sector enlargements is not permitted.

The selected range scale and the distance between range rings shall be indicated in metres or kilometres.

5.2.2.7.3 Conformance

The conformance tests are specified in clause 6.5.2.7.

5.2.2.8 Variable Range Marker (VRM)

5.2.2.8.1 Definition

A variable range marker is a concentric range ring with an adjustable radius. Additionally to the ring itself the actual radius of the VRM is displayed numerically.

5.2.2.8.2 Required test results

The radar equipment shall have a VRM in the form of a concentric ring, clearly distinguishable from the fixed range rings. The VRM shall be capable of taking the distance to any target within 5 s to any distance of the visible radar picture, with an error not exceeding 5 m or 1,5 % of the range scale in use, whereby the larger value shall apply in each case.

The distance adjusted with the VRM shall not change even after switch over to other range scales.

The VRM shall be accompanied by a numeric readout as a 3-digit-figure or 4-digit-figure with a reading resolution of 10 m, up to and including the 2 000 m range. The radius of the VRM shall correspond with the numerical readout and with the fixed distance rings.

Additional VRMs meeting the same requirements may be provided, in which case separate identifiable read-outs shall be provided.

The line thickness of the VRM shall not be greater than the maximum permissible thickness of the heading line (0,5 mm).

5.2.2.8.3 Conformance

The conformance tests are specified in clause 6.5.2.8.

5.2.2.9 Heading line and radar picture azimuth angular error

5.2.2.9.1 Definition

A heading line is a vertical line in the radar display starting from the centre of the radar picture and leading to the middle of the uppermost edge of the radar display, except when radar display is in landscape orientation, installed on a ferry.

The heading line represents a parallel line to, or the direction of the ship's longitudinal axis.

The radar picture azimuth error is the deviation of the radar picture orientation from the correct orientation, represented by the heading line.

5.2.2.9.2 Required test results

The heading line shall extend from the position on the radar display that corresponds to the antenna position up to the outermost edge of the radar picture.

On condition that the screen and picture brilliance is adjusted to make anything visible on the screen, the heading line shall be visible.

The thickness of the displayed heading line shall not be greater than 0,5° measured at maximum range at the edge of the radar display, when the display is centred.

The radar equipment shall have an adjusting device to enable correction of any azimuthal angular error. After correction of the angular error, the deviation of the radar pictures azimuthal angle from the heading line (keel line) shall not exceed 0,5°.

5.2.2.9.3 Conformance

The conformance tests are specified in clause 6.5.2.9.

5.2.2.10 Bearing facilities and bearing scale

5.2.2.10.1 Definition

Bearing facilities, i.e. an Electronic Bearing Line (EBL), allows to determine the azimuthal angle of a target with reference to the heading line (bearing angle). The bearing angle can be read on a bearing scale or on a numerical display.

A bearing scale is a scale arranged around the outermost edge of the radar picture.

5.2.2.10.2 Required test results

The radar equipment shall have a bearing scale arranged at the outermost edge of the radar picture. The bearings scale shall be divided into at least 72 parts each representing 5°.

The bearing scale shall be numbered three-figured from 000 to 360° in a clockwise direction. The numbering shall be provided in Arabic numerals every 10° or every 30°. A clear arrow sign may replace the figure 000.

Linear or non-linear bearing scales may be provided. The radar picture shall be within this scale.

The Electronic Bearing Line (EBL) shall be:

- clearly distinguishable from the heading line;

- displayed quasi-continuously;
- freely rotatable through 360° left and right;
- at most 0,5° wide at the outermost edge of the radar picture;
- extend from origin up to the bearing scale;
- provided with a three- or four-figure decimal indication in degrees.

Bearing facilities shall be capable of taking a bearing angle of any target within 5 s, with a maximum error of 1°.

5.2.2.10.3 Conformance

The conformance tests are specified in clause 6.5.2.10.

5.2.2.11 Nautical information and navigation lines

5.2.2.11.1 Definition

Nautical information and navigation lines are helpful information concerning the navigation additionally to the radar picture.

5.2.2.11.2 Required test results

If the nautical information presents the display of another navigational equipment i.e. a ROT-indicator, regarding the display and accuracy of nautical information the same requirements as those to the main equipment apply.

All screen information besides the radar picture shall be displayed quasi-statically and the refreshing rate shall satisfy the operational requirements.

Only heading lines, bearing lines, range rings, navigation lines, P-Line(s), Inland AIS symbols, AtoN symbols and Inland AIS labels (temporary) may superimpose the radar picture. Outside the radar picture and in addition to information on the operating conditions of the radar equipment, only nautical information such as that listed below may be displayed:

- rate of turn;
- speed of the vessel;
- rudder position;
- water depth;
- compass course.

Suitable alarms or indication of missing input shall be provided.

5.2.2.11.3 Conformance

The conformance tests are specified in clause 6.5.2.11.

5.2.2.12 Facilities for suppressing sea and rain clutter

5.2.2.12.1 Definition

Sea clutter is caused by reflection of the radar signal from surface waves in the vicinity of the vessel's radar and has the effect of brightening the centre area of the radar picture. By time depending modulation of the receivers sensitivity (STC, also sometimes called "Sea Clutter Suppression", SEA) the disturbing effect of see clutter can be reduced.

Rain clutter is caused by any kind of precipitation (rain, snow) has the effect of brightening affected areas of the radar picture. By suitable means, i.e. high passing the radar video signal (FTC, also sometimes called RAIN), the disturbing effect of rain clutter can be reduced.

5.2.2.12.2 Required test results

The radar equipment shall have facilities with manual controls for the suppression of clutter from sea and rain. Automatic acting facilities for the suppression of sea and rain clutter are not permitted.

The STC shall, at its maximum setting, be effective up to a distance of 1 300 m.

At maximum setting of FTC the radial extension of all echoes may shortened not under 5 m.

5.2.2.12.3 Conformance

The conformance tests are specified in clause 6.5.2.12.

5.2.2.13 Suppression of interference from other radars

5.2.2.13.1 Definition

Transmitting pulses of other radars can cause interferences in form of dashed spirals or lines on the own radar picture. By suitable means, i.e. interference rejection, the disturbing effect of other radars are reduced.

When using double-pulse transmission, radar transmits two pulses shortly after each other (double-pulse transmission).

5.2.2.13.2 Required test results

There shall be a switchable facility (Interference Rejection (IR)) enabling the reduction of interference caused by other radar equipment. IR shall have at least two levels of effectiveness.

First level of IR shall reduce interfering signal significantly; residuals may still be displayed. Highest level of IR shall suppress interfering signal completely.

The operation of this facility shall not result in the suppression of useful targets. In all levels of IR the echo blip of the small reflector (RCS = 1 m^2) shall be visible in at least 8 antenna scans (blip/scan-factor ≥ 0,8).

There shall be a switchable facility to modulate the Pulse Repetition Frequency (PRF) of the radar, called "staggering".

Manufacturer shall indicate when the radar uses double-pulse transmission.

5.2.2.13.3 Conformance

The conformance tests are specified in clause 6.5.2.13.

5.2.2.14 Compatibility with radar beacons and search and rescue radar transponders

5.2.2.14.1 Definition

Signals from radar beacons as specified in Recommendation ITU-R M.824-4 [i.2] are displayed as a coded radial line in the radar picture.

Signals from Search And Rescue Radar Transponders (SART) as specified in Recommendation ITU-R M.628-5 [i.3] are displayed as a series of 12 forward and return pulses along a radial line in the radar picture. Depending from the distance to the SART, not all of the 12 forward and return pulses are displayed in the radar; in addition, the intensity of each pulse may vary from low to stronger intensity.

5.2.2.14.2 Required test results

The signals from the radar beacon shall be displayed clearly with the rain clutter suppression (FTC) set to off.

The signals from the search and rescue radar transponder shall be displayed clearly with the rain clutter suppression (FTC) set to off.

5.2.2.14.3 Conformance

The conformance tests are specified in clause 6.5.2.14.

5.2.2.15 Special modes of operation

5.2.2.15.1 Definition

Radar manufacturers may implement special modes of operation.

5.2.2.15.2 Required test results

The radar shall start up in normal mode. Special modes as implemented by manufacturer shall be set active by intentional switching on only. When switched on, a special mode shall be clearly indicated.

If the special mode is not compatible with other features of the radar, these features shall be set inactive for the time the special mode is active. E.g. off-centring shall not be permitted when radar display is in landscape format.

Special mode shall be described in detail in user manual. All risks that might arise when using special mode shall be clearly indicated in manual.

5.2.2.15.3 Conformance

The conformance tests are specified in clause 6.5.2.15.

5.2.3 Operation controls and indicators

5.2.3.1 Directly accessible operation controls

5.2.3.1.1 Definition

Some operational functions need to be directly accessible. This can be achieved by using separate dedicated controls or by always visible control menus.

5.2.3.1.2 Required test results

The following functions shall have their own directly accessible controls:

- STBY/ON;
- RANGE;
- TUNING;
- GAIN;
- STC;
- FTC;
- VRM;
- EBL;
- SHM.

At least the controls for GAIN, STC and FTC shall be adjustable by means of a rotary knob or a comparable operation, and the effect of the controls shall be roughly proportional to their angle of rotation.

The anti-clutter operation controls STC and FTC shall be continuously adjustable from zero to the maximum effect.

The settings of the following functions shall be visible in all light conditions:

- PANEL ILLUMINATION (where applicable);
- TUNING;
- GAIN;
- FTC;
- MONITOR BRILLIANCE.

The control of the PANEL ILLUMINATION and MONITOR BRILLIANCE shall be located and adjusted by tactile (feel or touch) means.

5.2.3.1.3 Conformance

The conformance tests are specified in clause 6.5.3.1.

5.2.3.2 Brilliance controls

5.2.3.2.1 Definition

The required brilliance of the whole screen or of some display attributes depends on the environmental luminance, which can vary in a wide range. So the equipment needs controls to adjust the brilliance of the different display attributes.

5.2.3.2.2 Required test results

The respective brightness of the following display attributes shall be independently adjustable from zero to the level necessary for operation:

- radar picture;
- fixed range rings;
- variable range rings;
- bearing scale;
- bearing line;
- nautical information.

Provided that the difference in brightness of some of the displayed attributes is only slight and the fixed range rings, the variable range ring and the bearing line can be switched off independent of each other, there may be four brightness controls divided over the following values:

- radar picture and heading line;
- fixed range rings;
- variable range rings;
- bearing line and bearing scale;
- nautical information.

The brilliance of the heading line shall be adjustable but not be reducible to zero.

5.2.3.2.3 Conformance

The conformance tests are specified in clause 6.5.3.2.

5.2.3.3 Heading line on/off control (SHM)

5.2.3.3.1 Definition

In some cases it may be possible that the heading line masks a target. To ensure potential obscuration can be checked a means to temporarily suppress the heading line shall be provided.

5.2.3.3.2 Required test results

To switch off the heading line there shall be a control with automatic reset (e.g. spring-loaded switch).

Heading line shall when displayed always superimpose all other objects.

If measures are prepared to prevent hidden targets, the above mentioned control is not required.

5.2.3.3.3 Conformance

The conformance tests are specified in clause 6.5.3.3.

5.2.3.4 Frequency tuning control and indicator

5.2.3.4.1 Definition

With frequency tuning the receiver frequency will be adjusted to the frequency of the transmitter.

5.2.3.4.2 Required test results

A manual control to perform the frequency tuning or to activate an automatic frequency tuning shall be available.

The frequency tuning shall be effective in all ranges even without radar echoes. The frequency tuning shall be effective equally well when the gain is reduced or sea clutter suppression is activated.

The display unit shall be provided with a tuning indicator. The tuning scale shall have a length of at least 30 mm.

5.2.3.4.3 Conformance

The conformance tests are specified in clause 6.5.3.4.

5.2.4 Display unit characteristics

5.2.4.1 Display screen dimensions

5.2.4.1.1 Definition

The display unit is understood to be that part of the equipment that contains the screen. The screen is understood to be the low reflection indicator on which either only the radar picture is shown, or the radar picture together with additional nautical information.

Display screen dimension is defined in case of circular screens by the diameter and in case of rectangular screens by the edge length. Rectangular screens are recommended to be oriented in portrait form.

5.2.4.1.2 Required test results

The minimum dimension of the usable screen shall be 27 cm diameter in case of circular screens or 27 cm × 27 cm^2 in case of rectangular screens.

5.2.4.1.3 Conformance

The conformance tests are specified in clause 6.5.4.1.

5.2.4.2 Display screen brilliance

5.2.4.2.1 Definition

The ambient environmental brightness in a steer house can vary greatly between day and night, and the display screen brilliance requires a wide dynamic range, particularly to very low values for night time operation.

5.2.4.2.2 Required test results

For night time operation the display screen brilliance shall be capable of adjustment to the following luminance values:

- foreground area $\leq 5{,}00$ cd/m^2; (suitable area of white or lightest colour available - radar echo);
- background area $\leq 0{,}10$ cd/m^2; (suitable area of black or darkest colour available - no echoes or lines);
- contrast the contrast ratio between foreground and background areas shall be 50 : 1 or greater.

Under daylight ambient brightness it shall be possible to adjust the luminance controls such that the display can be clearly interpreted by the test crew.

Any vision aids that may be necessary shall be appropriate to the equipment and shall be attachable and removable in a simple manner. Visual aids shall be useable by wearers of spectacles.

5.2.4.2.3 Conformance

The conformance tests are specified in clause 6.5.4.2.

5.2.4.3 Display resolution

5.2.4.3.1 Definition

The display resolution is determined by the azimuthal and radial resolution requirements of the radar picture (see clauses 5.2.2.5 and 5.2.2.6).

5.2.4.3.2 Required test results

The required resolution of the radar picture in the 1 200 m range has a value of 5 m, which requires a pixel area size of not greater than 2,5 m in the 1 200 m range (2 400 m diameter). So the short edge of the screen or the diameter of a circular screen shall consist a minimum of 1 000 pixels.

5.2.4.3.3 Conformance

The conformance tests are specified in clause 6.5.4.3.

5.2.4.4 Picture generation characteristics

5.2.4.4.1 Definition

To avoid flickering either the whole picture will be redrawn several times in a second (raster scan presentation) or all unchanged parts of the picture stay and the changed parts of the picture only will be drawn new by replacing the previous parts.

Raster scan representation of a picture is understood to be the quasi-static representation of a stored picture in form of a television picture (fast following line after line and frame after frame).

Switching time is the time need to switch the colour of a pixel from black to white and back to black (sum of rise and fall time).

5.2.4.4.2 Required test results

The minimum picture repetition frequency shall be 50 Hz and the switching time shall not exceed 50 ms.

5.2.4.4.3 Conformance

The conformance tests are specified in clause 6.5.4.4.

5.2.4.5 Supplementary displays

5.2.4.5.1 Definition

There are different types of displays which might be connected to a radar:

- a "second display" is a screen connected to a second video output port of the radar. It shows exactly the content of the main radar screen;
- a "slave display" is a system connected to the radar, showing exactly the radar image of the main radar screen but might also show additional information (e.g. electronic charts, etc.). Radar provides radar information in form of an image. Each image covers an azimuth sector range of a few degrees only to prevent delay time;
- a "daughter display" is a system where the connected radar serves as a sensor; the radar provides unprocessed, sweep based raw radar information. The additional display processes and displays the radar informational independently from main radar.

5.2.4.5.2 Required test results

A "second display" shall comply with all hardware requirements for the main display when used for navigational purpose.

The radar image of a "slave display" shall be identical to the radar image shown on main screen at any time. When a chart is shown on the screen, scale and orientation of map and radar image shall match. A "slave display" shall comply with all requirements for the main display when used for navigational purpose.

A "daughter display" shall comply with all requirements applicable to navigational radar equipment when used for navigational purpose.

The display shall have an indication on the front side when it does not comply with the requirements of this clause and is therefore not permitted to be used for navigation purpose.

The operation manual shall contain a special remark concerning the possibility that switching the radar to a high range and the "daughter display" to a low range may decrease the radial resolution when viewed on the slave display.

5.2.4.5.3 Conformance

The conformance tests are specified in clause 6.5.4.5.

5.2.4.6 Screen reflection characteristics

5.2.4.6.1 Definition

Screen reflection coefficient is understood to be the quotient of the luminance of an illuminator in a certain distance and the luminance of the EUT (screen) in the same distance using the same illuminator. The screen is brought into the line of light at half the distance.

5.2.4.6.2 Required test results

The reflection coefficient ρ shall be not higher than 0,85 %.

5.2.4.6.3 Conformance

The conformance tests are specified in clause 6.5.4.6.

5.2.5 Radar picture characteristics

5.2.5.1 Radar picture

5.2.5.1.1 Definition

The raw radar picture is understood to be the scale representation of radar echoes of the surroundings on the display units screen from a complete antenna revolution relative to the ship (and its movement), whereby the ship's keel line and the heading line shall be arranged in a fixed position parallel to each other. The linearity error of the raw radar picture is the elliptical deviation of a circular presentation.

5.2.5.1.2 Required test results

The radar picture shall present an image of the echo independent of strength, in only one colour. The linearity error of the radar picture shall be less than 5 %. In all range scales up to 2 000 m, a fixed straight shore line at a distance of 30 m to the radar antenna shall be displayed as a straight coherent echo structure without observable distortions.

5.2.5.1.3 Conformance

The conformance tests are specified in clause 6.5.5.1.

5.2.5.2 Effective diameter of the radar picture

5.2.5.2.1 Definition

The effective diameter of the radar picture is understood to be the diameter of the largest complete circular radar picture, which can be shown within the bearing scale.

5.2.5.2.2 Required test results

The effective diameter of the visible radar picture shall not be less than 270 mm.

The diameter of the fixed range ring of the range scales specified in clause 5.2.2.7 shall be at least 90 % of the effective radar picture diameter (27 cm × 0,9 = 24,3 cm).

5.2.5.2.3 Conformance

The conformance tests are specified in clause 6.5.5.2.

5.2.5.3 Colours of picture presentation

5.2.5.3.1 Definition

The picture presentation contains the radar picture, nautical data and other attributes. To be better distinguishable picture parts can have different brilliances, different styles or different colours.

5.2.5.3.2 Required test results

The represented colour scheme shall be chosen on the basis of ergonomically and physiological factors.

If various colours can be reproduced on the screen, the actual radar picture shall be presented in monochrome.

The representation of indications in different colours shall not result in mixed colours by superimposing.

5.2.5.3.3 Conformance

The conformance tests are specified in clause 6.5.5.3.

5.2.5.4 Radar picture refresh rate and storage

5.2.5.4.1 Definition

All echoes as a result of transmitting a microwave pulse create one spoke of the radar picture. All consecutive spokes within one complete antenna revolution have to be stored in the display memory and create the radar picture. After one antenna revolution the process starts again, and the old spokes are overwritten by the new ones. In addition there is a time delay between the receipt of the radar signal and the display of the radar information due to processing the radar signal.

5.2.5.4.2 Required test results

Each echo on the screen shall be stored for at least the duration of one antenna rotation. The representation of the radar picture may be performed in two fashions: either by a continuous display or by periodical picture refresh.

The time span from the receipt of radar signal to display the radar information shall not be higher than 0,32 s.

With scan-to-scan correlation the maximum permitted time delay cannot be met. As a result, scan-to-scan correlation shall be used only in special mode. This means that radar is not permitted to start with this mode; it has to be intentionally switched on by skipper. The activation of this mode has to be indicated on the display. The manual has to give information that this mode might lead to a degradation of the radar picture as small fast vessels might not be displayed.

The difference in brightness between the writing of an echo and its afterglow during one antenna rotation shall be as small as possible.

The radar picture shown by the display shall be renewed by the actual radar picture within 2,5 s.

Picture freeze-up (screen picture not refreshed) shall not occur in any case. A fault, which prevents the update of a radar picture, shall delete the radar display area, and an appropriate alarm shall be given.

5.2.5.4.3 Conformance

The conformance tests are specified in clause 6.5.5.4.

5.2.5.5 Target trails

5.2.5.5.1 Definition

Trails are 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 as specified in IEC 62388 [i.5].

5.2.5.5.2 Required test results

It shall be possible to display the previous positions of targets by means of trails. The representation of the target trails shall be quasi-continuous. It is recommended that trails for radar echoes have the same colour as the radar echoes. It is also possible to show the trails in a different colour as the colour of the radar echoes, but the colour of the trails should not dominate the radar echoes. The brightness of the trails should always be lower than the radar echoes, no matter which colour or colour combination is used.

The trails shall be distinguishable from the targets and shall be capable of being switched off. The length of the trails may be user adjustable and be capable of being reset.

It shall be possible to adapt the length of the trail to the operational requirements, but it shall come up with a duration lasting 2 antenna revolutions. The target trail shall not impair the radar picture.

5.2.5.5.3 Conformance

The conformance tests are specified in clause 6.5.5.5.

5.2.5.6 Off-centring

5.2.5.6.1 Definition

Off-centring is a static shift of the radar picture with respect to the screen centre to enable an extended forward view.

5.2.5.6.2 Required test results

Off-centring shall be possible in all range scales specified in clause 5.2.2.7. In the range scales with extended forward view the range rings shall be extended and the variable range marker shall be adjustable and readable up to the maximum of the displayed range.

Off-centring shall result exclusively in an extension of the forward view and shall be adjustable within the range from 10 % to 35 % of the effective picture diameter (see clause 5.2.5.2).

A permanent fixed extension of the radar picture in the forward direction is permitted, provided that in the circular part of the picture the effective diameter is greater than 243 mm and that the bearing scale is designed in such a way that a bearing can be taken in accordance with the requirements of the present document. In this case a facility for off centring as mentioned in this clause is not required.

5.2.5.6.3 Conformance

The conformance tests are specified in clause 6.5.5.6.

5.2.6 Antenna and antenna drive characteristics

5.2.6.1 Radiation pattern in the horizontal plane

5.2.6.1.1 Definition

The radiation pattern in the horizontal plane is the relative gain factor of the antenna and the azimuth angle referred to the maximum gain in the main lobe (maximum gain = 0 dB). Due to the high dynamic range of targets RCSs a high difference in gain between the main lobe and the side lobes is required.

5.2.6.1.2 Required test results

The horizontal radiation pattern of the antenna shall meet the following requirements:

- -3 dB beam width of the main beam maximum 1,2°;
- 20 dB beam width of the main beam maximum 3,0°;
- side-lobe attenuation within ±10° around the main lobe at least 25 dB;
- side-lobe attenuation outside ±10° around the main lobe at least 32 dB.

The microwave signal radiated from the antenna in working position shall be horizontally polarized.

5.2.6.1.3 Conformance

The conformance tests are specified in clause 6.5.6.1.

5.2.6.2 Radiation pattern in the vertical plane

5.2.6.2.1 Definition

The radiation pattern in the vertical plane is the relative gain factor of the antenna and the elevation angle referred to the maximum gain in the main lobe (maximum gain = 0 dB). Due to the high dynamic range of targets RCSs a high difference in gain between the main lobe and the side lobes is required.

5.2.6.2.2 Required test results

The vertical radiation pattern of the antenna measured in one direction shall meet the following requirements:

- -3 dB beam width of the main lobe maximum 30°;
- the maximum of the main lobe shall be in the horizontal axis of the normal mounting position;
- side lobe attenuation at least 25 dB.

The microwave signal radiated from the antenna in working position shall be horizontally polarized.

5.2.6.2.3 Conformance

The conformance tests are specified in clause 6.5.6.2.

5.2.6.3 Antenna drive characteristics

5.2.6.3.1 Definition

To detect radar echoes of all directions the antenna needs to rotate around a vertical axis (in the horizontal plane). The picture renewal rate will be determined by the antenna rotation rate. For special purposes a sector blanking is required, which means the disabling of transmission in a sector in the horizontal plane.

5.2.6.3.2 Required test results

The antenna drive with all provided antennas shall be such as to allow start and correct operation at wind speeds of up to 100 km per hour. The manufacturer shall declare that compliance to this requirement is achieved and shall supply relevant documentation.

The scan shall be continuous clockwise in the horizontal plane with an antenna rotation rate not less than 24 rpm through 360° of azimuth. Accordingly, the time for one antenna revolution shall not exceed 2,5 s.

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

5.2.6.3.3 Conformance

The conformance tests are specified in clause 6.5.6.3.

5.2.7 Interfaces

5.2.7.1 Analogue input and display for ROT indicators

5.2.7.1.1 Definition

The Rate-Of-Turn indicator (ROT) is an important information the skipper needs to steer the vessel, especially during the navigation with radar in poor visibility conditions. The useful measuring range depends on the vessels mass.

5.2.7.1.2 Required test results

The analogue input of the ROT interface shall have a sensitivity of 20 mV/°/min and an input resistance of not less than 1 000 Ω. A positive input signal shall cause a movement of the displayed ROT value (bar) to starboard, a negative to port.

The ROT display scale shall have a minimum scale length of 20 cm and be oriented horizontal centred to the upper edge of the screen and above the radar picture. The complete requirements to ROT indicators are found in the CESNI ES-TRIN standard [i.1].

5.2.7.1.3 Conformance

The conformance tests are specified in clause 6.5.7.1.

5.2.7.2 Analogue output interface for raw radar

5.2.7.2.1 Definition

An analogue interface may be provided comprising radar information.

5.2.7.2.2 Required test results

An analogue interface - if provided - shall consist at least of four different signals:

- ACP: Azimuth Clock Pulse;
- ARP: Azimuth Reference Pulse;
- Tr: Trigger signal;
- V: Video signal.

The radar picture of both the main and slave displays shall not be modified or degraded.

By using this interface it shall be possible for connected equipment to produce a complete radar picture fulfilling the requirements of the present document.

5.2.7.2.3 Conformance

The conformance tests are specified in clause 6.5.7.2.

5.2.7.3 Interfaces for nautical sensors

5.2.7.3.1 Definition

Interfaces for nautical sensors provide the possibility to display nautical information on the screen.

5.2.7.3.2 Required test results

Connecting or disconnecting an external sensor or short circuiting any interface line to ground shall not modify or degrade the radar picture of the main display or the radar equipment in any case.

All interface operation menus and displays shall be placed outside of the radar picture or, if specified, in the intended area on the screen. Existing requirements concerning the operation of interface equipment shall be fulfilled.

5.2.7.3.3 Conformance

The conformance tests are specified in clause 6.5.7.3.

5.2.8 Safety distance requirements

5.2.8.1 Compass safety distance requirements

5.2.8.1.1 Definition

The compass safety distance is to be understood as the minimum distance between a magnetic compass and the installed component (indoor unit or outdoor unit) of the radar equipment as specified by the equipment manufacturer.
ISO 25862 [2] defines "vicinity", relative to the compass.

5.2.8.1.2 Required test results

Each unit of equipment shall be clearly marked with the minimum safety distance at which it may be mounted from compasses.

The outdoor unit as well as indoor unit of the equipment have to be marked with the compass safety distance as described in ISO 25862 [2]. If the marked compass safety distance is stated as 1,5 m or more, no further actions are required. If the claimed compass safety distance of the equipment is lower than 1,5 m, a stamp of approval, provided by an accredited laboratory shall be presented.

5.2.8.1.3 Conformance

The conformance tests are specified in clause 6.5.8.1.

5.2.9 Display of other navigation information

5.2.9.1 Display of tracking and tracing information

5.2.9.1.1 Definition

When connected to a tracking and tracing device (e.g. Inland AIS), information of and from other vessels may be displayed, like:

- position;
- orientation;
- dimensions;
- heading;
- COG;
- SOG;
- number of blue cones;
- status of blue panel.

5.2.9.1.2 Required test results

The other vessel, represented by a symbol, shall only be shown when:

- the information is up-to-date (real-time), and
- the age of information does not exceed the maximum time out values provided in table 2 (see also IEC 62388 [i.5]). The symbols shall be marked as outdated. The AIS targets should be marked as outdated if the position information is older than half of the timeout value or the age of the information exceeds 30 s for moving vessels.

Table 2: AIS timeout values

Category of vessel	Nominal reporting interval class A	Maximum time out value class A	Nominal reporting interval class B	Maximum time out value class B
Vessel at anchor or moored and not moving faster than 3 knots (class B not moving faster than 2 knots)	3 min	18 min	3 min	18 min
Vessel at anchor or moored and moving at more than 3 knots	10 s	60 s	3 min	18 min
Vessel operating in SOLAS mode, moving 0 to 14 knots	10 s	60 s	30 s	180 s
Vessel operating in SOLAS mode, moving 0 to 14 knots and changing course	3 1/3 s	60 s	30 s	180 s
Vessel operating in SOLAS mode, moving 14 to 23 knots	6 s	36 s	30 s	180 s
Vessel operating in SOLAS mode, moving 14 to 23 knots and changing course	2 s	36 s	30 s	180 s
Vessel operating in SOLAS mode, moving faster than 23 knots	2 s	30 s	30 s	180 s
Vessel operating in SOLAS mode, moving faster than 23 knots and changing course	2 s	30 s	30 s	180 s
Vessel operating in inland waterway mode	2 - 10 s	60 s	-	-

The position information of the own vessel shall only be displayed when the position is detected by an on board subsystem and not if the position is received from a repeater station.

Only if the heading of other vessels is available, the position and the orientation of those other vessels may be presented by:

- a directed triangle; or
- a true outline (to scale).

In all other cases a generic symbol shall be used (an octagon is recommended, a circle shall not be used for applications which are certified according to maritime standards).

If an AIS is connected, Information regarding the position of AIS base stations, AIS Aids to Navigation (AtoN) and AIS Search and Rescue Transmitters (SART) shall be displayed.

It shall be possible to display all information transmitted by an AIS on user request.

The number of the blue cones/lights shall only be displayed in the pick report.

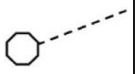
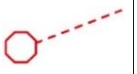
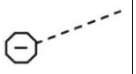
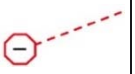
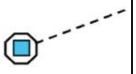
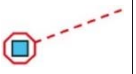
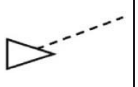
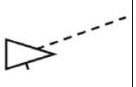
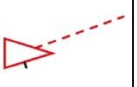
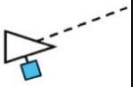
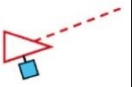
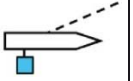
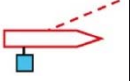
The information on the intention (blue sign) shall only be displayed on the right side of the symbol, if the heading of the vessel is available. If no heading information is available the information shall only be displayed in a direction independent form.

Information on the blue sign shall only be displayed if all three values can be clearly distinguished:

- the blue sign is not connected or the status of the connection is not available;
- the blue sign is set;
- the blue sign is not set.

Table 3 is providing an example for the display.

Table 3: AIS visualization of blue sign status

Visualization of Blue Sign status 0 to 2 and dangerous goods								
Blue sign			Not connected or not available		Not Set		Set	
Blue cones			no	1 to 3	no	1 to 3	no	1 to 3
Heading	No	Symbol						
	Yes	Symbol						
		True shape						

Suitable alarm or indication of missing input from - if connected - GNSS receiver, AIS and heading device shall be provided.

5.2.9.1.3 Conformance

The conformance tests are specified in clause 6.5.9.1.

5.2.9.2 Display of navigation guiding lines

5.2.9.2.1 Definition

Automatic track-keeping systems use guiding lines to show current and predicted tracks of the vessel on appropriate display systems like Inland ECDIS or radar.

5.2.9.2.2 Required test results

The guiding lines presented on the radar screen shall not interfere with radar echoes or other radar information shown on the screen.

5.2.9.2.3 Conformance

The conformance tests are specified in clause 6.5.9.2.

6 Testing for compliance with technical requirements

6.1 General requirements

The manufacturer shall ensure that all operating modes and product configurations are in compliance with the technical requirements in the present document.

EUT shall comprise scanner unit, transceiver, display and operational controls as a minimum.

6.2 Standard operating mode of the radar equipment

Unless otherwise stated the radar equipment shall be set to the standard operating mode which is understood to be as follows:

Operation state: on (antenna turns);

Antenna height: 7 m;

RANGE: 1 200 m;

TUNE setting: optimal;

GAIN setting: optimal;

STC setting: zero;

FTC setting: off;

Range rings: visible;

VRM: visible;

EBL: visible;

Brilliance of all attributes: optimal (well readable).

6.3 Environmental conditions for testing

6.3.1 Test conditions

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use, which, as a minimum, shall be that specified in the test conditions contained in the present document.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

Unless otherwise stated, all tests shall take place under the test conditions as described in clause 6.3.2.

6.3.2 Normal test conditions

6.3.2.1 Introduction

The various tests as described in the present document shall take place in three different environments:

- in a laboratory;
- at a test field; and
- on board a river vessel.

Where the particular tests take place depends on the task and is described in the test method. Unless otherwise stated, all tests shall take place under the following Normal test conditions. During the tests the radar equipment shall be operated as stated in the test description or in the standard operation mode as described in clause 6.2.

6.3.2.2 Normal temperature and humidity

The temperature and humidity conditions for tests shall be a combination of temperature and humidity within the following ranges:

a) temperature: +15 ºC to +35 ºC;

b) relative humidity: 20 % to 75 %.

6.3.2.3 Normal test power supply

6.3.2.3.1 AC test power supply

The test voltage for equipment to be connected to an AC power supply shall be the nominal mains voltage declared by the manufacturer -10 % to +10 %. For the purpose of the present document, the nominal voltage shall be the declared voltage or any of the declared voltages for which the equipment is indicated as having been designed. The frequency of the test voltage shall be 50 Hz ± 1 Hz.

6.3.2.3.2 DC test power supply

Where the equipment is designed to operate from a DC source, the normal test voltage shall be the nominal voltage as declared by the manufacturer -10 % to +30 %.

The internal impedance of the test power source shall be low enough for its effect on the test results to be negligible. For the purpose of testing the power source voltage shall be measured at the input terminals of the equipment.

During testing, the power source voltages shall be maintained within a tolerance of ±3 % relative to the voltage level at the beginning of each test.

6.3.3 Extreme test conditions

6.3.3.1 Indoor unit

The temperature and humidity conditions for extreme tests shall be a combination of nominal temperature and humidity within the following ranges:

a) temperature: 0 ºC to +40 ºC;

b) relative humidity: not exceeding 75 %.

6.3.3.2 Outdoor unit

The temperature and humidity conditions for extreme tests shall be a combination of nominal temperature and humidity within the following ranges:

a) temperature: -20 ºC to +55 ºC;

b) relative humidity: not exceeding 93 %.

6.3.3.3 Extreme power supply voltage test conditions

Where required the EUT shall comply with the extreme power supply voltage conditions as specified in table 4.

Table 4: Extreme power supply voltage and frequency tolerances

Power supply	Voltage variation %	Frequency variation %
AC	±10	±5
DC	+20 -10	Not applicable

6.3.3.4 Extreme vibration test conditions

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

a) 2 Hz (-0 +3) Hz and up to 13,2 Hz with an excursion of ±1 mm ± 10 % (7 m/s^2 maximum acceleration at 13,2 Hz);

b) above 13,2 Hz and up to 100 Hz with a constant maximum acceleration of 7 m/s^2.

6.4 Interpretation of the measurements results

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as such that the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document.

6.5 Performance tests

6.5.1 Tests under extreme conditions

6.5.1.1 Performance check procedure

After the respective test under extreme conditions as described in the present document is completed, the radar should be initiated from OFF to STANDBY and, after the warm up period, switched to ON.

The results obtained shall be compared to the required test results in clause 5.2.1.1.2 in order to prove compliance with the requirement.

6.5.1.2 Temperature test of the indoor unit

Before testing the indoor unit the equipment shall be switched off and the outdoor unit placed outside of the test chamber in conditions as described in clauses 6.3.2.2 and 6.3.2.3 of the present document.

The indoor unit shall be placed in the test chamber at normal temperature. Then the test temperature shall be reduced to 0 ºC with a maximum rate of change of 1 ºC/minute.

Before conducting tests at the low extreme temperature the equipment in the test chamber shall have reached thermal equilibrium and be subjected to the low extreme temperature for a period of two hours.

After the above mentioned equilibrium period performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.1.2 in order to prove compliance with the requirement.

The test temperature shall be increased to 40 ºC with a maximum rate of change of 1 ºC/minute.

Before conducting tests at the high extreme temperature the equipment in the test chamber shall have reached thermal equilibrium and be subjected to the high extreme temperature for a period of two hours.

After the above mentioned equilibrium period performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.1.2 in order to prove compliance with the requirement.

6.5.1.3 Temperature test of the outdoor unit

Before testing the outdoor unit the equipment shall be switched off and the indoor unit shall be placed outside of the test chamber at conditions as described in clauses 6.3.2.2 and 6.3.2.3.

The outdoor unit shall be placed in the test chamber at normal temperature. Then the test temperature shall be reduced to -20 ºC with a maximum rate of change of 1 ºC/minute.

Before conducting tests at the low extreme temperature the equipment in the test chamber shall have reached thermal equilibrium and be subjected to the high extreme temperature for a period of 10 hours to 16 hours.

After the above mentioned equilibrium period performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.3.2 in order to prove compliance with the requirement.

Then the test temperature shall be increased to 55 ºC with a maximum slewing rate of 1 ºC/minute.

Before conducting tests at the high extreme temperature the equipment in the test chamber shall have reached thermal equilibrium and be subjected to the low extreme temperature for a period of 10 hours to 16 hours.

After the above mentioned equilibrium period performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.3.2 in order to prove compliance with the requirement.

At the end of the test, with the equipment still in the chamber, the chamber shall be brought to normal temperature in not less than one hour. The equipment shall then be exposed to normal temperature and relative humidity for not less than three hours or until moisture has dispersed, whichever is the longer, before the next test is carried out. Alternatively, observing the same precautions, the equipment may be returned directly to the conditions required for the start of the next test.

After the above mentioned equilibrium period performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.3.2 in order to prove compliance with the requirement.

6.5.1.4 Damp heat test of the outdoor unit

The outdoor unit including the antenna shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be raised to +40 °C with a maximum rate of change of 1 °C/minute, and the relative humidity raised to 93 % over a period of three hours. These conditions shall be maintained for a period of 10 hours to 16 hours.

Then the EUT shall be switched on and shall be subjected to performance checks as described in clause 5.2.1.1, while temperature and relative humidity of the chamber are maintained as specified.

The results obtained shall be compared to the required test results in clause 5.2.1.4.2 in order to prove compliance with the requirement.

After finishing the performance checks, with the EUT still in the chamber, the chamber shall be brought to room temperature in not less than one hour.

6.5.1.5 Extreme power voltage and frequency test

The equipment shall be operated under normal room temperatures (between 15 ºC and 25 ºC), with the nominal power supply voltage and, if powered by AC, with the nominal frequency.

After a warm up time of 30 minutes the supply voltage and, if powered by AC, the frequency are reduced to the minimum value as stated in clause 6.3.3.3 and performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.5.2 in order to prove compliance with the requirement.

Subsequently the supply voltage and, if powered by AC, the frequency are increased to the maximum value as stated in clause 6.3.3.3 and performance checks as described in clause 5.2.1.1 shall be performed.

The results obtained shall be compared to the required test results in clause 5.2.1.5.2 in order to prove compliance with the requirement.

6.5.1.6 Extreme vibration test

The EUT shall be subjected to sinusoidal vertical vibration in accordance to IEC EN 60945 [3] at all frequencies between:

a) 2 Hz (-0 +3) Hz and up to 13,2 Hz with an excursion of ±1 mm (±10 %) (7 m/s^2 maximum acceleration at 13,2 Hz);

b) above 13,2 Hz and up to 100 Hz with a constant maximum acceleration of 7 m/s^2.

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

A resonance search shall be carried out throughout the test. During the resonance search the EUT shall be externally observed, by unaided visual and aural means, for obvious signs of any resonances of components or sub-assemblies that may affect the integrity of the EUT.

Such observations shall be recorded in the test report. If any resonance, as measured by a sensor fixed to the outside of the EUT at the location where obvious signs of resonance have been observed, has a magnitude ratio ≥ 5 measured relative to the surface where the EUT is fastened, the EUT shall be subjected to a vibration endurance test at each resonant frequency at the vibration level specified in the test with a duration of 2 h. When resonant frequencies with magnitude ratios ≥ 5 are harmonically related, only the fundamental frequency shall be tested. If no resonance with a magnitude ratio ≥ 5 occurs, the endurance test shall be carried out at one single observed frequency. If no resonance occurred, the endurance test shall be carried out at a frequency of 30 Hz. The procedure shall be repeated with vibration in each of two mutually perpendicular directions in the horizontal plane.

Performance check(s) as described in clause 5.2.1.1 shall be carried out at least once during each endurance test period, and once before the end of each endurance test period.

The results obtained shall be compared to the required test results in clause 5.2.1.6.2 in order to prove compliance with the requirement.

6.5.2 Operational and functional requirements

6.5.2.1 Start-up time

Starting from the OFF position the main switch shall be set to the STBY state and the time until the equipment reports ready will be measured.

After the equipment reports ready the main switch shall be set from the STBY to the ON state, and the time the equipment takes to be operational will be measured.

The results obtained shall be compared to the required test results in clause 5.2.2.1.2 in order to prove compliance with the requirement.

6.5.2.2 System sensitivity

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. By using an antenna height of 7 m, a range scale of 1 200 m and optimal settings of all relevant operation controls the visibility of all targets up to 1 200 m from the antenna should be observed for ten antenna revolutions. Within the ten revolutions those with a visible echo of the 1 m^2 reflector in 1 200 m distance shall be counted.

The results obtained shall be compared to the required test results in clause 5.2.2.1.2 in order to prove compliance with the requirement.

6.5.2.3 Gain dynamic range

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. The STC control shall be set to its optimum value, while the FTC control shall be switched to the "Off" position. The GAIN shall be adjusted in such a way that in the area beyond the effective range of the STC noise is just suppressed. All controls that influence picture quality shall be adjusted appropriately and not changed for the duration of the test. The visibility of all reflectors of the test field are observed with successive antenna heights of 5 m, 7 m and 10 m above the surface of the test field.

At each antenna height the gain control shall be adjusted to achieve the optimum picture.

The results obtained shall be compared to the required test results in clause 5.2.2.3.2 in order to prove compliance with the requirement.

6.5.2.4 Minimum range

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. The STC control shall be set to its optimum value, while the FTC control shall be switched to the "Off" position. The GAIN shall be adjusted in such a way that in the area beyond the effective range of the STC noise is just suppressed. All controls that influence picture quality shall be adjusted appropriately and not changed for the duration of the test. The visibility of all reflectors of the test field are observed with successive antenna heights of 5 m, 7 m and 10 m above the surface of the test field.

The visibility of all reflectors including the nearest reflector of the test field are observed with successive antenna heights of 5 m, 7 m and 10 m above the surface of the test field.

The visibility of the first radar reflector will be observed in all low range scales up to and including 1 200 m.

The results obtained shall be compared to the required test results in clause 5.2.2.4.2 in order to prove compliance with the requirement.

6.5.2.5 Radial resolution capability

In range scales lower then 2 000 m the selection of longer pulse lengths than the minimum value shall not be used.

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. The STC control shall be set to its optimum value, while the FTC control shall be switched to the "Off" position. The GAIN shall be adjusted in such a way that in the area beyond the effective range of the STC noise is just suppressed. All controls that influence picture quality shall be adjusted appropriately and not changed for the duration of the test. The visibility of all reflectors of the test field are observed with successive antenna heights of 5 m, 7 m and 10 m above the surface of the test field.

The results obtained shall be compared to the required test results in clause 5.2.2.5.2 in order to prove compliance with the requirement.

6.5.2.6 Azimuthal resolution capability

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. The STC control shall be adjusted to the optimum setting, while the FTC shall be switched "Off". The GAIN shall be adjusted in such a way that in the area beyond the effective range of the STC noise is just suppressed. All controls that influence picture quality shall be adjusted appropriately and not changed for the duration of the test. The visibility of all reflectors of the test field are observed with successive antenna heights of 5 m, 7 m and 10 m above the surface of the test field.

The results obtained shall be compared to the required test results in clause 5.2.2.6.2 in order to prove compliance with the requirement.

6.5.2.7 Range scales and fixed range rings

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2.

All defined range scales are chosen in succession and the fixed range rings are counted. The accuracy of the ranges and fixed rings are tested by comparing the distance rings with the reflectors of the test field.

The results obtained shall be compared to the required test results in clause 5.2.2.7.2 in order to prove compliance with the requirement.

6.5.2.8 Variable Range Marker (VRM)

A test field as described in annex A shall be used. Using the standard operating mode as defined in clause 6.2 the accuracy of the range rings and variable range marker are measured using the reflectors of the test field. Check that the requirements are met for each VRM provided and on each range scale up to 16 kilometres. The accuracy of fixed range rings and VRM shall be maintained in both cases, with the display centred and off-centred.

The results obtained shall be compared to the required test results in clause 5.2.2.8.2 in order to prove compliance with the requirement.

6.5.2.9 Heading line and radar picture azimuth angular error

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2.

The requirements for the heading line indication are checked by inspection. The thickness of the displayed heading is controlled.

The accuracy of the radar picture orientation with reference to the heading line will be tested.

The results obtained shall be compared to the required test results in clause 5.2.2.9.2 in order to prove compliance with the requirement.

6.5.2.10 Bearing facilities and bearing scale

The radar equipment is set to the standard operation mode as defined in clause 6.2.

The attributes of the bearing scale are identified with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.2.10.2 in order to prove compliance with the requirement.

6.5.2.11 Nautical information and navigation lines

The radar equipment is set to the standard operation mode as defined in clause 6.2.

All available nautical information and orientation lines are tested with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.2.11.2 in order to prove compliance with the requirement.

6.5.2.12 Facilities for suppressing sea and rain clutter

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2.

The effects of STC and FTC are tested with respect to the required results.

The results obtained shall be compared to the required test results in clause 5.2.2.12.2 in order to prove compliance with the requirement.

6.5.2.13 Suppression of interference from other radars

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. The STC control shall be set to its optimum value, while the FTC control shall be switched to the "Off" position. GAIN shall be adjusted in such a way that in the area beyond the effective range of the STC noise is just suppressed. Staggering shall be switched off.

A second conventional navigation radar device, that fulfils the requirements of the present document, is placed at a distance 40 m away in the direction of the line of reflectors at a height of 2 m. The radar is set to standard operation mode as defined in clause 6.2 and put into operation.

On the display of EUT the occurrence of inferences in form of dashed spirals or lines are observed. Interference rejection facility is activated, starting with the lowest level. At all stages, the visibility of interferences shall be observed and the visibility of the 1 m^2 reflector in 1 200 m distance shall be counted over 10 antenna revolutions.

The test shall then re repeated with "staggering" switched on.

The results obtained shall be compared to the required test results in clause 5.2.2.13.2 in order to prove compliance with the requirement.

6.5.2.14 Compatibility with radar beacons and search and rescue radar transponders

A test field as described in annex A is used with either:

- a x-band radar beacon with a Morse "T" (25 µs long dash) in a distance of 1 200 m far from the radar antenna; or
- an x-band search and rescue radar transponder in a distance of 800 m far from the radar antenna.

The radar equipment is set to the standard operation mode as defined in clause 6.2 and the range scale will be changed to an appropriate one.

The results obtained shall be compared to the required test results in clause 5.2.2.14.2 in order to prove compliance with the requirement.

6.5.2.15 Special modes of operation

Special mode shall be activated. It is tested by visual inspection if indication for special mode is indicated. All relevant functions are tested with respect of compatibility with special mode.

Radar is then restarted. It is tested by visual inspection if special mode is active after restart.

User manual is checked by visual inspection for detailed description of special mode and possible warning for usage.

The results obtained shall be compared to the required test results in clause 5.2.2.15.2 in order to prove compliance with the requirement.

6.5.3 Operation controls and indicators

6.5.3.1 Directly accessible operation controls

The radar equipment is set to the standard operation mode as defined in clause 6.2.

All relevant functions are tested with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.3.1.2 in order to prove compliance with the requirement.

6.5.3.2 Brilliance controls

The radar equipment is set to the standard operation mode as defined in clause 6.2.

All relevant functions are tested with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.3.2.2 in order to prove compliance with the requirement.

6.5.3.3 Heading line on/off control (SHM)

The radar equipment is set to the standard operation mode as defined in clause 6.2.

All relevant functions are tested with respect to the required test results.

The SHM on/off key is used and the resulting effect will be controlled.

The results obtained shall be compared to the required test results in clause 5.2.3.3.2 in order to prove compliance with the requirement.

6.5.3.4 Frequency tuning control and indicator

The radar equipment is set to the standard operation mode as defined in clause 6.2.

In all ranges up to and including 16 km a frequency tuning will be performed. The tuning indicator as well as the radar picture itself are controlled with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.3.4.2 in order to prove compliance with the requirement.

6.5.4 Display unit characteristics

6.5.4.1 Display screen dimensions

The usable area of the screen will be measured with a ruler.

The results obtained shall be compared to the required test results in clause 5.2.4.1.2 in order to prove compliance with the requirement.

6.5.4.2 Display screen brilliance

The radar equipment is set to the standard operation mode as defined in clause 6.2.

The radar echo colour shall be set to white colour.

As preparation for the test the radar display and the test crew will be placed in a dark room for a minimum of 30 minutes.

The foreground screen brilliance will be adjusted to the lowest adjustable value. Then the luminances were determined by a luminance meter.

Following the low brightness test the room ambient illumination shall be raised to bright daylight levels and the luminance controls suitably adjusted. The test crew shall then conduct a visual assessment to ensure that the display can be clearly interpreted.

The results obtained shall be compared to the required test results in clause 5.2.4.2.2 in order to prove compliance with the requirement.

6.5.4.3 Display resolution

Since the screen resolution of raster scan devices will be determined by the pixel counts of each screen edge, these will be assessed.

The results obtained shall be compared to the required test results in clause 5.2.4.3.2 in order to prove compliance with the requirement.

6.5.4.4 Picture generation characteristics

The radar equipment is set to the standard operation mode as defined in clause 6.2.

In case of a raster scan device the picture repetition frequency will be measured. On a static device the switching time to take over the new picture will be distinguished by measuring the rise time (change of colour of a pixel from white to black) and the fall time (change of colour of a pixel from white to black).

The results obtained shall be compared to the required test results in clause 5.2.4.4.2 in order to prove compliance with the requirement.

6.5.4.5 Supplementary displays

When intended for navigation purpose, "second display" is tested by applying all clauses related to the hardware of the main display. When not intended for navigation purpose, the appropriate indicator shall be checked by visual inspection.

"Slave display" is tested by visual comparing radar image with radar image of main display. All features that have an impact of the radar image shall be tested (off-centring, FTC, STC, GAIN, range rings, EBL, VRM, etc.). If applicable, the match of orientation and scale of chart and radar image is tested in all ranges.

When intended for navigation purpose, "slave display" is tested by applying all clauses related to the main display. When not intended for navigation purpose, the appropriate indicator shall be checked by visual inspection.

"Daughter display" is tested by applying all requirements applicable to navigational radar equipment.

The results obtained shall be compared to the required test results in clause 5.2.4.5.2 in order to prove compliance with the requirement.

6.5.4.6 Screen reflection characteristics

The test shall be performed as described in annex D.

The results obtained shall be compared to the required test results in clause 5.2.4.6.2 in order to prove compliance with the requirement.

6.5.5 Radar picture characteristics

6.5.5.1 Radar picture

This test will be performed on a test field as described in annex A as well as on board of a test vessel. The radar equipment shall be set to the standard operation mode as defined in clause 6.2.

The presentation of the radar picture concerning the scale, the brilliance, the used colours and the linearity will be controlled and compared with the requirements.

The results obtained shall be compared to the required test results in clause 5.2.5.1.2 in order to prove compliance with the requirement.

6.5.5.2 Effective diameter of the radar picture

The test of the effective diameter can take place either in a laboratory or in a test field as described in annex A. The radar equipment shall be set to the standard operation mode as defined in clause 6.2 but with an appropriate antenna height. The effective diameter of the radar picture is determined by linear measurement with a rigid ruler.

The results obtained shall be compared to the required test results in clause 5.2.5.2.2 in order to prove compliance with the requirement.

6.5.5.3 Colours of picture presentation

The picture presentation and the colour scheme will be checked by visual inspection.

The results obtained shall be compared to the required test results in clause 5.2.5.3.2 in order to prove compliance with the requirement.

6.5.5.4 Radar picture refresh rate and storage

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2.

The results obtained shall be compared to the required test results in clause 5.2.5.4.2 in order to prove compliance with the requirement.

6.5.5.5 Target trails

The radar equipment shall be installed on a vessel, its heading line aligned parallel to ships ahead axis. During the test the radar picture and the trails are observed and verified. In case of different modes, each mode shall be checked independently.

The results obtained shall be compared to the required test results in clause 5.2.5.5.2 in order to prove compliance with the requirement.

6.5.5.6 Off-centring

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. The relevant switch will be set to "Off-centring".

The results obtained shall be compared to the required test results in clause 5.2.5.6.2 in order to prove compliance with the requirement.

6.5.6 Antenna and antenna drive characteristics

6.5.6.1 Radiation pattern in the horizontal plane

The antenna will be powered by a constant level microwave generator and mounted on top of a rotating turn table at a height of 5 m. In a distance of 200 times the length of the antenna aperture in the horizontal plane, a microwave receiver geared to the radar antenna measures the microwave radiation level. Other equivalent methods are permitted.

The results obtained shall be compared to the required test results in clause 5.2.6.1.2 in order to prove compliance with the requirement.

6.5.6.2 Radiation pattern in the vertical plane

The antenna will be powered by a constant level microwave generator and mounted on top of a rotating turn table at a height of 5 m; where the antenna has been turned through 90° (skewed) and the main antenna lobe remains parallel to the ground. At a distance of 200 times the length of the antenna aperture (in the horizontal plane) and at a height of 5 m, a microwave receiver pointing directly to the radar antenna shall measure the microwave radiation level.

The results obtained shall be compared to the required test results in clause 5.2.6.2.2 in order to prove compliance with the requirement.

6.5.6.3 Antenna drive characteristics

A test field as described in annex A shall be used and the radar equipment set to the standard operation mode as defined in clause 6.2. With a stopwatch the time for 10 antenna revolutions will be measured. This time divided by 10 delivers the rotation time for one antenna revolution.

If sector blanking is implemented, this function shall be tested by defining a sector including the complete test field. When sector blanking is active, the visibility of all reflectors shall be observed and the indication of this mode shall be checked.

The results obtained shall be compared to the required test results in clause 5.2.6.3.2 in order to prove compliance with the requirement.

6.5.7 Interfaces

6.5.7.1 Analogue input and display for ROT indicators

On the ROT interface of the radar equipment a voltage will be applied and altered between -7,5 V and +7,5 V. Direction and value of ROT display are observed and measured.

The results obtained shall be compared to the required test results in clause 5.2.7.1.2 in order to prove compliance with the requirement.

6.5.7.2 Analogue output interface for raw radar

The electrical circuit shall be tested for being fail safe. In practical tests the influence of connecting and disconnecting any interface or short circuiting any interface line to ground to the radar picture of the main display shall be observed.

The picture of the slave display shall be tested in the same manner as a main display.

The results obtained shall be compared to the required test results in clause 5.2.7.2.2 in order to prove compliance with the requirement.

6.5.7.3 Interfaces for nautical sensors

The foreseen sensors are connected with the interface and the radar display shall be observed.

The results obtained shall be compared to the required test results in clause 5.2.7.3.2 in order to prove compliance with the requirement.

6.5.8 Safety distance requirements

6.5.8.1 Compass safety distance requirements

The marked compass safety distance on the equipment as described in ISO 25862 [2] shall be established.

The results obtained shall be compared to the required test results in clause 5.2.8.1.2 in order to prove compliance with the requirement.

6.5.9 Display of other navigation information

6.5.9.1 Display of tracking and tracing information

This test will be performed on board of a test vessel. The radar equipment is set to the standard operation mode as defined in clause 6.2.

All relevant functions are tested with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.9.1.2 in order to prove compliance with the requirement.

6.5.9.2 Display of navigation guiding lines

The radar equipment is set to the standard operation mode as defined in clause 6.2.

This test will be performed on board of a test vessel. If no vessel equipped with an automatic track - keeping system is available, the test can be performed in a laboratory by feeding a simulated data stream into radar.

All relevant functions are tested with respect to the required test results.

The results obtained shall be compared to the required test results in clause 5.2.9.2.2 in order to prove compliance with the requirement.

Annex A (normative): Set-up of the radar reflectors at the test field and preparation of the radar equipment under test

A.1 Test site

The test field shown in clause B.3 for the testing of radar equipment shall be arranged on a calm water surface at least 1,5 km long and 0,3 km wide, or on a terrain with equivalent reflection properties.

A.2 Standard reflectors

A standard reflector in the present document is to be understood as a radar reflector with an equivalent Radar Cross Section of RCS = 10 m^2 at a wavelength of 3,2 cm. If the reflector has not a unidirectional reflection characteristic, so as a corner reflector, it shall be adjusted and fixed with its main lobe in direction of the radar antenna both in azimuth and in elevation.

The dimensions of the reflectors determined for the testing of range and discrimination at a wavelength of 3,2 cm shall also be used when the radar equipment under test has a wavelength other than 3,2 cm.

A.3 Set-up of the radar reflectors at the test field

Distances and positions mentioned in the following text are horizontal measurements from the radar's axis of rotation, at ground level (this is shown as the 'antenna position' in figures in annex A and annex B).

As shown in figure A.1, standard reflectors shall be set up at distances of 15 m, 30 m, 45 m, 60 m, 85 m, 300 m, 800 m, 1 170 m, 1 185 m and 1 200 m from the antenna position.

Beside the standard reflector at 85 m, standard reflectors shall be set up at a distance of 5 m on both sides, at right angles to the line of bearing.

Beside the standard reflector at 300 m, a reflector with an equivalent Radar Cross Section of 300 m^2 shall be set up at a distance of 18 m, at right angles to the line of bearing.

Further reflectors with an equivalent Radar Cross Section of 1 m^2 and 1 000 m^2 shall be set up at an azimuthal angle to each other of at least 15^o at the same distance of 300 m from the antenna.

Beside the standard reflector at 1 200 m, standard reflectors and a reflector with a Radar Cross Section of 1 m^2 shall be set up at a distance of 30 m on both sides, at right angles to the line of bearing.

The reflectors shall be set up at such a height above the surface of the water or of the terrain that their effective radar return meets the specified value.

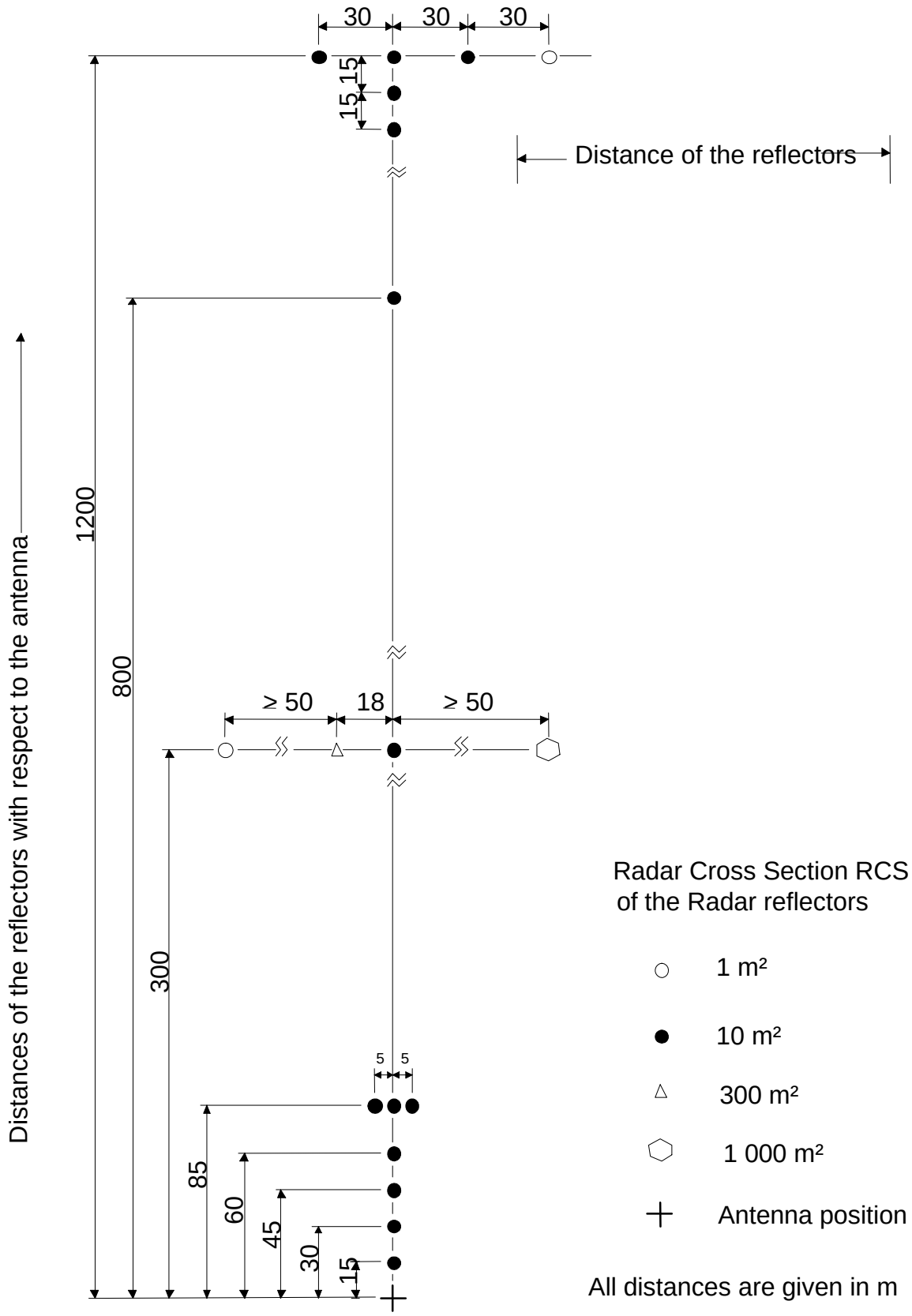


Figure A.1: Set-up of the radar reflectors to determine the radar picture resolution

A.4 Preparation of radar equipment to test

The radar antenna shall be mounted on top of a hydraulic mast enabling any desired height between 5 m and 10 m above the surface of the water or of the terrain. Unless otherwise stated during all appropriate tests, the radar antenna shall be set to a height of between 6 m and 8 m above the surface or water.

The radar equipment shall be adjusted to the best quality of picture. The gain shall be adjusted in such a way that in the area beyond the range of operation of the anti-clutter control, noise can just no longer be seen. The control of the sea-clutter suppression (STC) shall be set at minimum, while the rain-clutter suppression (FTC) shall be switched to the "Off" position. All controls that influence picture quality shall not be changed for the duration of the test at a certain antenna height and be fixed in an appropriate way.

Annex B (informative): Minimum range, radial resolution and azimuthal resolutions

B.1 Minimum range

Minimum range is the shortest distance from which it is possible to detect and to display a target in the vicinity of the radar antenna (see figure B.1).

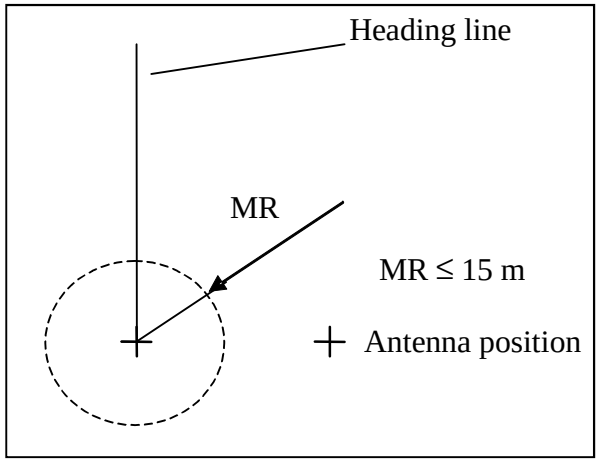


Figure B.1: Definition of the Minimum Range (MR)

B.2 Radial resolution

Radial resolution is to be understood as the minimum required distance between two reflectors at the same bearing which allows to distinguish two separate echoes (see figure B.2).

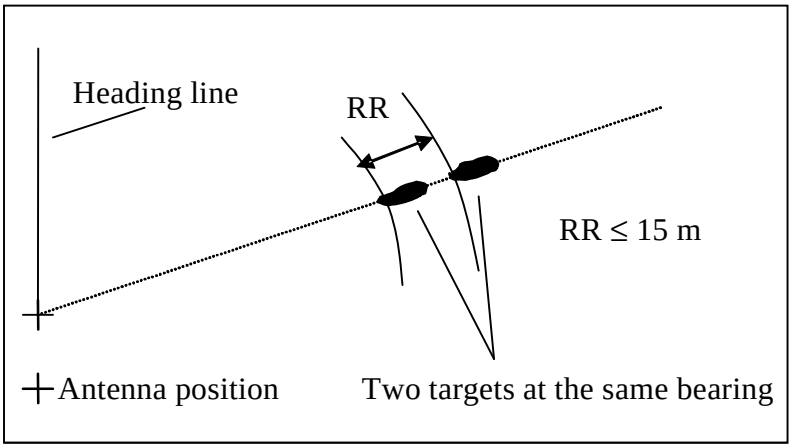


Figure B.2: Definition of the Radial Resolution (RR)

B.3 Azimuthal resolution in all range scales up to and including 1 200 m

Azimuthal resolution is to be understood as the minimum required distance between two reflectors at the same range with respect to the radar antenna which allows to distinguish two separate echoes (see figures B.3 and B.4).

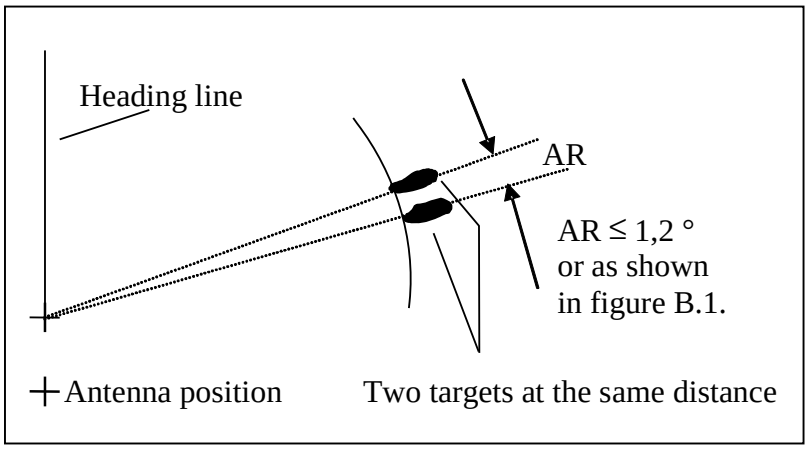


Figure B.3: Definition of the Azimuthal Resolution (AR)

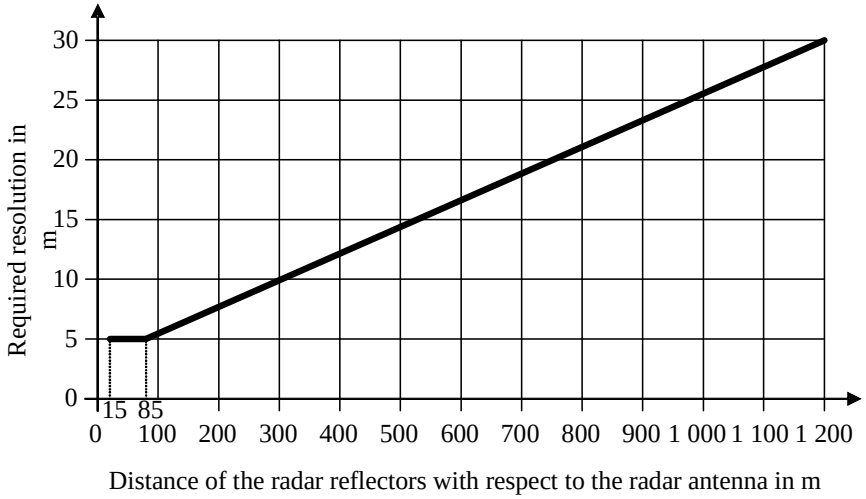


Figure B.4: Azimuthal Resolution depending on the range

Annex C (informative): Calculation of the equivalent Radar Cross Section (RCS)

C.1 Definition

The only body with omni-directional reflection characteristics is a sphere. To define the reflection capability of any object, the cross section of a sphere with the same reflection capability as the compared object delivers the RCS of the object.

The equivalent Radar Cross Section (RCS) (Formula sign: σ, unit: m^2) of a radar reflector (corner reflector) with triangular areas for a frequency of 9 400 MHz ($\lambda \cong 3{,}2$ cm) is calculated according to the formula (C.1):

$$\sigma = \frac{4 \times \pi \times a^4}{3 \times 0{,}032^2} \quad \text{(C.1)}$$

where a = edge length in metres (m) as shown in figure C.1.

A standard reflector as defined in the present document has a Radar Cross Section of $\sigma = 10\ m^2$. To have this RCS the short edges of the triangular areas of a corner reflector has an edge length of a = 0,222 m.

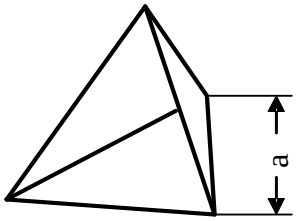


Figure C.1: Edge a of a corner reflector

Annex D (normative): Measuring the reflection coefficient

D.1 Principle of test

The EUT is secured such that the screen is vertical and the illuminator and the luminance meter arranged in a horizontal measurement plane, each being 800 mm in front of the EUT screen and separated by a 15° angle from a reference axis perpendicular to the EUT screen, see figure D.1.

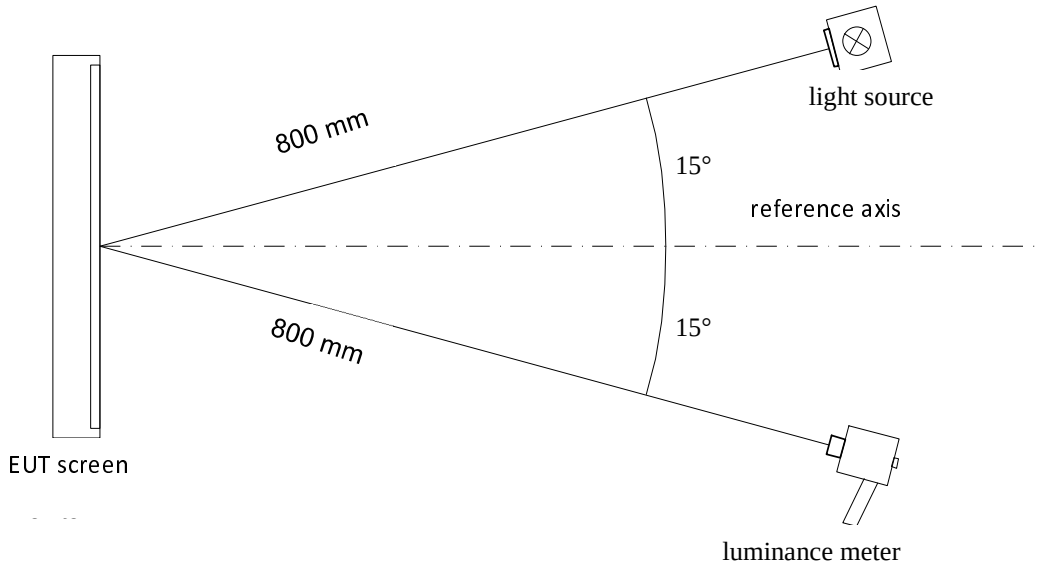


Figure D.1: Setup to measure the reflection of the radar screen

The readout of luminance meter is recorded as L_{Screen}.

The reflectance of the EUT is calculated as:

$$L_{screen} / L_{direct}$$

where L_{direct} is the luminance of the illuminator measured in a distance of 1 600 mm perpendicular to the EUT screen.

D.2 Preconditions

The following preconditions shall be applied:

- All measurements should be conducted in a dark room that is capable of simulating the ambient light requirements of IHO standards for ECDIS displays under 'Dusk' and 'Night' conditions. Further details can be found in IEC 62288 [i.6], clause 4.4.1, table 1.
- A high quality front surface mirror should be used to this test method with reflection coefficient of near 100 % reflection. The mirror serves as a tool for aligning the EUT and setting the focus of luminance meter correctly.
- A suitable white light illuminator capable of providing a stable evenly illuminated spot on the EUT screen surface at the test distance. Such an illuminator is likely to use a high power neutral white LED with a colour temperature of 4 000 K supplied by a constant current power supply and incorporating suitable lens, diffuser and housing elements. The illuminator shall provide a lumenance of at least 1 000 cd/m².
- To ensure stable illumination for the test the illuminator should be warmed up at least 30 minutes before any measurement is taken.

- The display under test (EUT) shall be unpowered since this test measure the physical reflectivity of the screen surface and any underlying image could interfer with the measurement.

D.3 Measurement setup

The setup to measure the reflected luminance shall be according to figures D.2, D.3 and D.4.

D.4 Measuring the reflection of the radar screen

D.4.1 Measuring the luminance of the illuminator

The luminance of the illuminator is measured in a direct line of sight (figure D.2).

The measurement shall be conducted such that the illuminator and luminance meter are vertically and horizontally aligned with the reference axis. The distance between illuminator and luminance shall be 1 600 mm.

The luminance meter shall be adjusted such that the measurement spot in the viewfinder can be seen in the center of the diffuser lens of the illuminator.

The luminance meter lens shall be focused on the housing of the illuminator.

The luminance meter reading should be taken and recorded as L_{direct}.

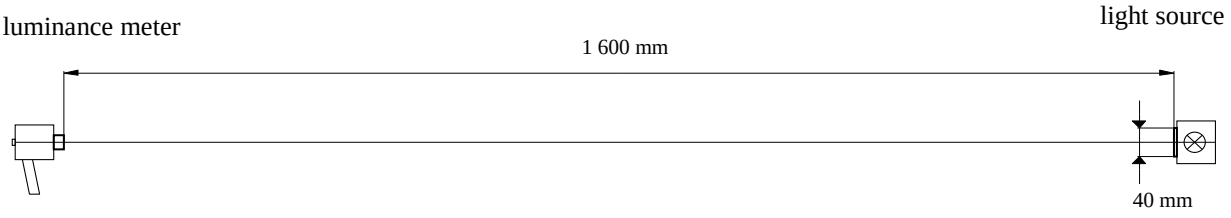


Figure D.2: Measuring the luminance of the illuminator

D.4.2 Measuring the luminance of radar screen

The measurement shall be conducted such that the screen is vertical perpendicular to the reference axis and the illuminator and the luminance meter arranged in a horizontal measurement plane, each being 800 mm in front of the EUT screen and separated by a 15° angle from a reference axis perpendicular to the EUT screen.

The front surface mirror, set at the position of the EUT, shall be adjusted such that it is is perpendicular both horizontally and vertically to the reference line.

As an alternative a thin front surface mirror shall be placed on the EUT screen surface using any convenient temporary fixture to hold it in place. In this case the mirror and screen are adjusted simustanously.

The luminance meter shall be adjusted such that the measurement spot in the viewfinder can be seen via the mirror in the center of the illuminator. Slight adjustment of the illuminator mount might be needed to facilitate this.

The luminance meter lens shall be focused on the housing of the illuminator via the image in the mirror not on the mirror itself. After this step, no adjustment shall be applied to the luminance meter anymore.
See figure D.3.

The luminance meter reading should be taken and recorded as L_{mirror} for reference if the test house procedure allows for virtual L_{direct} readings based on L_{mirror} during multiple measurements.

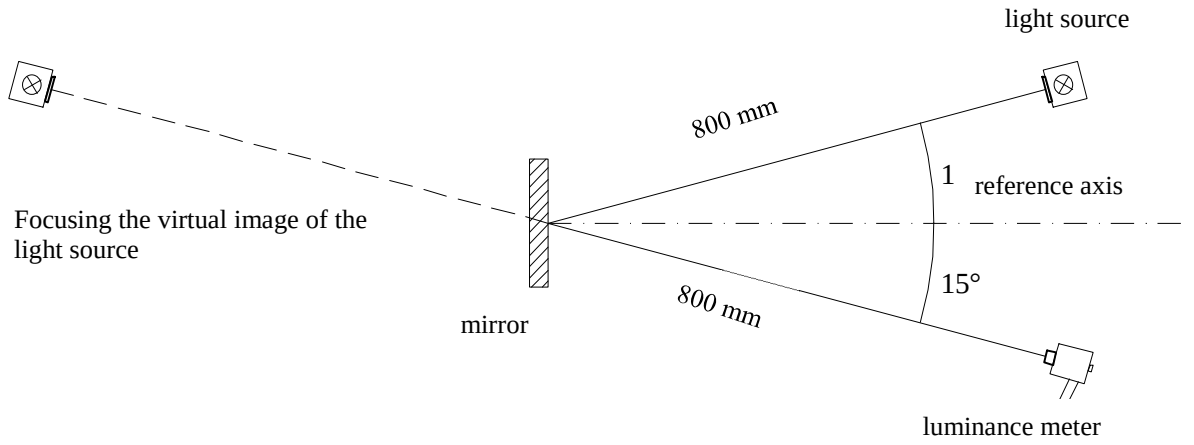


Figure D.3: Setup for calibration

Then the mirror shall be replaced by the EUT such that the EUT is set to exactly the same position as the mirror was set before. This shall be done by using an approriate temporary reference plane.

In case of utilizing a thin mirror placed in front of the surface of the screen, this mirror shall then be carefully removed so that no other item of the setup is moved or changed.

Once all alignments and focusing have been established all mounting and adjustments shall be fixed in place and great care shall be taken not to move anything. See figure D.4.

The luminance meter reading shall be taken and recorded as L_{Screen}.

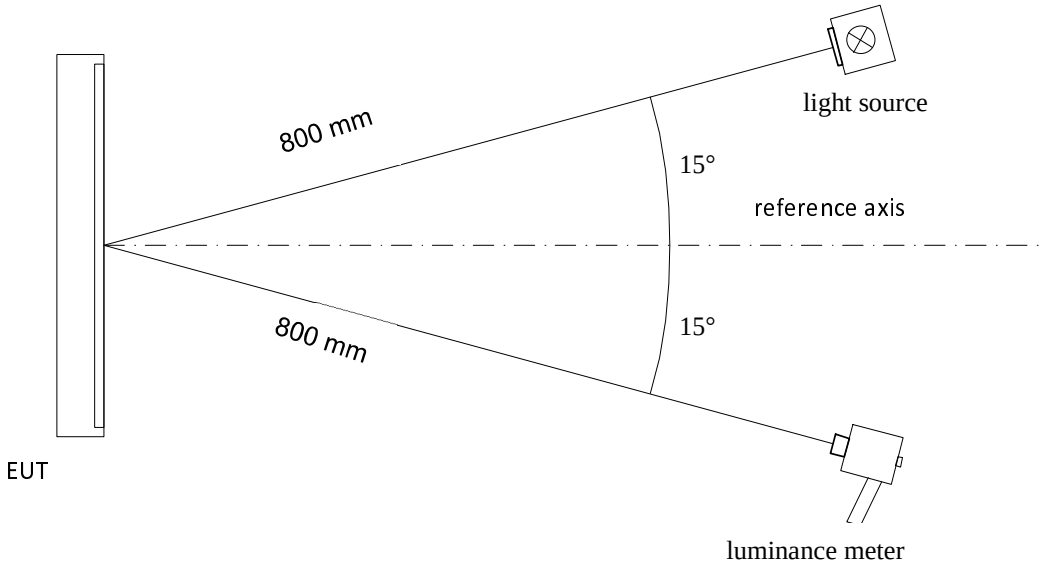


Figure D.4: Setup to measure the reflectance of radar screen

D.5 Calculating of reflection coefficient

Reflection coefficient ρ shall be calculated according to the following equation:

$$\rho = \frac{L_{Screen}}{L_{direct}}$$

This is the primary equation and is recognized to take precedence in conformance assessment, however its use alone relies on a high quality and expensive optical bench when the set-up uses a reference mirror and physical transfer using a reference plane to place the EUT screen in place. With a simpler optical bench the test method using a thin front surface mirror is recommended as the EUT display screen does not have to be handled so much as alignment is established simultaneously and L_{mirror} can be used appropriately to reduce any systematic errors introduced by slight misalignments of the EUT screen from a true vertical and perpendicular axis to the reference line.

To validate use of L_{mirror} the loss due to the front surface mirror should be calculated using measurements taken and recorded during the test session.

$$loss = \frac{Lmirror}{Ldirect} \times 100 - 100$$

For a quality front surface mirror the loss should be in the range -3,5 % and -6 % any greater and the mirror should be either cleaned or replaced if cleaning is ineffective.

Where L_{mirror} is used the test report shall include the loss figure for the front surface mirror calculated from measurements taken and explain how L_{mirror} is used in calculation and/or verification of the reflection coefficient.

History

Document history			
V1.0.1	April 2021	EN Approval Procedure	AP 20210630: 2021-04-01 to 2021-06-30