

TECHNICAL SPECIFICATION



Wind energy generation systems –
Part 29: Marking and lighting of wind turbines

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS –

Part 29: Marking and lighting of wind turbines

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IEC TS 61400-29 has been prepared by IEC technical committee 88: Wind energy generation systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
88/894/DTS	88/913/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61400 series, published under the general title *Wind energy generation systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

As the Wind Industry grows, airspace users (military, civil and emergency aircraft) need to continue to operate safely in an environment that includes wind turbines, and the two industries need to exist harmoniously.

To assist in creating a safe environment, some wind turbines are required to have aeronautical lights so they can be seen by airspace users. Unfortunately, some of these lights can have an adverse visual impact, which produces lighting pollution for nearby communities.

Annex 14 to the Convention on International Civil Aviation published by the International Civil Aviation Organization (ICAO) contains Standards and Recommended Practices (specifications) that prescribe the marking and lighting of wind turbines. However, many countries have interpreted these specifications differently and issued their own guidelines and conditions to suit their local requirements. Therefore, there is little homogeneity and wind turbine manufacturers are obliged to produce bespoke designs to suit specific markets.

There are currently approximately 20 different marking and lighting specifications for countries such as Belgium, Brazil, Canada, Finland, France, Germany and Japan. In many cases, those requirements are very similar. However, they often differ in terms of light intensity, positioning and markings, which could lead to confusion and reduction in air safety.

In some cases wind farms that are separated by only a few kilometers are marked and illuminated in accordance with different guidelines. This includes the transition from the onshore to the offshore wind environment, and vice versa.

This document reflects the need to allow the coexistence of wind turbines and aviation, ensuring that the ICAO Standards and Recommended Practices are followed but also balances with the environmental impact on nearby residents.

References to national regulations are important in this document, given the regional specific circumstances required in many cases. Users should be aware that national and/or "local" regulations can apply. The aim is to encourage safe airspace but with minimum light pollution.

NOTE Throughout the drafting process for this document, the National Guidelines, related to lighting and marking wind turbines, of many ICAO Member States have been used as a resource. However, the guidance documents are too numerous to list and, therefore, reference to any non-normative documents has been omitted.

WIND ENERGY GENERATION SYSTEMS –

Part 29: Marking and lighting of wind turbines

1 Scope

This part of IEC 61400, which is a Technical Specification, instils good practice for aviation lighting and marking of wind turbines in both onshore and offshore domains. Consideration is given to visible lighting and infrared (IR) lighting, which is necessary to maintain conspicuity to users of night vision goggles (NVGs).

ICAO Annex 14 Standards and Recommended Practices have been used as the basis to develop supplementary harmonised specifications to assist with implementation.

This document provides a set of technical requirements for marking and lighting of wind turbines with a tip height from/at 150 meters and below 315 meters Above Ground Level (AGL), or Above Mean Sea Level (AMSL) for offshore sites. This will improve situational awareness for airspace users, maintain safety of aircraft flying in the vicinity of wind turbines, and provide additional tools to assist with the reduction in environmental impacts consistent with aviation safety objectives. In the event that the wind turbine development exceeds 315 m tip height and the regulatory framework is updated to cater for these heights, this document will be reviewed and amended as necessary. In the absence of an update to the regulatory framework, the guidance in this document is to be followed as a minimum.

In some cases, lighting may be required for wind turbines at or below 150 meters tip height. However, this is not in the scope of this document and in these situations, the developer should contact the relevant National Aviation Authority or Planning Authority for further guidance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61400-3-1:2019, *Wind energy generation systems - Part 3-1: Design requirements for fixed offshore wind turbines*

IEC 62443-4-2:2019, *Security for industrial automation and control systems - Part 4-2: Technical security requirements for IACS components*

International Civil Aviation Organization, Annex 14, *Aerodromes – Volume I – Aerodromes Design and Operations*. 8th Edition, July 2018

International Civil Aviation Organization, *Aerodrome Design Manual – Part 4 – Visual Aids* (Doc 9157 – Part 4). 5th Edition. 2021

European Union Aviation Safety Agency (EASA), *Certification Specifications and Guidance Material for Aerodromes Design CS-ADR-DSN*, Issue 5, June 2021

Federal Aviation Administration. Advisory Circular 150/5345-43J – *Specification for Obstruction Lighting Equipment*, 11 March 2019

Federal Aviation Administration. 70/7460-1M – *Obstruction Marking and Lighting*, 16 November 2020

IALA Recommendation R0139 (O-139) , *The Marking of Man-Made Offshore Structures*, Edition 3.0, December 2021

NOTE Although too many to list explicitly, in drafting this document the national guidelines of many ICAO Member States, for lighting and marking wind turbines, have been given due consideration. In some cases, specific examples have been provided from national guidelines to enhance the international guidance in this document.

3 Terms and definitions

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

3.1

aerodrome

defined area (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft

3.2

aviation Obstacle Lights

warning lights (visual and infrared) used to reduce hazards to aircraft by indicating the presence of the obstacles

3.3

aviation Obstacle Markings

warning markings used to reduce hazards to aircraft by indicating the presence of the obstacles

3.4

candela

International System of Units (SI) base unit of luminous intensity that denotes the luminous power per unit solid angle emitted by a point light source in a particular direction

3.5

cluster configuration wind farm

wind turbines arranged in a non-linear configuration (see 3.10)

3.6

daytime light

period(s) of the day when the background luminance is above 500 cd/m²

3.7

effective luminous intensity

effective luminous intensity of a flashing light is equal to the intensity of a steady-burning (fixed) light of the same colour which produces the same visual range under identical conditions of observation

3.8

grid configuration wind farm

wind turbines arranged in a geographical shape such as a square or a rectangle, with each turbine placed a consistent distance apart in rows

3.9

LED technology

light emitting diode (LED) is a semiconductor light source that emits light if electrical current flows through it

Note 1 to entry: It can emit visible, IR or ultraviolet radiation depending on the semiconductor material and the doping wavelength. LEDs are energy efficient and have a long lifespan.

3.10

linear configuration wind farm

wind turbines arranged in linear configuration are placed in a row along a ridgeline, the face of a mountain, or along the borders of a hill or field

Note 1 to entry: The line may be ragged in shape or be periodically broken.

3.11

luminance

luminous intensity per unit emitting area. It is a photometric quantity which may be applied to light sources but also to light which is reflected or passes through a particular area

Note 1 to entry: Its unit is 'Candela per Square Meter' (cd/m^2).

3.12

nanometer

unit of length in the metric system, equal to one billionth of a meter

Note 1 to entry: The international unit for nanometer, nm is $10^{(-9)}$ m.

3.13

nautical mile

unit of measurement used in both air and marine navigation

Note 1 to entry: The international nautical mile is exactly 1 852 meters.

3.14

night-time light

period(s) of the day when the background luminance is below $50 \text{ cd}/\text{m}^2$

3.15

night vision goggles

helmet mounted night vision enhancement aid that utilises image intensifier technology and is sensitive to light wavelengths between 660 and 920 nanometers

3.16

obstacle

fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:

- a) are located on an area intended for the surface movement of aircraft; or
- b) extend above a defined surface intended to protect aircraft in flight; or
- c) stand outside those defined surfaces assessed as being a hazard to air navigation

3.17

offshore wind turbine

wind turbine that converts kinetic energy in the wind into electrical energy and has a sub-structure that is subject to hydrodynamic loading and is founded on the seabed, including floating structures

3.18

onshore wind turbine

wind turbine that converts kinetic energy in the wind into electrical energy located on a land mass

3.19**tip height of a wind turbine**

maximum height AGL (onshore) and AMSL (offshore), of the tip of the turbine blades at their highest point

3.20**twilight-time light**

light during the period(s) of the day when the background luminance is between 50 and 500 cd/m²

3.21**visibility**

aeronautical visibility is the greater of:

- a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognised when observed against a bright background, represented by the meteorological optical range (MOR)
- b) the greatest distance at which lights in the vicinity of 1000 candelas (cd) can be seen and identified against an unlit background, which varies with the background illumination

3.22**wind farm**

group of two or more wind turbines in the same geographical area, used to produce electricity

3.23**wind turbine**

structure intended for the production of electrical power; comprising a support tower, a nacelle, a generator unit, and rotor blades that are caused to rotate by the wind

4 Symbols and abbreviated terms**4.1 Abbreviations**

ADS	aircraft detection system
AGL	above ground level
AIP	Aeronautical Information Publication
AMSL	above mean sea level
cd	candela
CIE	International Commission on Illumination
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration
fpm	flashes per minute
IALA	International Association of Lighthouse Authorities
ICAO	International Civil Aviation Organization
IEC	International Electrotechnical Commission
IR	infrared
ISO	International Organization for Standardization
JORF	Journal officiel de la République française (Official Journal of the French Republic)
LED	light emitting diode
MOR	meteorological optical range
NM	nautical mile
NOTAM	notice to airmen