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| IALA Guideline |

G1???

AtoN equipment exposed to extreme environmental conditions

Edition 1.0

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# INTRODUCTION

Since its beginnings, the signalling system has been implemented to provide the seafarers with the necessary information to travel safely. In this sense, the world-wide trade development and, as a matter of fact, the navigation routes extending across ports oriented to commerce, sports and leisure activities have been evolving in relation to their management, such as, load traffic vessels entrance and exit scheme, value of the load being shipped, required efficiency in navigation, among others. This efficiency scenario, operation windows or mooring planning and pier release directly affects the Competent Authorities who are responsible of granting the Services of Aids to Navigation in relation to the treatment of the environment variables, recording scope, extreme values, its early detection, measurement and distribution to the seafarer.

# SCOPE

This document aims to reinforce the most relevant information associated with these variables if they occur under extreme conditions including the current guidelines which are considered to have incidence in the Aids to Navigation.

The design of the aid to navigation and its equipment, or, the performance characteristics of it under extreme climate conditions may not be available in the market at present, hence, the requirements definition should be described and be specific.

# GENERAL INFORMATION

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# ENVIRONMENTAL CONDITIONS

## Visibility

Fog is an atmospheric phenomenon in which the visibility of the sky is reduced due to the high presence of smoke, dust or any other particles suspended in the air. According to the World Meteorological Organization the darkening on the horizon can be distinguished between mist, ice mist, vapour mist (steam), fog, smoke, volcanic ash, dust, sand or snow.

However, the turbidity can generally be measured by means of the Pollutant Standard Index (PSI) which states the air quality or the pollutant level in it. This index can vary according to the country which consults it, since different indexes are used all over the world, such as the Air Quality Health

### difference between haze, fog and mist

These three phenomena entail a reduced visibility due to climate conditions (in relation to fog and mist) and in relation to the air pollution (in relation to the haze). This is the main difference between these three concepts, fog and mist are formed by suspended drops of water whereas haze can be formed by extremely small and tiny particles of air suspended.

The natural phenomenon of mist occurs when the hot air “crashes” against cold surfaces and the humidity “thickens” or condenses resulting in small amounts of water in the air.

Although the mist and the fog are similar phenomena, there is a difference between each other; the visibility distance, i.e. if the visibility distance is of one kilometre or shorter than a kilometre it is often named as mist, but if it is larger than a kilometre, it is called fog.



1. Image shows the presence of fog in a waterway

### Dust

Guideline 1136 “Providing AtoN Services in Extremely Hot and Humid Climates” considers the incidence that dust may have in the different physical properties, industrial as well as natural, which can block flashlights or day marks of aids to navigation and which may affect the luminous and visualization range, as well as the solar panels which, if covered in dust, can reduce their energy generation capacity. Furthermore, extreme dust also present risks related to health, such as respiratory problems. Dust is considered as a way of transporting pollutants and, as a matter of fact, it affects the safety of the personal in charge of assisting the AtoN.

Generally, sandstorms start as a dark orange cloud followed by heavy winds which can make the Competent Authority to impose restrictions on the navigation in canals, manoeuvring areas, entry to ports or harbours, among others.

### SMOKE

In particular regions, agriculture producers resort to the controlled burning of wild vegetation in those areas placed near inner navigation areas aiming to regenerate the soil and make it productive. However, these fires can occur accidentally forming clouds made of smoke which cause the loss of visibility for the seafarer, as well as health disorders on the living beings inhabiting the area (fauna and human beings).

The simultaneity of the environment variables in extreme conditions plus the human action help the propagation of the flames, and, at the same time, the propagation of the smoke, for example:

* Droughts,
* Winds,
* High temperatures.





1. Image shows the presence of smoke in a waterway

### INCIDENCE IN NAVIGATION

The main impact in navigation, associated with the loss of visibility or the detection of limited visibility due to the mist, haze, dust, sand or smoke, is the closure of the maritime transport by the Competent Authority.

Depending on the port management, the closure may not affect the vessel traffic or it can impose a restriction in navigation, such as delays in operations during a period of hours and to reopen, again, after this period has finished, once the visibility conditions have improved.

The loss or reduction of visibility due to the presence of mist or fog do not affect the useful life of the aid to navigation. However, it reduces the visual range and affects the safety to navigation.

Guideline 1090 “The Use of Audible Signs” tackles the loss of visibility issue to the presence of mist issue and defines this phenomenon as follows: “establishment of the considerations under which an audible signal can be used and the disadvantages of its use due to the complexity to identify the direction or vicinity from where the sound comes from, as well as stating the patterns in relation to usual range and nominal use.”

At present, there exist electronic aids capable of warning the seafarer in situations of low visibility. Hence, its implementation depends on the organization which grants the Service of Aids to Navigation which may not be the same as the service performed by the Maritime Authority. In this light, the seafarer can be confused: on the one hand, it is possible that the aids to navigation placed on the bridge encourage him to navigate under low visibility conditions willing to finish his journey in the agreed time and, the Competent Authority or Port Authority restricts its navigation permissions until the visibility conditions change, being this the criterion to be established.

How is it established the criterion by which the Maritime or Port Authority restrict the navigation?

### INCIDENCE IN ENERGY GENERATION

The phenomenon related to the presence of haze, fog, dust or smoke affects the performance of the solar panels since the remaining insolation charging hours can be reduced in such places where the presence of haze and fog events occur during autumn or winter.

The concept of inceidence of the visibility mentioned in Guideline G1108 “The Challenges of Providing AtoN Services in Polar Regions” takes into account the different geographical sceneries or navigational routes placed in high or low latitudes (Arctic or Antarctic navigation). Visibility on navigation depends on the adjustment of the human eye or on the contrast between the darkness during the day in winter and the brightness during summer months; both factors affect visibility in navigation.

### INCIDENCE IN PEOPLE’S HEALTH

Dust and smoke have a harmful effect on people’s health. Besides eye irritation and nasal congestion, it can also affect lungs and cause severe headaches. Moreover, both phenomena can deteriorate allergic and asthmatic people’s life, as well as affecting people’s sense of smell.

It is evident that animals suffer from these consequences because of the fires which result in devastated habitats, dead livestock and dramatic impacts on the autochthonous fauna which inevitably jeopardise the ecosystem of the region.

## Temperature

The effect of the temperature on the aids to navigation and its components are widely known, and its incidence depends on the range of magnitude. In order to assess the effects that the extreme temperature values cause on the aids to navigation, several specifications have been developed and all the content included in Guidelines G1108 “Providingf AtoN Services in Polar Regions”, G1067-0 “Selection of Energy Systems for Aids to Navigation and Related Equipment” and G1067-3 “Energy Storage for Aids to Navigation” has also been considered.

Under normal conditions, the selection and design of the energy system to be implemented in the aids to navigation (AtoN) will depend on the available options for the generation and storage of energy to be used in the AtoN.

Guidelines G1067-0 “Selection of Energy Systems for Aids to Navigation and Related Equipment” and G1067-3 “Energy Storage for Aids to Navigation” establish that when the external provider of energy is difficult or impossible to be installed, the solar energy, the wind energy, or any other source of renewable energy should be considered as the succeeding best option and, in such situations when the renewable energy is not feasible to be used, primary batteries can be used instead.

Tables which serve as a guide for the election of the energy system and for the recommended storage system considering extreme temperatures as one of the variables for the analysis can be found in the guidelines mentioned before.

These alternatives of energy generation will be affected by the extreme temperature values which can be measured in the installation or functioning sites. Extremely low temperatures can affect the performance of the external equipment: it can shorten the expected useful life of the equipment and make certain materials become fragile.

Moreover, the selection of lubricants to be used in movable parts should be considered. Examples can be mentioned as follows:

* They will give a poor performance in the component of the energy system, freezing of minor batteries. Hence, major batteries should be used;
* Ice generation cycles, freezing of the axis of the wind generators;
* The formation of ice in antennas and the concentration of snow can cause several problems in different systems;
* Low performance on the components of the energy system will be due to low temperatures;
* Low temperatures can also generate cycles of ice generation;
* High temperatures can affect the useful life of the battery.

### OPERATING TEMPERATURE

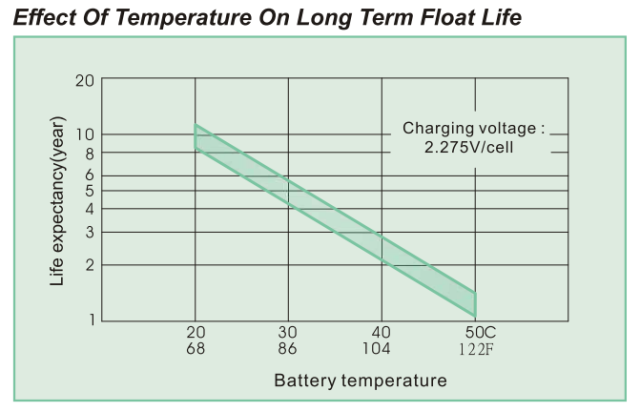
The range of temperature during the operation experienced by the battery will considerably affect its useful life and it is a significant factor in the election of the battery.

Batteries should operate at the specified temperatures stated by the manufacturer. Its operation outside these ranges will have a side effect in its capacity and useful life (life cycle) and it can also be hazardous.

Calculating battery life cycles depend on several factors such as maintenance, percentage of discharge, battery temperature, amount of times the battery is discharged, buzzing, etc.

A high temperature of the cell can be generated by the environment temperature or else by an excessive charge. In both cases the possible effects can be the following:

* Ageing acceleration,
* Spontaneous sulphation,
* Active matter dissolution.



1. Lead Acid Batteries ageing curve in relation to the temperature

### STORAGE TEMPERATURE

Regardless the technical considerations according to the preservation in stock, it is important to highlight that, at the moment of receiving the refreshment load, the storage temperature should be lower than 25°C.

When batteries are stored over long terms and at temperatures which are higher than 25 °C, together with large storage periods without a refreshment load, this results in a diminished capacity. Hence, the useful life of the battery will be shorter.

During storage the following instructions should be considered:

* Automatic discharge rate in relation to the environment temperature. The lower the temperature, the lower the discharge of the battery will be.
* Batteries should be stored in a dry, clean and ventilated place at an environment temperature between (0° C to 25° C).

1039-Ed.2-Designing-Solar-Power-Systems-for-Aids-to-Navigation\_Dec2017

## Moving landscape

1108-Ed.1-Providing-AtoN-services-in-Polar-Regions\_Dec2013-003

## Natural resources

## Hydrography

The environmental variables measured in extreme values affect the hydrography, for example, the loosening of large masses of ice which may imply a risk to navigation, extreme value of low tides, high tides or flooding, which can substantially modify the morphology of the canal bed due to the high associated sedimentation rate, the coast erosion with the possible loss of fixed signals installed on the coastline or the need to relocate them. Because of all these factors, it is necessary for the mariner to ensure himself the availability of the cartography and the information regarding the updated state of the signalling system.

Even though all mariners know the compulsory use of the cartography, sailing directions and tide tables for navigation, it is possible that extreme high values of wind, current, sea waves, tide, reduced visibility because of the snow or heavy rainfalls, dust storm, among other factors, can mislead the master of the ship or else lead him to make a wrong manoeuvre.

1108-Ed.1-Providing-AtoN-services-in-Polar-Regions\_Dec2013-003.

## Humidity

1007-Ed.1.1-Lighthouse-Maintenance\_Dec2005

1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

application-of-ais-aton-on-buoys-1098

## Extreme weather events

1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

1108-Ed.1-Providing-AtoN-services-in-Polar-Regions\_Dec2013-003

## High Ultra‐Violet Levels

1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

1006-Ed.-4-Plastic-Buoys\_Dec-2018

German test effect of UV on colour, red and green in cooperation with Menas.

Result of test might be added to 2.2.5:

“High UV light levels in prolonged periods of strong sunlight can cause degradation of material properties including colour retention, plastic lenses, steel and plastic buoys, structures, coating systems and electronic equipment and fixtures.

UV exposure can also be a significant risk to workers and requires careful management and specific mitigation controls.”

## Marine Growth

1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

1077-Ed.1-Maintenance-of-Aids-to-Navigation\_Dec2009

## Water Temperature and Quality

### Flora and Fauna

* 1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

## wave hight/impact

The wave effect is strictly linked with the performance of the aids to navigation, its influence in the inner navigational waterways, access canals and the port functionality.

### INCIDENCE ON PORT OPERATIONS

There exist ports in which the vessels entrance and exit it is determined by the wave height registered in its vicinity. The wave height can be foreseen by means of simulations, weather forecast or it can be measured by means of special buoys which measure the energy transmitted by the wave which, afterwards, it will be turned in three more meaningful patterns to interpret the vicinity wave climate nearby: height, direction and period.

This incidence of the waves is known as “swell effect”, and since it depends on the natural environment where the port is placed, it can only be mitigated with civil engineering construction works such as extending the breakwater, changing the alignment of the access canal, among others, seeking to increase the port operations.

### INCIDENCE DUE TO THE PLACE OF INSTALLATION OF THE BUOY

Guideline 1066 “The Design of Floating Aid to Navigation Moorings” tackles the problem of the concordance of the location of the signals and the breaking of the wave, this event happens when the wave height is a quarter higher (or even a greater value) than the depth of water which makes the wave direct a great amount of energy to the buoy which leads in the mooring charge not being able to absorb the high charges generated by a buoy which has been swept away by the waves. This event can lead to the rupture of the chain or make the dead weight being dragged to other place which presents the opportunity to use elastic anchorage as a solution to these scenarios.

Basically speaking, mooring of a buoy has, apparently, two contradictory functions. On the one hand, it keeps the buoy on its place, but on the other hand, the mooring has to follow the waves dynamics in order to be capable of reducing the charges in the mooring and to absorb the energy created by the movements of the buoy and to compensate the differences between the levels of the water, the tides, the waves, etc.

### INCIDENCE DUE TO TRANSMITTED FORCES

The wave impact always has negative consequences on the aids to navigation which should be considered at the moment of being designed. These consequences depend, mainly, if the aids to navigation are fixed or floating aids.

Every time the mooring chain abruptly reaches its end, even in shallow waters, it has as a consequence high peaks of force.

In floating Aids to Navigation, the waves affect directly the stability of the signal and, as a matter of fact, the vertical deviation of the lightning system implemented.

Guideline 1066- “The Design of Floating Aid to Navigation Moorings.”

Guideline 1099-Hydrostatic Buoy Design.

Since the wave impact is direct in fixed Aids to Navigation, beacons and mainly lighthouses placed in rocky ridges, the impact generates a constant deterioration of the structure which should be taken into account since the structure is also ageing.

Plymouth University, together with other organizations, have recently carried out a detailed analysis which grants the chance of visualizing a sample of selected lighthouses and the impact that waves have on them, the deflections and tensions to which the crucial areas of the structure are exposed to, together with physical modelations. This development allows that the lighthouse structure can respond with the aim of implementing a maintenance plan oriented to mitigate the deterioration made by the wave impacts and to design a new aid to navigation to determine the crucial value of waves which could make a signal collapse.

## Low/high tide

### Extreme Tidal

Extreme tidal phenomena can be manifested in the maritime area as well as well as in river areas. In both cases they can occur because of clearly identified, well-known and, to some extent, foreseen situations or events.

An extraordinary event of hydrometrical value is associated to a water rising or fall (event)of the sea created by the simultaneity of the astronomic and the meteorological tide.

The tide range or scope can me measured as the vertical difference between a high and a low tide. The most extreme extraordinary tide values occur according to the lunar phase (full or new moon) when the gravitational force of the sun and the moon are in phase, this kind of tide is known as Spring Tide.

|  |  |  |
| --- | --- | --- |
| **Location** | **Country** | **Tidal Range (feet)** |
| The Bay of Fundy | Canada | 38.4 |
| Ungava Bay, Quebec | Canada | 32.0 |
| Avonmouth / River Severn | England | 31.5 |
| Cook Inlet, Alaska | USA | 30.3 |
| Rio Gallegos (Reduccion Beacon) | Argentina | 29.0 |
| Hudson Bay | Greenland | 28.5 |
| Granville | France | 28.2 |
| Banco Direccion, Magellan Strait | Chile | 28.0 |
| Cancale | France | 27.8 |
| Iles Chausey | France | 26.9 |

Since the astronomic tide is the periodical variation of the hydrometrical level as a response of the gravitational interactions between the sun, the moon and the earth, it can be known with acceptable accuracy. Moreover, it is published by the responsible organizations for its establishment and the dissemination of the document globally known as Tidal Table.

Conversely, the meteorological tide has its origins in the daily or seasonal variations of the weather conditions which can occur periodically and can be foreseen.

In river flow regimes, an extraordinary event of hydrometrical values is associated with an increase or decrease of the rainfall cycle occurring in the inflow basin, which is strictly linked to climate change.

#### Incidence on ports access channel

The astronomical tide, a rare event which can be commonly visualized in coastal areas, occurs when the sea moves away from the shore in distances which can be measured by the human eye. This rare natural phenomenon together with the gravity force of one of the particular lunar phases (full moon) applies on the water masses and to the climate condition, named as water fall, occurs monthly with a different intensity. However, there exist instances in which the simultaneity effects can make it become crucial for the navigation.

The fall effect can provoke that smaller ships, such as fishing or service boats, ground in the seabed because of this natural phenomenon which, in some cases, prevent navigation through the waterway or else, assist small boats which affect the normal course of action of the port. This phenomenon can be seen in sport piers placed in bays or inlets. In commercial ports where the water depth is considerably higher than the effect produced by the fall, this phenomenon can impose restrictions in the ship draught and evidently, this situation gains greater importance when the bottom of the entrance canal is mainly formed by rock sediments making the under keel clearance become crucial.

Commercial ports designed and built in areas where the fall effect can affect its commercial operation often install an integrated system of continuous measuring of the hydrometrical value. Besides, the tidal current which, associated with the weather forecast, allows the designing and the optimization of the so called tidal windows.

#### Incidence on the river regime

These waterways cohabit with hydrological realities which can completely vary from time to time, being decisive for the regional economies which belong to the logistic system that communicates the traffic, ruled by the convoys of barges, and to a lesser extent, by self-propelled ships with load capacity (tank barges, container ships or cargo ships in general) between the Up River (river ports) and the Down River (sea ports).

Inner waterways globally known as Mississippi, Amazonas, Paraná, Rhin, among others, can be subjected to extraordinary rising or fall values which will impact in the operative restrictions of the upload and download of transported goods, logistics of the ship enlistment operation, as well as the modification of the waterway because of the dynamic process of erosion and sedimentation associated to the hydrometrical levels.

The situation described in the waterways and access canals entails to define the severity of the hydrometrical measuring in tide extreme value events.

Tidal measuring is always referenced to a benchmark or to an altrimetical network of fixed points established to a national or regional level with the purpose of making the measuring become similar and allowing the seafarers to carry out the reductions and corrections because of the tide and, thus, know the depth of the navigational waterway referred to on the same map.

The extraordinary minimum or maximum values can cause problems in the measuring station, given the fact that the hydrometrical levels can be higher than the installation height of the measuring equipment, leading to force the authorities to relocate the station and correlate the new measuring with the historic records since a mistake in the measuring will impact strictly in the determination of the water depth on behalf of the seafarer.

* Maximum values can be higher than the installation height of the measuring equipment;
* Minimum values can be lower than the register capacity in the installation place of the measuring equipment.

Example: data (hydrometrical station installed in the original place); reference is only made to the correction done because of the movement with the purpose of exemplifying the problem of one mistaken measuring of tide by temporarily relocating the station.

1. Tide at 12 am tide: 4.5 metres.
2. Water column at 12 am: 12.5 metres.
3. Depth to zero at 12 am (2-1): 8.00 metres.

Example 2: (relocated hydrometrical station without being linked to the original network)

1. Tide at 12 am tide: 6.5 metres
2. Water column at 12 am: 12.5 metres.
3. Depth to zero at 12 am (2-1): 6.00 (creation of restrictions in navigation)

Example 2: (relocated hydrometrical station without being linked to the original network)

1. Tide at 12 am tide: 2.5 metres
2. Water column at 12 am: 12.5 metres.
3. Depth to zero at 12 am (2-1): 10.00: undetected low seabed.

### Floodings

The sustained and gradual increase of the water volume in rivers in which a waterway develops can generate, when the hydrometrical height keeps extreme values, negative consequences in the signalling system due to the possible influx of aquatic vegetation or logs, and their action on the floating signals, since they can get entangled in the anchoring system resulting in the signal anchor dragging, the possible rupture of the anchoring or even though, the sinking or loss of it.

Regarding the fixed signalling system (beacon) it can occur than in the areas where these signals are installed, they can potentially be exposed to erosions or collapse which may affect the stability of these signals.



1. Images showing how vegetation impact on buoys

Likewise, ship sailing can be affected by the excessive growth of the hydrometrical level because of the loss of manoeuvring due to a higher speed of the current, lack of reference of the coastline, distortion of the visual marks and the radar image which is interpreted by the mariner at the moment of navigating.



1. Image showing the loss of reference of the coast because of the growth of the waterway

## Enviromental sensitive areas

Guideline G1036 “Environmental Management in Aids to Navigation” develops the impact that the aids to navigation have in the environment and establish the general patterns for the management of waste pollution, acoustic pollution, as well as luminous pollution, and the protection of habitats, flora and fauna, among others.

## BIRD FOULING

1091-Ed.2-Bird-deterrents-and-Bird-Fouling-Solutions

Bird fouling comes primarily from sea-birds landing and roosting, or attempting to land and roost, on an AtoN site. The discharge of faecal matter is what causes the bird fouling, but it can also be related to shedding of feathers, nesting debris and presence of rotting food. Bird fouling can have, among others, the following detrimental effects on AtoN sites:

• Excessive bird lime coverage on lanterns or optics, causing obstruction of the light source, resulting in reduced nautical range or in severe cases, total outage of the AtoN;

• Excessive bird lime coverage of solar panels, reducing the active area of the panel and severely limiting battery charging capacity, which can lead to negative effects on night-time signalling functions of the lantern and may eventually lead to total battery discharge and subsequent outages of the AtoN;

• Bird lime coverage on lighthouses or other daymarks can cause a change in the colour, severely affecting the ability of that AtoN to provide clear information to the user;

• Bird lime is highly caustic and can increase corrosion rates on AtoN structures, fittings and components, resulting in accelerated deterioration and reduced life span, higher maintenance costs and unsafe structures;

• Bird fouling on any site generally pollutes and contaminates, causing a number of associated issues.



1. Images showing the effect of bird fouling on buoys

Guideline 1091 develop the different methods to mitigate bird fouling on AtoN structures, such as implementing commercial products and deterrent systems, the application of engineering solutions, structural changes or revised installation methods where impossible to deter bird colonies, minimizing the negative effect of birds fouling. The exact method should be tailored to suit a particular site, situation and, in some cases, may need to be designed to suit the visitation habits of a particular species of bird.

1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

Consideration with bird fouling in hot climates is that it can be baked on due to the extreme heat, making it very difficult and time consuming to remove. Intensive cleaning can create dust which poses inhalation related health and safety risks to workers. Bird deterrents should be used wherever possible to prevent this problem.

Some ways used to prevent this effect:

* Install the most appropriate bird deterrent for the location and bird species. ‐ These action prevent the bird fouling
* Paint over the surface colour with a special ant graffiti product. ‐ These action not prevent the bird fouling but ensure an easily remove with water pressure. (**Example pic here.)**

# ACRONYMS & Definitions

## Acronyms

IMO International Maritime Organization (Acronym style)

MBS IALA Maritime Buoyage System

AtoN

## Definitions

The definition of terms used in this Guideline can be found in the International Dictionary of Marine Aids to

Navigation (IALA Dictionary) at (<http://www.iala‐aism.org/wiki/dictionary>).

# REFERENCES

Guideline 1136-Ed.1-Providing-AtoN-Services-In-Extremely-Hot-and-Humid-Climates\_Dec2017

Guideline 1091-Ed.2-Bird-deterrents-and-Bird-Fouling-Solutions

Guideline 1066- “The Design of Floating Aid to Navigation Moorings.”

Guideline 1099-Hydrostatic Buoy Design.

Guideline 1090 “The Use of Audible Signs”

Guideline G1108 “The Challenges of Providing AtoN Services in Polar Regions”

Guideline G1067-0 “Selection of Energy Systems for Aids to Navigation and Related Equipment”

Guideline G1067-3 “Energy Storage for Aids to Navigation”

Guideline 1039-Ed.2-Designing-Solar-Power-Systems-for-Aids-to-Navigation\_Dec2017

Guideline 1007-Ed.1.1-Lighthouse-Maintenance\_Dec2005

Guideline 1098 Application of AIS-AtoN on buoys

Guideline 1006-Ed.-4-Plastic-Buoys\_Dec-2018