

# INTERNATIONAL STANDARD

# IEC 61400-11

Second edition  
2002-12

---

---

## Wind turbine generator systems –

### Part 11: Acoustic noise measurement techniques

*Aérogénérateurs –*

*Partie 11:  
Techniques de mesure du bruit acoustique*

© IEC 2002 — Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: [inmail@iec.ch](mailto:inmail@iec.ch) Web: [www.iec.ch](http://www.iec.ch)



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

PRICE CODE

X

*For price, see current catalogue*

## CONTENTS

FOREWORD .....	4
INTRODUCTION .....	5
1 Scope .....	6
2 Normative references.....	6
3 Definitions .....	7
4 Symbols and units .....	8
5 Outline of method .....	9
6 Instrumentation.....	10
6.1 Acoustic instruments.....	10
6.2 Non-acoustic Instruments .....	11
6.3 Traceable calibration .....	12
7 Measurements and measurement procedures.....	12
7.1 Measurement positions.....	12
7.2 Acoustic measurements.....	13
7.3 Non-acoustic measurements.....	15
8 Data reduction procedures.....	17
8.1 Wind speed .....	17
8.2 Correction for background noise.....	18
8.3 Apparent sound power levels.....	18
8.4 One-third octave band levels .....	19
8.5 Tonality .....	19
8.6 Directivity (optional).....	22
9 Information to be reported.....	23
9.1 Characterisation of the wind turbine.....	23
9.2 Physical environment.....	24
9.3 Instrumentation.....	24
9.4 Acoustic data.....	24
9.5 Non-acoustic data.....	25
9.6 Uncertainty .....	25
Annex A (informative) Other possible characteristics of wind turbine noise emission and their quantification.....	35
Annex B (informative) Criteria for recording/playback equipment.....	37
Annex C (Informative) Assessment of turbulence intensity .....	39
Annex D (informative) Assessment of measurement uncertainty.....	40
Bibliography.....	43
Figure 1 – Mounting of the microphone .....	26
Figure 2 – Picture of microphone and board.....	27
Figure 3 – Standard pattern for microphone measurement positions (plan view).....	28
Figure 4 – Illustration of the definitions of $R_0$ and slant distance $R_1$ .....	29

Figure 5 – Allowable region for meteorological mast position as a function of $\beta$ – plan view.....	30
Figure 6 – Allowable range for anemometer height – cross section .....	31
Figure 7 – Workflow chart for tonality procedure .....	32
Figure 8 – Illustration of $L_{70\%}$ level in the critical band .....	33
Figure 9 – Illustration of lines below the $L_{70\%} + 6\text{dB}$ criterion .....	33
Figure 10 – Illustration of $L_{\text{pn,avg}}$ level and lines classified as masking.....	34
Figure 11 – Illustration of classifying all spectral lines .....	34
Figure B.1 – Tolerances for frequency characteristic, IEC 60651 type 1 .....	37
Table 1 – Roughness length .....	18
Table 2 – Frequency resolution .....	19
Table D.1 – Examples of possible values of type B uncertainty components relevant for apparent sound power level .....	41

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### WIND TURBINE GENERATOR SYSTEMS –

### Part 11: Acoustic noise measurement techniques

#### FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The 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 turbine systems.

This second edition of IEC 61400-11 cancels and replaces the first edition published in 1998 and constitutes a technical revision.

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

FDIS	Report on voting
88/166/FDIS	88/171/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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

## 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.

## 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*