**SLOVENSKI STANDARD**

# SIST EN IEC 61400-24:2019/oprA1:2023

**01-oktober-2023**

---

**Sistemi za proizvodnjo energije na veter - 24. del: Zaščita pred delovanjem strele - Dopolnilo A1**

Wind energy generation systems - Part 24: Lightning protection

Windenergieanlagen - Teil 24: Blitzschutz

Systèmes de génération d'énergie éolienne - Partie 24: Protection contre la foudre



**Ta slovenski standard je istoveten z: EN IEC 61400-24:2019/prA1:2023**

---

<u>**ICS:**</u>

| | | |
|---|---|---|
| 27.180 | Vetrne elektrarne | Wind turbine energy systems |
| 91.120.40 | Zaščita pred strelo | Lightning protection |

**SIST EN IEC 61400-24:2019/oprA1:2023 en**

# 88/965/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

| | |
|---|---|
| PROJECT NUMBER: **IEC 61400-24/AMD1 ED2** | |
| DATE OF CIRCULATION: **2023-08-11** | CLOSING DATE FOR VOTING: **2023-11-03** |
| SUPERSEDES DOCUMENTS: **88/928/CD, 88/948A/CC** | |

IEC TC 88 : WIND ENERGY GENERATION SYSTEMS

| | |
|---|---|
| SECRETARIAT: Denmark | SECRETARY: Mrs Christine Weibøl Bertelsen |
| OF INTEREST TO THE FOLLOWING COMMITTEES: TC 81 | PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary. |

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY

☒ SUBMITTED FOR CENELEC PARALLEL VOTING

☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

**Attention IEC-CENELEC parallel voting**

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.

The CENELEC members are invited to vote through the CENELEC online voting system.



This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any relevant "In Some Countries" clauses to be included should this proposal proceed. Recipients are reminded that the CDV stage is the final stage for submitting ISC clauses. (See AC/22/2007 or NEW GUIDANCE DOC).

TITLE:

**Amendment 1 – Wind energy generation systems – Part 24: Lightning protection**

PROPOSED STABILITY DATE: 2026

NOTE FROM TC/SC OFFICERS:

In order to assist MT 24 when sorting and compiling the given comments on the CDV document, it is of great importance that all comments given in the comments form refer to both clause and line numbers in the CDV document.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____________

**WIND ENERGY GENERATION SYSTEMS –**

**Part 24: Lightning protection**

**AMENDMENT 1**

# FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

Amendment 1 to IEC 61400-24:2019 has been prepared by IEC technical committee 88: Wind energy generation systems.

The text of this Amendment is based on the following documents:

| Draft | Report on voting |
|---|---|
| XX/XX/XXXX | XX/XX/XXX |

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 Amendment 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/.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

# INTRODUCTION

This amendment to IEC 61400-24:2019 addresses an update of the content in Annex L regarding monitoring systems for detecting lightning strikes on wind turbines.

# Annex L
(informative)

## Lightning detection and measurement systems

## L.1 General

It is recommended that wind turbines are equipped with systems capable of detecting lightning, measuring its current components, and processing the parameters of the lightning strikes. The purpose of such systems is to:

- provide information to the operator on the occurrence of lightning strikes to the wind turbine and to give input to operation and maintenance regimes;
- provide valuable data on lightning strikes to wind turbines thus allowing post-assessment of the lightning magnitude/characteristics and contribution to the operator's risk assessment processes.
- enable the operator to compare the measured current parameters of lightning strikes to the lightning protection level, LPL, used for designing the wind turbine lightning protection system (e.g. for assessing if the lightning current intercepted by the LPS is below or above the values defined in Table 1 of IEC61400-24)
- avoid hazardous activities such as maintenance when there is a risk of lightning strike.

### L.1.1 Nomenclature



The following nomenclature apply for the current Annex.

1) Lightning detection systems
   a) Thunderstorm warning systems (TWS), detecting lightning by monitoring the electrostatic and electromagnetic fields
   b) Lightning Location systems (LLS), locate individual cloud-to-ground and intra-cloud discharges (e.g. return strokes, Intra-Cloud pulses) in lightning flashes based on direction finding (magnetic or interferometry), difference of time of arrival or both.



2) Lightning measurement systems (LMS), measuring lightning events and their features with devices installed on the turbine. These systems range from a combination of simple electromechanical event counters to complex systems measuring and analyzing lightning parameters.

## L.2 Benefits of lightning detection and measurement systems

There are many benefits of measuring actual lightning exposure. Depending on the specific stakeholder, a non-exhaustive list is included in Tables L.1 – L.3. The industry is encouraged to share lightning data across all stakeholders (OEM/Owner/Insurance), to ensure benefits across the entire value chain.

**Table L.1 – Considerations and benefits for the OEM (Original Equipment Manufacturer)**

| Statement | Value Aspect |
|---|---|
| For turbines delivered with long service contracts, the OEM (Original Equipment Manufacturer) with a service contract would like to know when the receptor/LPS has reached the design lifetime and needs to be replaced. This can be achieved by monitoring the accumulated charge and specific energy for each blade and correlating with test performance of the receptor/LPS. | This enables condition-based maintenance or repair, lowering downtime and unexpected damage costs significantly. Maintenance is cheaper than repair. |
| The OEM would like to know all information of strikes, to determine the efficiency of the receptors/LPS (the observed number of strikes intercepted correctly divided by the total number of strikes to the turbine/blade observed – section 3.12) | This information is used to market the OEM products, *"with a field efficiency of XX%, our turbines comply fully with YY".* |

| | |
|---|---|
| Every strike will be different, and cross correlating strike information with other sensor signals can provide valuable information to the OEM to fully understand the turbine operation and design performance. | Get more information on the lightning susceptibility of the turbines, to enable stronger and cheaper designs for future turbines. |
| Turbine LPS have developed intensively during the past 10-20 years, and OEMs are still following different paradigms for the design and verification air terminations, down conductors and lightning coordination with additional conductive components like CFRP.<br><br>If a blade design, known from verification tests or modelling, is challenged by certain features of the lightning current, an active monitoring of the lightning exposure will allow targeted maintenance.<br><br>Not all lightning strikes exhibit the same strike parameters, hence the consequence of strikes will differ. | By measuring all strikes in field, evaluating the strike parameters, and comparing them to design performance from laboratory tests and/or modelling verification, the consequence of specific strikes can be assessed.<br><br>By evaluating the consequence of each lightning event, maintenance and inspections can be tailored and optimized. |
| In case lightning damages occur, the detailed measurements of the lightning parameters can be used to assign and split the cost of repair between OEM and owner/operator. | Enable the discussion on splitting costs of blade damages based on lightning impact. |

**Table L.2 – Considerations and benefits for owner and/or operator**

| Statement | Value Aspect |
|---|---|
| The operator would like to know if a lightning flash exceeded IEC LPL current parameters to which the turbine has been certified as this is useful information in relation to warranty and insurance. | Lightning damage is paid by the responsible party. |
| The owner and/or operator would like to know if a lightning flash was potentially dangerous to the turbine. | In case the measurement can be used to identify a strike as representing a risk, the turbine could be checked (online or on site) before it is restarted. This could prevent further damage on the turbine. |
| The Owner and/or Operator would like to know when the receptor and/or LPS has reached the design lifetime and needs to be replaced. This is performed by monitoring the accumulated charge and/or specific energy in each blade and correlating it with the receptor and/or LPS performance as proven by testing according to Annex D.<br><br>Additionally, the collection of lightning exposure will enable a determination of potential LPS performance degradation. | This enables condition-based maintenance/repair, lower downtime and unexpected damage cost significantly. Maintenance is cheaper than repair. |
| A correlation of lightning performance across large fleets with LMS, will provide knowledge on the performance of a specific design, and enable customisation of the LPS design to specific site conditions (altitude, lightning regime, number of WTs in the WF, etc | Enable the Owner to select turbines with documented good experience on the lightning performance, as required by the specific site. |
| Every strike will be different, and cross correlating strike information with other sensor signals can provide valuable information to the owner and/or operator to fully understand the turbine operation and design performance. | Get more information to support condition-based maintenance strategies. |
| In case lightning damages occur, the detailed measurements of the lightning parameters can be used to assign and split the cost of repair between OEM and owner/operator. | Enable the discussion on splitting costs of blade damages based on lightning impact. |



**Table L.3 – Considerations and benefits for the Insurance company**

| Statement | Value Aspect |
|---|---|
| Sites with severe lightning exposure will potentially have more downtime to allow for extra service and maintenance, and the damage rate in terms of failures per year may also be larger. The insurance company could customize the insurance tariff according to site conditions in terms of challenging lightning activity, such that sites experiencing significant lightning activity could be priced higher than sites with limited lightning activity | Utilizing a dynamic insurance premium, where that insurance premiums scale with documented lightning activity, would allow the insurance company to target the premiums more correctly to the risk. |
| A correlation of lightning performance across large fleets, will provide knowledge of which designs that work well and which designs that doesn't for similar lightning environments. Since the lightning environment is documented by LMS, a correlation between insurance claims and LMS | Optimize insurance premiums and exclude designs with poor |

| | |
|---|---|
| data will provide the needed information (e.g. protection efficiency of the LPS). | performance, to eventually optimise the insurance business. |
| A blade certified according to IEC/RE OD-501 (referencing to IEC 61400-24 for lightning matters) eventually means that the turbine should be able to continue operation without the need of repair until next scheduled maintenance, see 8.2.2. An additional perception is that strikes outside the range of the LPL are disregarded. In both cases, knowledge on the actual strike data is useful for deciding the insurance coverage. | Qualify discussion of insurance coverage by providing actual lightning strike data. |
| In the event that blades suffer damages due to lightning, a discussion on insurance coverage can be assisted by accurate measurements. The insurance companies could require the installation of proper LMS to quantify the lightning exposure (current magnitude, specific energy, flash charge, accumulated charge, dI/dt, etc.). | Discussions on lightning exposure can be eliminated, once suitable LMS complying to industry standards are used efficiently. |

## L.3 Lightning detection and measurement systems

Lightning detection and measurement systems are devices that provide information about lightning affecting the wind turbine. By detecting the presence of lightning strikes on and/or around the wind turbine, different strategies for optimized operation or maintenance of the turbines can be implemented.

A brief description of the different options are given below.

### L.3.1 Lightning detection systems

The standard IEC 62793:2020 Thunderstorm warning systems - Protection against lightning, describes sensors and networks able to provide real-time information on the risk of lightning strike. Sensors measuring electrostatic field detect lightning related conditions and are usually employed as local detectors since they measure the formation, approach or dissipation of the thunderstorm in the area where they are installed.

Sensors measuring electromagnetic field produced by lightning strokes are used in LLS, which use multiple antennae to locate lightning strokes based on direction-finding, time of arrival, or interferometric techniques. Data from these systems are generally available in real-time according to IEC 62793 requirements.

It is important for the user of data from TWS and LLS to know several parameters that affect the performance of the system. Considerations relevant to lightning detection systems are listed in Table L.4.

**Table L.4 – Considerations relevant for lightning detection systems (TWS and LLS)**

| Topics | Considerations |
|---|---|
| Detection efficiency (DE) | One of the parameters is the detection efficiency (DE). Flash DE (DEf) and stroke DE (DEs) are differentiated. Since a lightning flash is composed by one or several strokes, DEf is typically higher than stroke DEs. It is important to note that lightning detection systems detect strokes and the grouping of strokes into flashes is done according to some criteria. These criteria should be known or defined by the user. DE depends on several parameters such as the number of sensors available, the distances between sensors and the geometry of the sensor positions around the point of interest; the performance of the sensors (noise level at each sensor site, availability, etc.); the number of sensors required and used for detection; and several other parameters. Relative DE of a lightning detection system can be obtained by analysing the current distribution at the point of interest and at a reference location (e.g. centre of the system).<br><br>For further details, consider IEC 62793 and IEC 62858. |
| Location accuracy | The location accuracy of such systems can be limited from tens of metres to a few kilometres. Location accuracy for an individual stroke depends, among some other factors, on the current parameters of that particular stroke and the lightning detection system performance at the point of interest at the point in time. Hence location accuracy is not constant for all the strokes and at all the locations of the point of interest.<br><br>For further details, consider IEC 62793 and IEC 62858. |
| Information about the data | Location accuracy and DE also depend on the settings of the data analysis process used for determining a solution (stroke location and parameters). Since lightning data can be used for several purposes, the user of lightning data should agree with the lightning data provider about the type of data to be delivered depending on the purpose. As an example, very high |

| | |
|---|---|
| | location accuracy is not necessary for lightning warning purposes but a good DEs or capability of detecting intra cloud lightning can be convenient.<br>Some lightning data providers apply different filters to the data. Information about such filters should be provided to the user. |
| Limitations | Lightning detection systems often cannot detect lightning with magnitudes less than 3-5 kA. In addition, the location accuracy of the systems can be limited to from a few hundred meters to a few kilometres. Therefore, compared to the Lightning measurement systems described in section L.2.2. Lightning detection systems are not suitable for applications that requires accurate detection of lightning events attaching to the wind turbines directly.<br>TWS and LLS often exhibit a lower DE for upward strikes, and since the fraction of upward strikes in general increases with structure height, this is a point requiring special attention for the application in wind turbines. |
| Recommended use | Lightning detection systems are an effective means of understanding the historic and current lightning environment on site, and how thunderclouds are approaching the wind turbines. Risk assessments to predict the lightning exposure prior to wind farm installation is relying on accurate lightning location systems.<br>However, lightning detection systems based on measurements of electromagnetic field variations due to lightning can't be used to give forewarning against thunderstorm until the first lightning happens. Hence lightning detection systems are most efficient with active thunderstorms that approach the area of interest, while they don't necessarily provide warning against the first lightning from a thundercloud that develops inside the area of interest.<br>Lightning warning systems that are based on electrostatic field variations can issue warnings against lightning even though no lightning strikes to ground occur. Hence if such warning devices are too sensitive, they can lead to un-wanted many interruptions if used to stop work or stop operation. |

### L.3.2 Lightning measurement systems (LMS)



Lightning measurement systems are devices that provide information about lightning strikes on a wind turbine by measuring various parameters caused by that lightning strike (e.g., current magnitude, specific energy, flash charge, accumulated charge, di/dt, transient magnetic fields generated by lightning currents flowing through down conductors including the tower).



#### L.3.2.1 Lightning event counters and peak current sensors

Lightning counters and peak current sensor cards (PCS) provide minimal information about lightning events to a wind turbine. The simplest lightning counters (e.g. electromechanical) just provide the number of strikes. Electronic lightning counters can also provide time stamp and estimation of lightning parameters. Peak current sensor cards provide an estimation of the maximum peak current for the time period since the sensor was installed.

**Table L.5 – Considerations relevant for lightning event counters and peak current sensors**

| Types | Considerations |
|---|---|
| Lightning strike counters | Lightning counters designed in accordance with IEC 62561-6 may not be suitable for wind turbines exposed to large fractions of upward lightning.<br>Some lightning counters also estimate one or several current parameters: peak current, charge, specific energy. Devices designed for the standard lightning currents (e.g. IEC 62561-6) will not provide realistic data for all the strikes. The manufacturer should define test waveforms including continuing currents. The manufacturer should provide the reference waveforms and the uncertainties. The manufacturer should provide information about the frequency response of the sensitivity and uncertainty of the estimated parameters.<br>The measurement capability of lightning counters used in wind turbines should demonstrate sensitivity to upward lightning.<br>Manufacturer should provide the sensitivity versus frequency curve. |
| Peak current sensors | This type of sensors designed and calibrated only with the standard lightning current waveforms might not be suitable for the registration of real lightning currents. The manufacturer should provide information about the performance of the sensor at typical lightning currents of wind turbines.<br>The manufacturer should provide information about the minimum detectable current and the tested waveforms. |