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Part 21: Horizontal axis wind turbines

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Partie 21: Turbines éoliennes à axe horizontal

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

This first edition of ISO 20816-21 cancels and replaces the first edition of ISO 10816-21:2015, which has been technically revised taking into account the information contained in VDI 3834-2 for direct drive wind turbines.

The main changes are as follows:

— scope expansion to include Group 2 wind turbine without gearboxes;

— revision of text and content so that the document can be applied to both groups of wind turbines;

— vibrations of different types of wind turbines are clearly identified and figures show measurement positions (see Annex C);

— revision and standardization of assessment tables for both types of wind turbines (see Annex A);

— clarification of descriptions of technical functionality of wind turbines (see Annex B);

— added a proposal for protocols for acceptance measurements (see Annex D);

— updated and supplemented information on relevant documents (see Bibliography).

The list of all parts in the ISO 20816 series and ISO 10816 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The ISO 20816 series of documents provides general guidance relating to the measurement and evaluation of vibration measured on rotating and non-rotating parts of machines. This document provides recommendations for the measurement and evaluation criteria for wind turbines. Additional guidance is given to account for the vibration of the wind turbine tower and nacelle caused by the effects of wind, flow disturbances due to the tower (tower dam effect) and the natural vibration of the rotor blades and structure itself (tower and foundation). For offshore wind turbines, guidance is given to take account of the vibration response due to sea swell, which differs from the response of land-based wind turbines in terms of the temporal vibration behaviour and spectra.

ISO 20816-1 deals with the measurement and evaluation of machine vibration and serves as the basis for other documents dealing with specific considerations for different machine types, including wind turbines.

In contrast to the other parts of the ISO 20816 series, this document considers vibration not generated by the machine itself, but excited by wind and, in case of offshore wind turbines, additionally by sea swell. Due to the flexibility of the blades and tower and the low rotor rotational speeds, it is necessary to include the low-frequency vibration in the measurement and evaluation criteria.

The construction methods used and the conditions under which wind turbines are built and operated, entail that presenting general guidelines for the vibration evaluation of their structures is not possible. However, the measurement procedures and criteria for evaluating the vibration of their structures explained in ISO 4866 can be used for guidance. Furthermore, offshore wind turbine structural vibration monitoring is covered in VDI 4551.

The necessity to measure and evaluate the low-frequency vibration of wind turbine components as a response to periodic and stochastic excitation sources requires additional evaluation of quantities in addition to those described in this document (see 4.5). This is complicated by the effects of wind and waves on the wind turbine structure, which can lead to high-amplitude low-frequency vibration.

Due to the influence of the vibration magnitude on the induced stresses of all wind turbine components and thus on their operational reliability and service life, it is in the interest of all stakeholders involved in the manufacture, ownership, operation, service, maintenance, and financing of wind turbines to have a widely accepted document, which provides clear criteria and recommendations regarding the measurement and evaluation of their mechanical vibration.

The aim of this document is to standardize the vibration measurements to be performed, to facilitate their evaluation and to allow a comparative assessment to be made of the measured vibration between different wind turbines and their components. This document does not address the diagnostic evaluation of the condition of the wind turbine components themselves. The evaluation criteria described in this document serve to ensure reliable, safe long-term wind turbine operation.

In addition, evaluation zone boundaries are set, which enable conclusions to be drawn regarding the general state of wind turbine components or the overall system. Evaluation zone boundary values are not intended to be used as contractual acceptance values.

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Mechanical vibration — Measurement and evaluation of machine vibration —

Part 21: Horizontal axis wind turbines

1 Scope

This document provides information regarding the measurement and evaluation of the mechanical vibration of wind turbines and their components. The working principles of wind turbines covered by this document are described in Annex B.

The installation site and type of mechanical drive train of the wind turbine influence the vibration magnitude, so for the purposes of this document wind turbines have been divided into two groups:

a) Group 1: Horizontal axis wind turbine installations with generators coupled to the rotor via a gearbox; and

b) Group 2: Horizontal axis wind turbine installations with generators coupled to the rotor without a gearbox (direct drive wind turbines).

The requirements of this document apply to both Group 1 and Group 2 wind turbines with a rated generator output exceeding 200 kW.

This document recommends zones for evaluating the vibration at continuous load operation. However, in most cases these evaluation zone boundaries are not suitable for the early detection of faults. Annex A presents evaluation zone boundaries based on vibration data collected from thousands of wind turbines with rated generator outputs of 5 MW or less, which can be helpful in facilitating discussion between users and manufacturers when considering early fault detection.

The evaluation criteria described in this document serve to ensure safe, reliable, long-term operation of the wind turbine and its components. It is intended to standardize the vibration measurements taken, to assist in their evaluation and to facilitate a comparative evaluation of the vibration measured in wind turbines and their components. In addition, recommendations are given for the determination of operational vibration limit values.

The type and implementation of broad-band vibration monitoring methods to be used for wind turbines are addressed in this document, along with evaluation criteria for assessing vibration severity. This document does not address diagnosis or fault detection, although the measurement equipment described can be used for vibration monitoring.

NOTE 1 For information regarding vibration condition monitoring see the ISO 13373 series. For Information regarding condition monitoring and diagnostics of wind turbines see the ISO 16079 series.

NOTE 2 IEC 61400-13 describes load measurements that can be taken using strain gauges mounted on the wind turbine support structure and blades. For procedures to assist the detection of rolling bearing and gearbox defects see ISO 13373-2. For the measurement and evaluation of structure-borne noise in wind turbines fitted with rolling bearings see VDI 3832.

NOTE 3 Evaluation of the unbalance of the slowly turning wind turbine rotor requires the use of measurement techniques and analysis which consider both mass and aerodynamic unbalance. To assess the influence of the rotor unbalance on vibrations see VDI 3834-1:2015-08, Annex B.

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The requirements described in this document do not apply to the acceptance measurements for wind turbine gearboxes and generators taken in the manufacturer's test facility.

NOTE 4 Acceptance measurements for wind turbine gearboxes and generators, taken in the manufacturers test facility, are assessed as described in ISO 20816-9 and/or IEC 60034-14.

This document does not provide evaluation zones for vibration measurements taken on rotating parts (shaft relative displacement) due to the small number of turbines on which such measurements are/have been taken.

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.

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

ISO 20816-1:2016, *Mechanical vibration — Measurement and evaluation of machine vibration — Part 1: General guidelines*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
assessment acceleration
a_{w0}
broad-band root-mean-square (r.m.s.) value of acceleration in a given frequency band, measured over a fixed period

3.2
assessment velocity
v_{w0}
broad-band root-mean-square (r.m.s.) value of vibration velocity in a given frequency band, measured over a fixed period

4 Measurement procedures

4.1 General

The measurement procedures to be followed and the instrumentation which shall be used are specified in ISO 20816-1, subject to the requirements given in this clause.

Care shall be taken to ensure that the measurement system is not influenced by environmental factors such as

a) temperature variation,

b) magnetic fields, including magnetisation of the wind turbine shaft(s),

c) external sound fields,

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