|  |
| --- |
| IALA Guideline |

G1???

on radar reflectors

Edition 1.0

March 2019

Revisions to this IALA Document are to be noted in the table prior to the issue of a revised document.

|  |  |  |
| --- | --- | --- |
| Date | Page / Section Revised | Requirement for Revision |
| 03/2019 approved by Council | Initial document |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

1 INTRODUCTION 5

2 Scope 5

3 General information 5

3.1 EXPLANATION OF HOW THEY WORK 5

3.2 reflection characteristic of radar reflectors 6

3.3 DEFINITION OF RADAR CROSS SECTION (RCS) 6

3.4 Typical designs 7

3.4.1 omnidirectional designs 7

3.4.2 directional designs 8

4 detection range of radar reflectors 9

4.1 maximum range under ideal conditions 9

4.1.1 REFLECTOR HEIGHT 9

4.2 Parameters that affect the range of radar reflectors 10

4.2.1 tilt / heel angle 10

4.2.2 seastate/impact of weather 10

4.2.3 multipath 10

4.2.4 Tolerance Requirements / Manufacturing accuracy 10

4.2.5 Surface Finish 10

4.2.6 shadowing of the radar reflector 10

4.2.7 impact of plastic 11

4.2.8 impact of frequencies 11

4.2.9 NT RADAR 11

5 trials 11

6 measurement 11

7 simulation 11

8 goods in inspection ???? 11

9 maintenance (within scope??) 11

9.1 maintenance for outside mounted radar reflectors 11

9.2 maintenance for covered radar reflectors 11

10 materials 11

11 Surface Protection 11

11.1 Geometry: 11

11.2 effect of the manufacturing quality, rectangularity 11

11.3 effect of the material: 11

11.4 Measurement 11

11.5 (Example Heading level 2) 15

11.6 (Example Heading level 2) 15

12 AIMS AND OBJECTIVES (Example Heading level 1) 15

13 Example Heading level 1 15

13.1 (Example Heading level 2) 16

13.1.1 (Example heading level 3) 16

14 Example Heading level 1 16

14.1 TABLES 16

15 FIGURES 17

16 DEFINITIONS 18

17 ACRONYMS 18

18 REFERENCES 18

List of Tables

Table 1 Example of a table with the significant information in the first column 4

Table 2 Example of a table with the significant information in the first row 4

Table 3 Example of a table with coloured rows 4

Table 4 Example table 4

List of Figures

Figure 1 Example figure caption 4

Figure 2 Another example figure caption 4

List of Equations

Equation 1 Geographical range 4

Equation 2 Theory of Special Relativity 4

# INTRODUCTION

According to the IMO Resolution Msc.192(79) (Adopted On 6 December 2004) Adoption Of The Revised Performance Standards For Radar Equipment, TABLE 2 “Minimum detection ranges in clutter-free conditions”, typical navigation buoys with a height of 3,5 m above sea level must be detectable in a range of 4.6 NM in the X-band and 3.0 NM in the S band. The typical navigation buoy is taken as 5.0 m2 for X-Band and 0.5 m2 for S-Band; for typical channel markers, with an RCS of 1.0 m2 (X-band) and 0.1 m2 (S-band) and height of 1 metre, a detection range of 2.0 and 1.0 NM respectively.

If these demands cannot be achieved by the buoys structure itself, the addition of a radar reflector is necessary.

It is not easy to determine the radar reflection behaviour of the buoy structure. The advantages of a radar reflector is, that it has a defined radar reflection characteristic.

Radar reflectors on structures……demand for it…

To enhance the visibility and the probability of detection using shipborne radar active or passive radar reflectors may be utilized. They can be mounted on buoys, beacons, structures, vessels etc.

A radar reflector is defined by IALA as a device specially arranged to have the property of reflecting incident electromagnetic energy parallel to the direction of incidence to enhance the radar response. Active radar reflectors are electronic devices, often referred to as radar target enhancers (RTE).

Passive radar reflectors are mechanical devices, which do not consist of any electrical devices that receive, amplify and return a radar signal.

This guideline only deals with passive radar reflectors. Shipborne radar reflectors are out of scope of this document. For more information look at:XXXXXXXXXXXXX IMO requires small vessels to have a radar reflector compliant with ISO 8729-1

RESOLUTION MSC.192(79) (adopted on 6 December 2004) ADOPTION OF THE REVISED PERFORMANCE STANDARDS FOR RADAR EQUIPMEN, TABLE 2 Minimum detection ranges in clutter-free conditions

Passive Radar reflectors are available in a wide variety of sizes, shapes and reflection characteristics.

# Scope

This guideline has been developed to assist aids to navigation (AtoN) manufacturers and authorities when developing and selecting radar reflectors. It also contains remarks concerning …….

# General information

## EXPLANATION OF HOW THEY WORK

* Explain RF-reflection: RTEs work by reflecting radar energy directly back to the radar antenna so that AtoN appears to be a larger target.
* Refection elements are: sheet, crossed plates, corner

Passive Target Enhancement by Radar Reflectors

It was recognised in the early days of radar that some targets (such as wooden boats or

buoys) need some form of echo enhancement to ensure reliable detection at an adequate

range. Passive radar reflectors are the simplest of the target enhancement techniques

available today.

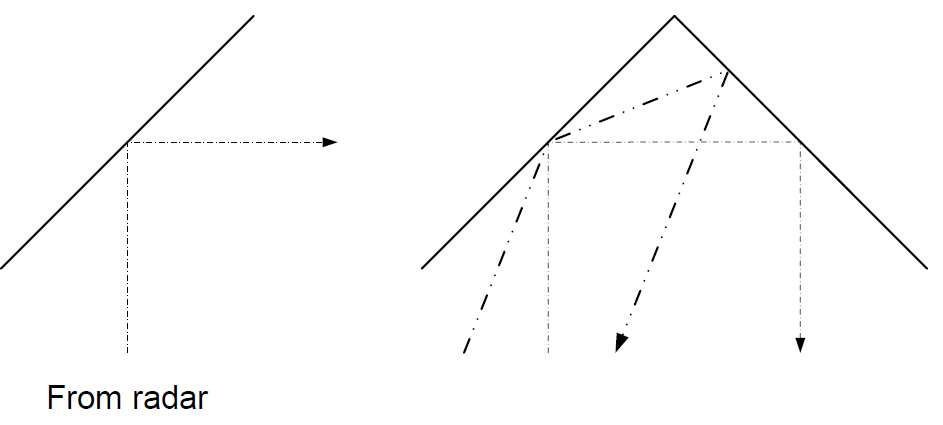


Figure 1: Reflection from a flat plate and a corner reflector

Figure 1 illustrates the basic principle used in the construction of most radar reflectors. Radio waves at the radar frequencies propagate and interact with surrounding objects much like light rays, large4 smooth conducting surfaces acting as ‘mirrors’. When a conductive flat surface is viewed obliquely, the incoming radar rays are diverted away from the radar, the rays obeying Snell’s law of reflection. If, however, a corner reflector is formed using two flat plates as shown in Figure 1, the rays are directed back to the radar, almost irrespective of the viewing angle. Note that the fact that an object is made of a conductive material does not necessarily mean that it constitutes a good radar target. From radar Figure 1: Reflection from a flat plate and a corner reflector. A simple dihedral corner reflector is adequate on non-floating objects. If the attitude of the target is changing as it moves in a seaway it is necessary to use a trihedral corner. The trihedral corner will ensure that the energy is returned even though the target is moving through a large angle in both the horizontal and vertical planes.

corner reflector: reflector, consisting of flat conducting surfaces intersecting mutually at right angles, that reflects the greater part of the incident waves parallel to their direction of incidence (ISO 8729)

## reflection characteristic of radar reflectors

True 360º coverage in the horizontal plane can be achieved by arranging several corner

reflectors into a cluster. The majority of radar reflectors used in the maritime field are corner clusters [RD2]. Various arrangements are used, typically made up of 5, 6, 8 or 10 corners,

## DEFINITION OF RADAR CROSS SECTION (RCS)

BARTON 1 , “Measure of the reflective strength of a target”. The E. W. Handbook of U.S. Navy defines, “A measure of the radar reflection characteristics of a target. It is equal to the power reflected back to the radar divided by power density of the wave striking the target. For most targets, the radar cross section is the area of the cross section of the sphere that would reflect the same energy back to the radar if the sphere were substituted. RCS of sphere is independent of frequency if operating in the far field region”.

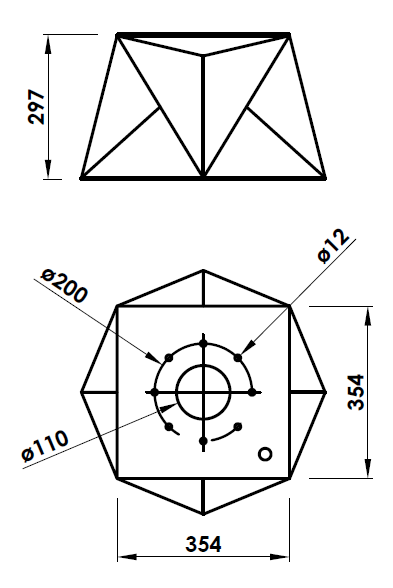
SKOLNIK 2 provides the following short and concise definition, “The radar cross section of a target is the (fictional) area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target”.

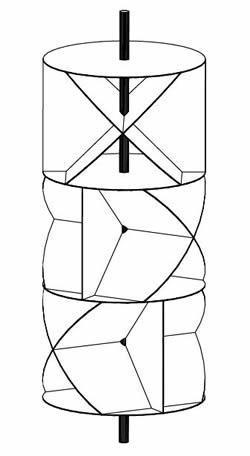
## Typical designs

Each of the configurations having somewhat different RCS characteristics. However, the reflector is a passive device, and as such, only returns as much energy as is incident on it. As will be shown later in the report, the maximum RCS of a reflector is proportionate to the square of its effective area, or the fourth power of its side length - so with reflectors size matters. Combination of reflection elements to a radar reflector generate different reflection characteristsics,

### omnidirectional designs

* omnidirectional designs are used for buoys, which have no special orientation



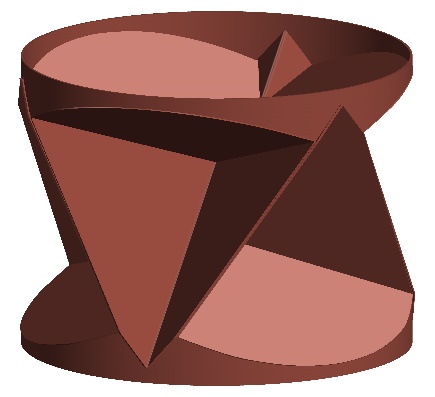












ISO 8729: 5.2 Reflecting pattern in horizontal plane

5.2.1 *The radar reflector* shall *have a Stated Performance Level of at least 7,5 m2 at X-Band and 0,5 m2 at S-band. The SPL* shall *be maintained over a total angle of at least 280°.* The response shall, at the assessed level for each polar plot:

* not have any nulls greater than a single angle of 10°; and
* not have a distance between nulls of less than 20°.
* Nulls of less than 5° shall be ignored for this calculation.

ALIGN THE FOLLOWING TO BUOYS, see also IALA G1065 (light):

NOTE Typical azimuthal polar diagrams for passive radar reflector at X-band are given in Figures B.1 and B.2.

5.2.2 For power driven vessels and sailing vessels designed to operate with little heel (catamaran/trimaran), this performance shall be maintained through angles of (athwartships) heel 10° either side of vertical. For other vessels, the reflector shall maintain this performance over 20° either side of vertical.

### directional designs

* Directional designs are used for limited angle of approach, for example structures or buoys with direction.



C:\Users\peter\Desktop\ENG9\working_papers\Bilder\20506805.Kegeltoppzeichen tagesleutgrün, für Einheitstonne.tif

C:\Users\peter\Desktop\ENG9\working_papers\Bilder\20506806.Balltoppzeichen tagesleuchtrot-grün für Einheitstonne.tif

C:\Users\peter\Desktop\ENG9\working_papers\Bilder\20506807.Zylindertoppzeichen tagesleuchtrot, für Einheitstonne.tif



# detection range of radar reflectors

## maximum range under ideal conditions

* Function of radar antenna height, mounting height of the radar reflector, RCS. (Polarization…)

### REFLECTOR HEIGHT

* Speckter paper 4.2.3: The final parameter to be considered is the reflector height above sea level. As is well known from visual target detection at long ranges, the target and/or observer heights have to be- increased with increasing range due to the curvature. The range in nautical miles of the optical horizon is given by the formula: R(opt) =2.1 (vHt + .flo) ' :o~ ,-,,\_-' "vlhere Ht = target height and • \_ ;. \_\_ 0-. \_~\_p~ = observer height, both in meters This, formula can also be used for a rough estimation of the radar horizon. - The observer and target heights have to be substituted by\_. t...h --e- -\_r.e\_f--lector and antenna heights respectively. It should be noted that this formula results in values for the radar range that are too optimistic under normal atmospheric conditions. For a conservative range estimation only 60 to 90% of the optical range should be used. Rradai> % 0, 6 •• , O. 9 Rapt 1 - '~-;.'.'=-This~considerable reduction in range is caused by the strong interference-effect of the inultipath propagation across the sea:. Under the assumption of a ship I s antenna height between 10 and 20 m, the reflector heights necessary to obtain specified ranges have-been-listed in Table 2. Again, these figures apply to X-band radar only. S-band radars are far less capable of detecting targets near the water surface owing to their longer wave .length. This fact has one important advantage, but at the same time it also has an important disadvantage. The waves of a rough .. sea cause less sea clutter but, on the other hand, the reflector height has to be increased by a factor of 2 to 3 for an equal -probability of detection. Such a substantial increase in -'--reflector-height cannot be implemented. in most cases, especially. when:' small targets like buoys are involved
* RESOLUTION MSC.164(78) (adopted on 17May 2004) REVISED PERFORMANCE STANDARDS FOR RADAR REFLECTORS: The radar reflector should have a “Stated Performance Level” measured in square metres radar cross section (m2 RCS) of at least 7.5 m2 in X-band and 0.5 m2 in S-band mounted at a minimum height of 4 m above water level.
* The reflection characteristic, i.e. the spatial distribution of the RCS values has to be considered.
* Examples of variation of diameter, height, range (ship antenna height assumed to be between 10 and 20 m)
* X-band radars (wavelength = 3,2 cm), for S-band radars (wavelength = 10 cm) the RCS drops by a factor of 10.
* S-band, reduction in RCS, propagation in s-band, requirements by IMO (MARIO)

|  |  |  |  |
| --- | --- | --- | --- |
| RCS max. (m^2) | Typical diameter of the reflector (m) | Height of radar reflector above sea level (m) | Range max. (m) |
| 400 | 1 | 3.5 - 4 | 7 |
| 30 | 0.5 | 2 | 4 |
| ? |  |  |  |
| ? |  |  |  |
| ? |  |  |  |
|  |  |  |  |

## Parameters that affect the range of radar reflectors

### tilt / heel angle

### seastate/impact of weather

### multipath

### Tolerance Requirements / Manufacturing accuracy

As with all types of cluster reflectors the individual reflecting elements (i.e. the corner reflectors) have to be manufactured to close tolerances, otherwise the reflected wave will diverge from the exact direction back to the illuminating radar. For best results all three plates of each corner reflector must be perfectly flat, and the corner angles must be exactly at right angles. In a production process some deviations are unavoidable and result in certain loss of performance. Unfortunately, the allowable rectangular tolerance and deviations from perfect flatness become smaller as the size of the reflector gets larger. The following angular tolerances should not be exceeded:

|  |  |
| --- | --- |
| reflector diameter | maximum angular tolerance |
| 0,5m | ± 1 to 2° |
| 1m | ± 0.5 to 1° |

|  |  |
| --- | --- |
| reflector diameter | maximum flatness tolerance |
| 0,5m | ± XXXXX mm |
| 1m | ± XXXXX mm |

Even under these conditions a noticeable loss of performance can occur if all tolerances of a corner reflector accumulate (all tolerances of the same sign).

### Surface Finish

In a marine environment most metals require a surface protection against corrosion. Thin layers' of paint which are directly applied for this purpose to the reflecting surface do not degrade the performance of the radar reflector.

This situation is entirely different if a protective cover is applied. A serious loss in performance occurs if the cover is not properly designed. Important design parameters of the cover are the material and its wall thickness with respect to the frequency band used.

### shadowing of the radar reflector

If only one plate of a corner reflector is substantially masked by an obstacle, the total corner reflector is rendered ineffective (the radar wave "bounces" three times, once on each plate of the corner reflector, before returning back to the radar). Therefore care should be taken that constructional elements that are mounted in front of the reflector do not cause a serious degradation of the performance. The projected area of these elements should be small compared with the Size of corner reflector.

### impact of plastic

### impact of frequencies

### NT RADAR

# trials

# measurement

# simulation

# goods in inspection ????

# maintenance (within scope??)

## maintenance for outside mounted radar reflectors

* Cleaning
* Visual inspection: angles, corrosion, rectangularity, mechanical damage
* Renew the coating….Link to maintenance guideline 1077

## maintenance for covered radar reflectors

* No maintenance required or possible

# materials

* The materials used for the radar reflector shall be of sufficient strength and quality as to make the reflector capable of maintaining reflection performance under the conditions of stress due to sea states, vibration, humidity and change of temperature likely to be experienced in the marine environment and capable of withstanding the environmental conditions.
* Radar reflectors consisting from good electric conductivity materials such as metal. In practice aluminium and steel/stainless steel are typically used.
* Even a very thin layer of metal can make an object strongly radar reflective.
* Usually corner clusters are manufactured from plates of steel or aluminium. But any other material of high electrical conductivity can be employed as well. From a radar point of view only a thin metallic layer is required for a perfect reflection. Thus, a plastic material like GRP with a metallized surface or with a metallized nylon mesh embedded in it yields has similar good results.

# Surface Protection

# Geometry:

# effect of the manufacturing quality, rectangularity

# effect of the material:

# Measurement

# Environmental requirements (ISO 8729)

The radar reflector shall comply with all requirements for

⎯ dry heat,

⎯ low temperature,

⎯ vibration,

⎯ rain and spray,

⎯ solar radiation,

⎯ corrosion, and

⎯ compass safe distance

specified in IEC 60945.

## (Example Heading level 2)

Body text

## (Example Heading level 2)

Body text

# AIMS AND OBJECTIVES (Example Heading level 1)

Body text (left justified)

Body text (left justified)

1. List 1.
2. List1.

List 1 text (for subsequent text at the same level).

1. List 1:
   1. List a.
   2. List a.

List a text (for subsequent text at the same level).

* 1. List a:
     1. List i.

List I text (for subsequent text at the same level).

* Bullet 1;

Bullet 1 text (for subsequent text for the same bullet).

* Bullet 1:
* Bullet 2;

Bullet 2 text (for subsequent text for the same level).

* Bullet 2:
* Bullet 3;

Bullet 3 text (for subsequent text for the same level)

* Bullet 3.

# Example Heading level 1

Body text

## (Example Heading level 2)

Body text

1. Geographical range

Where:

*Rg* is the geographical range (nautical miles) (alternatively NM)

*ho* is the elevation of observer’s eye (metres) (alternatively m)

*Hm* is the elevation of the mark (metres) (alternatively m)

### (Example heading level 3)

Body text.

1. Theory of Special Relativity

Where:

*E* is the kinetic energy (Joules) (alternatively J)

*m* is the mass (kilograms) (alternatively Kg)

*c* is the speed of light (metres/second) (alternatively m/s)

#### (Example heading level 4)

Body text.

# Example Heading level 1[[1]](#footnote-1)

Body text. Bullets have only one sentence. Anything further needs to appear in the relevant 'bullet text' style.

* Bullet 1:
* Bullet 1:
* Bullet 1.

## TABLES

Body text

1. Example of a table caption; table with the significant information in the first column

|  |  |
| --- | --- |
| Table heading | Table text |
| Table heading | Table text |
| Table heading | Table text |
| Table heading | Table text |
| Table heading | Table text |
| Table heading | Table text |

1. Example of a table caption; table with the significant information in the first row[[2]](#footnote-2)

|  |  |  |
| --- | --- | --- |
| **Table heading** | Table heading | Table heading |
| Table text | 1. Table List 11    1. Table list a   Table list i | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |

Example of ‘normal text’ following a Table

1. Example of a table caption; table with coloured rows

|  |  |  |
| --- | --- | --- |
| Table heading | Table heading | Table heading |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |

**Note:** Colours for text and cell shading need to be selected from the permitted palette (see ANNEX C)

# FIGURES



1. Example figure caption



1. Another example figure caption

# DEFINITIONS

*Suggested text:* The definitions of terms used in this IALA Guideline can be found in the International Dictionary of Marine Aids to Navigation (IALA Dictionary) at <http://www.iala-aism.org/wiki/dictionary> and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

# ACRONYMS

IMO International Maritime Organization (Acronym style)

# REFERENCES

1. Abcd
2. Efgh
4. EXAMPLE OF AN ANNEX - LANDSCAPE

Body text

1. example of ANNEX heading level 1

Body text

* 1. example of annex heading level 2

Body text

* + 1. Example of annex heading level 3

Body text

* + - 1. Example of Annex heading level 4

Body text

1. Example table caption

| No | Title/Topic | IMO References | Requirements | Possible Audit Questions | Remarks |
| --- | --- | --- | --- | --- | --- |
| 1 | Table text | Table text | Table text | Table text | Table text |
| Table text | Table text |
| Table text | Table text |

1. EXAMPLE OF AN APPENDIX TITLE
2. APPENDIX HEADING 1

Body text

* 1. APPENDIX HEADING 2

Body text

* + 1. APPENDIX HEADING 3

Body text

* + - 1. Appendix Heading 4

Body text

1. (EXAMPLE ANNEX TITLE)
2. Introduction (Example Annex Heading 1)

Body text.

* 1. Example of ANNEX HEADING Level 2

Body text

* + 1. Example of annex heading level 3

Body text

* + - 1. Example of Annex heading level 4

Body text

1. PERMITTED COLOUR PALETTE

The IALA colour palette is divided in 3 palettes of different level of hierarchy that has to be respected.

Corporate colours (Not shown)

IALA’s corporate colour palette is directly inspired from the colours in our logotype:

* dark blue
* white
* yellow
* gradient blue

Primary & secondary colours

The primary colours are to be applied in complement with the corporate colours.

This second level of colours gives rhythm and helps to segment our publications.

The secondary colours are used to highlight information, titles in a minor proportion only.

These colours can’t be replaced by other tints.

**PANTONE PROCESS CYAN C CMYK :** C 100

**RGB :** R 0 - G 159 - B 223

**CMYK : 50 % OF THE TONE RGB :** R 131 - G 208 - B 245

**CMYK : 50 % OF THE TONE RGB :** R 148 - G 217 - B 213

**CMYK : 50 % OF THE TONE RGB :** R171 - G 219 - B 233

**CMYK : 50 % OF THE TONE RGB :** R 178 - G 193 - B 237

**PANTONE 326C CMYK :** C 81 - Y 39

**RGB :** R 0 - G 175 - B 170

**PANTONE 7703 C**

**CMYK :** C 79 - M 2 - Y 10 - K 11

**RGB :** R 0 - G 181 - B 208

**PANTONE 660 C CMYK :** C 88 - M 50

**RGB :** R 64 - G 126 - B 201

**CMYK : 20 % OF THE TONE RGB :** R 212 - G 237 - B 252

**CMYK : 20 % OF THE TONE RGB :** R 213 - G 240 - B 237

**CMYK : 20 % OF THE TONE RGB :** R 216 - G238 - B 245

**CMYK : 20 % OF THE TONE RGB :** R 218 - G 223 - B 246

**PANTONE 258 C CMYK :** C 51 - M 79

**RGB :** R 153 - G 80 - B 159

**CMYK : 50 % OF THE TONE RGB :** R 201 - G 169 - B 208

**CMYK : 50 % OF THE TONE RGB :** R 183 - G214 - B 155

**CMYK : 50 % OF THE TONE RGB :** R 246 - G 174- B 135

**CMYK : 50 % OF THE TONE RGB :** R 157 - G 157 - B 156

**PANTONE 739 C**

**CMYK :** C 78- Y 95- K 5

**RGB :** R82 - G 174 - B 50

**PANTONE 2347 C**

**CMYK :**M 88 - Y 100

**RGB :** R 230 - G 56 - B 17

**PANTONE COOL GRAY 11 C CMYK :** K 100

**RGB :** R 87 - G 87 - B 86

**CMYK : 20 % OF THE TONE RGB :** R 232 - G 221 - B 288

**CMYK : 20 % OF THE TONE RGB :** R226 - G 238 - B 217

**CMYK : 20 % OF THE TONE RGB :** R 253 - G 224- B 208

**CMYK : 20 % OF THE TONE RGB :** R218 - G 218 - B 218

**CMYK : 10 % OF THE TONE RGB :** R 237 - G 237 - B 237

Guideline

Recommendation

Model Course

PRIMARY COLOURS

SECONDARY COLOURS

Develop new guideline on radar reflector (reflection) properties

General

• definition of radar reflector

Radar reflector is a RTE (radar target enhancer) device specially arranged to have the property of reflecting incident electromagnetic energy parallel to the direction of incidence to enhance the radar response.

Please note that this is the term as it stands in the original IALA Dictionary edition (1970-1989)

BARTON 1 , “Measure of the reflective strength of a target”. The E. W. Handbook of U.S. Navy defines, “A measure of the radar reflection characteristics of a target. It is equal to the power reflected back to the radar divided by power density of the wave striking the target. For most targets, the radar cross section is the area of the cross section of the sphere that would reflect the same energy back to the radar if the sphere were substituted. RCS of sphere is independent of frequency if operating in the far field region”.

SKOLNIK 2 provides the following short and concise definition, “The radar cross section of a target is the (fictional) area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target”.

• explanation of how they work

RTEs work by reflecting radar energy directly back to the radarantenna so that AtoN appears to be a larger target.

• theoretical calculations of RF energy return based on size and geometry

• range

• explanation of radar cross section (this allows radars to be directly compared when the test geometry is the same, angle of heel)

Radar cross-section (RCS) is a measure of how detectable an object is by radar. A larger RCS indicates that an object is more easily detected.

An object reflects a limited amount of radar energy back to the source. The factors that influence this include:

 the material of which the target is made;

 the absolute size of the target;

 the relative size of the target (in relation to the wavelength of the illuminating radar);

 the incident angle (angle at which the radar beam hits a particular portion of the target, which depends upon the shape of the target and its orientation to the radar source);

 the reflected angle (angle at which the reflected beam leaves the part of the target hit; it depends upon incident angle);

 the polarization of the transmitted and the received radiation with respect to the orientation of the target.

• examples of different types

• explanation of the factors that affect the reflection performance

o size: As a rule, the larger an object, the stronger its radar reflection and thus the greater its RCS. Also, radar of one band may not even detect certain size objects. For example, 10 cm (S-band radar) can detect rain drops but not clouds whose droplets are too small.

o Geometry:

o heel angle

o height of radar reflector

o effect of the radar antenna height

o effect of the radar frequency / x-s-band

o effect of the manufacturing quality, rectangularity

o effect of the material: Materials such as metal are strongly radar reflective and tend to produce strong signals. Wood and cloth (such as portions of planes and balloons used to be commonly made) or plastic and fibreglass are less reflective or indeed transparent to radar making them suitable for radomes. Even a very thin layer of metal can make an object strongly radar reflective. Chaff is often made from metallised plastic or glass (in a similar manner to metallised foils on food stuffs) with microscopically thin layers of metal. Also, some devices are designed to be Radar active, such as radar antennas and this will increase RCS.

o mounting inside of a plastic buoy

RCS is a function of:

o Position of transmitter/receiver relative to target

o Target geometry and material composition

o Angular orientation of target relative to transmitter/receiver

o Frequency or wavelength, · Antenna polarisation.

Measurement

• introduction to measurement

• explanation of measurement in an anechoic chamber in accordance withan aproved international standard to certify the reflective properties of a radar reflector.

Practical use of radar reflectors

• What size of Radar Reflector is required ?

• IALA VTS Guideline 1111 suggests that a Aids to Navigation with radar reflector will be from 4 (S-band) to 10m2 (x-band) RCS (Discuss) – (table 8 on page 32)

• IMO requires small vessels to have a radar reflector compliant with ISO 8729-1 (Discuss)

• The selection of the radar reflector is affected by the ability of the buoy to support a particular type and size of reflector. (Discuss limitations / restrictions).

• Select the largest reflector that will fit on the buoy with the greatest consistency of RCS return across angless of heel deemed appropriate (+/- 10 degrees ?? ; +/- 20 degrees ??)

Collect information about the technical background

• Classify different radar reflector types, their properties and performance

• Define measurement methodsDevelop guidance on quantifying buoy characteristics to meet nautical and operational requirements and ways to verify them

A radar reflector is a passive device designed to return the incident radar pulses of electromagnetic energy back towards the source and thereby enhance the response on the radar display.

“IALA Guideline 1111 – Preparation of Operational and Technical Performance Requirements for VTS Systems” provides general information about the anticipated radar reflection of vessels with radar reflectors but does not include information about the different reflector types and their performance.

ISO 8729-1:2010 concerns passive reflectors and gives specifications for the construction, performance, testing, inspection and installation of radar reflectors. In the moment IALA has no appropriate guideline concerning this.

Develop a guideline with an overview of radar reflector types, properties, performance and measurement.

1. Example footnote [↑](#footnote-ref-1)
2. Example of footnote [↑](#footnote-ref-2)