



INTERNATIONAL STANDARD

**Wind turbine generator systems –
Part 11: Acoustic noise measurement techniques**

Withhold

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Definitions	8
4 Symbols and units	9
5 Outline of method	10
6 Instrumentation	11
6.1 Acoustic instruments	11
6.2 Non-acoustic Instruments	13
6.3 Traceable calibration.....	13
7 Measurements and measurement procedures.....	14
7.1 Measurement positions	14
7.2 Acoustic measurements	15
7.3 Non-acoustic measurements	17
8 Data reduction procedures	20
8.1 Wind speed	20
8.2 Correction for background noise.....	21
8.3 Apparent sound power levels.....	21
8.4 One-third octave band levels.....	22
8.5 Tonality.....	22
8.6 Directivity (optional)	25
9 Information to be reported.....	25
9.1 Characterisation of the wind turbine	26
9.2 Physical environment	27
9.3 Instrumentation	27
9.4 Acoustic data.....	27
9.5 Non-acoustic data	28
9.6 Uncertainty.....	28
Annex A (informative) Other possible characteristics of wind turbine noise emission and their quantification	38
Annex B (informative) Criteria for recording/playback equipment	40
Annex C (Informative) Assessment of turbulence intensity	42
Annex D (informative) Assessment of measurement uncertainty	43
Bibliography.....	46
Figure 1 – Mounting of the microphone	29
Figure 2 – Picture of microphone and board.....	30
Figure 3 – Standard pattern for microphone measurement positions (plan view)	31
Figure 4 – Illustration of the definitions of R_0 and slant distance R_1	32

Figure 5 – Allowable region for meteorological mast position as a function of β – plan view	33
Figure 6 – Allowable range for anemometer height – cross section	34
Figure 7 – Workflow chart for tonality procedure	35
Figure 8 – Illustration of $L_{70\%}$ level in the critical band	36
Figure 9 – Illustration of lines below the $L_{70\%} + 6\text{dB}$ criterion	36
Figure 10 – Illustration of $L_{\text{pn,avg}}$ level and lines classified as masking	37
Figure 11 – Illustration of classifying all spectral lines	37
Figure B.1 – Tolerances for frequency characteristic, IEC 60651 type 1	40
Table 1 – Roughness length	20
Table 2 – Frequency resolution	22
Table D.1 – Examples of possible values of type B uncertainty components relevant for apparent sound power level	44

Withdrawn

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINE GENERATOR SYSTEMS –

Part 11: Acoustic noise measurement techniques

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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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 IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61400-11 has been prepared by IEC technical committee 88: Wind turbines.

This consolidated version of IEC 61400-11 consists of the second edition (2002) [documents 88/166/FDIS and 88/171/RVD] and its amendment 1 (2006) [documents 88/260/FDIS and 88/264/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

Withdrawn

INTRODUCTION

The purpose of this part of IEC 61400 is to provide a uniform methodology that will ensure consistency and accuracy in the measurement and analysis of acoustical emissions by wind turbine generator systems. The standard has been prepared with the anticipation that it would be applied by:

- the wind turbine manufacturer striving to meet well defined acoustic emission performance requirements and/or a possible declaration system;
- the wind turbine purchaser in specifying such performance requirements;
- the wind turbine operator who may be required to verify that stated, or required, acoustic performance specifications are met for new or refurbished units;
- the wind turbine planner or regulator who must be able to accurately and fairly define acoustical emission characteristics of a wind turbine in response to environmental regulations or permit requirements for new or modified installations.

This standard provides guidance in the measurement, analysis and reporting of complex acoustic emissions from wind turbine generator systems. The standard will benefit those parties involved in the manufacture, installation, planning and permitting, operation, utilization, and regulation of wind turbines. The measurement and analysis techniques recommended in this document should be applied by all parties to insure that continuing development and operation of wind turbines is carried out in an atmosphere of consistent and accurate communication relative to environmental concerns. This standard presents measurement and reporting procedures expected to provide accurate results that can be replicated by others.

Withhold

WIND TURBINE GENERATOR SYSTEMS –

Part 11: Acoustic noise measurement techniques

1 Scope

This part of IEC 61400 presents measurement procedures that enable noise emissions of a wind turbine to be characterised. This involves using measurement methods appropriate to noise emission assessment at locations close to the machine, in order to avoid errors due to sound propagation, but far enough away to allow for the finite source size. The procedures described are different in some respects from those that would be adopted for noise assessment in community noise studies. They are intended to facilitate characterisation of wind turbine noise with respect to a range of wind speeds and directions. Standardisation of measurement procedures will also facilitate comparisons between different wind turbines.

The procedures present methodologies that will enable the noise emissions of a single wind turbine to be characterised in a consistent and accurate manner. These procedures include the following:

- location of acoustic measurement positions;
- requirements for the acquisition of acoustic, meteorological, and associated wind turbine operational data;
- analysis of the data obtained and the content for the data report; and
- definition of specific acoustic emission parameters, and associated descriptors which are used for making environmental assessments.

The standard is not restricted to wind turbines of a particular size or type. The procedures described in this standard allow for the thorough description of the noise emission from a wind turbine. If, in some cases, less comprehensive measurements are needed, such measurements are made according to the relevant parts of this standard.

2 Normative references

The following referenced documents are indispensable for the application 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 60386:1972, *Method of measurement of speed fluctuations in sound recording and reproducing equipment*

IEC 60651:1979, *Sound level meters*

IEC 60688:1992, *Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals*

IEC 60804:2000, *Integrating-averaging sound level meters*

IEC 60942:1997, *Electroacoustics – Sound calibrators*

IEC 61260:1995, *Electroacoustics – Octave-band and fractional-octave-band filters*

IEC 61400-12:1998, *Wind turbine generator systems – Part 12: Wind turbine power performance testing*