IEC 61265

Edition 2.0 2018-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electroacoustics – Instruments for measurement of aircraft noise – Performance requirements for systems to measure sound pressure levels in noise certification of aircraft

Électroacoustique – Instruments pour la mesure du bruit des aéronefs – Exigences relatives aux systèmes de mesure des niveaux de pression acoustique pour la certification acoustique des aéronefs

IEC 61265:2018-05(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 21 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC 61265

Edition 2.0 2018-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electroacoustics – Instruments for measurement of aircraft noise – Performance requirements for systems to measure sound pressure levels in noise certification of aircraft

Électroacoustique – Instruments pour la mesure du bruit des aéronefs – Exigences relatives aux systèmes de mesure des niveaux de pression acoustique pour la certification acoustique des aéronefs

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 17.140.50; 49.020

ISBN 978-2-8322-5695-4

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ELECTROACOUSTICS – INSTRUMENTS FOR MEASUREMENT OF AIRCRAFT NOISE – PERFORMANCE REQUIREMENTS FOR SYSTEMS TO MEASURE SOUND PRESSURE LEVELS IN NOISE CERTIFICATION OF AIRCRAFT

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 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 61265 has been prepared by IEC technical committee 29: Electroacoustics.

This second edition cancels and replaces the first edition published in 1995. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) addition of guidance for measurements for aircraft other than large transport aeroplanes;
b) addition of microphones used in ground plane measurement systems;
c) addition of weighted sound level measurements other than one-third-octave band measurements, for certain aircraft types;
d) revision and clarification of requirements for digital audio recording;

e) addition of requirements for evaluation of measurement uncertainty.

The text of this International Standard is based on the following documents:

CDV	Report on voting
29/958/CDV	29/980A/RVC

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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

IEC 61265 provides requirements for the electroacoustical performance of instruments for measurement of the sound produced by aircraft in flight or on the ground, or by an aircraft engine installed on an outdoor test stand, for the purposes of demonstrating compliance with aircraft noise certification limits established by relevant national aviation authorities and for other comparisons among aircraft models. The instruments can be components of a complete measurement system. Methods are also indicated by which the performance of such instruments can be tested periodically.

Measurement and data-analysis procedures for aircraft noise certification are described in Volume I of Annex 16 to the Convention on International Civil Aviation, with further guidance and descriptions of acceptable "equivalent procedures" given in the *Environmental Technical Manual* prepared by the Committee on Aviation Environmental Protection (CAEP) of the International Civil Aviation Organization (ICAO). Together these documents are referred to in this document as "ICAO Annex 16". The procedures include measurement and analysis of the sound from aircraft in operation, and, in some circumstances, of the sound from static engines and engines under test, under given operating and atmospheric conditions.

Several of the requirements given in this document differ from the requirements of IEC 61672-1 for sound level meters, especially concerning the frequency and directional response, linear operating range and sensitivity to various environments. Many of these differences are due to the requirement for uniform response at a wide range of angles of sound arrival as an aircraft moves through the certification test flight. If the output signal from a measurement system conforming to this document is processed to yield an overall sound pressure level from all frequency bands, the level derived can differ from that obtained from a sound level meter conforming to IEC 61672-1.

Systems in accordance with this document are used to perform measurements meeting the requirements of ICAO Annex 16 or a certifying authority's specific procedures to demonstrate that a given aircraft complies with the limits for noise level near the ground over the course of a test flight. Uncertainty of each measurement is considered when establishing the test procedures, and it is not the intent of this document to duplicate the confidence interval analysis inherent in the noise flight test procedure.

ELECTROACOUSTICS – INSTRUMENTS FOR MEASUREMENT OF AIRCRAFT NOISE – PERFORMANCE REQUIREMENTS FOR SYSTEMS TO MEASURE SOUND PRESSURE LEVELS IN NOISE CERTIFICATION OF AIRCRAFT

1 Scope

This document specifies requirements for the electroacoustical performance of systems of instruments used to measure sound for the purposes of aircraft noise certification, and for other comparisons among aircraft models, and provides methods by which tests can be made periodically to verify that the performance continues to conform to the requirements within stated limits.

In general, a sound measurement system for this purpose comprises a combination of instruments extending from a microphone, including its windscreen and other accessories, through data recording and processing devices to a suitable output. Different measurement systems, regardless of their composition, perform the necessary functions in different ways and operate on either analogue or digital principles.

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 60942, *Electroacoustics – Sound calibrators*

IEC 61260-1, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
calibration record
time-pressure history or recorded value obtained during a calibration procedure, consisting of a measurement system output while its acoustic input is provided by a sound calibrator

3.2
effective perceived noise level
EPNL
EPNdB
single number evaluator of the subjective effects of aircraft noise on human beings, expressed in decibels (EPNdB) as described in ICAO Annex 16, Appendix I

Note 1 to entry: This note applies to the French language only.

3.3
floating-range measurement system
measurement system incorporating automatic level range switching

3.4
free-field microphone
microphone having substantially uniform frequency response to plane progressive sound waves arriving at angles substantially normal to the plane of the microphone diaphragm

3.5
free-field sensitivity
<microphone system> quotient of the root-mean-square voltage at the output of a microphone system by the root-mean-square sound pressure that would exist at the position of the microphone in the absence of the microphone, for a sinusoidal plane progressive sound wave of specified frequency, at a specified sound-incidence angle

Note 1 to entry: The free-field sensitivity is expressed in volts per pascal.

3.6
free-field sensitivity level
<microphone system> twenty times the logarithm to the base ten of the ratio of the free-field sensitivity to the reference sensitivity of one volt per pascal

Note 1 to entry: The free-field sensitivity level is expressed in decibels.

Note 2 to entry: The free-field sensitivity level can be determined by subtracting the sound pressure level (re 20 µPa expressed in dB) of the sound incident on the microphone from the voltage level (re 1 V expressed in dB) at the output of the microphone system, and adding 93,98 dB to the result.

3.7
grazing incidence
condition where sound from the source of interest impinges on the microphone primarily at an incidence angle parallel to the plane of the microphone diaphragm

3.8
L_{ASmax}
maximum value obtained during a given time period or event of A-frequency-weighted, S-time-weighted sound pressure level

3.9
L_{AE}
sound exposure level (SEL) of the time integral of squared A-weighted sound pressure over a given time period or event, with reference to the square of the reference sound pressure of 20 µPa, and a reference duration of one second, as provided by an integrating sound level meter in accordance with ICAO Annex 16, Appendix 4

Note 1 to entry: L_{AE} is expressed in decibels.

EXAMPLE L_{AE} is the sound energy of an acoustic event lasting one second that is equal to the sound energy of the measured event over the time interval that the A-weighted sound pressure level is within 10 dB of its maximum value. It is typically 7 dB to 12 dB higher than the L_{Amax} during the same interval.

3.10
level difference
measured one-third-octave band output signal level on any level range, adjusted for the difference between the settings of the level range controls on the level range and the reference level range, minus the level of the corresponding electrical input signal

Note 1 to entry: The level difference is expressed in decibels.

3.11
level non-linearity
level difference on any level range, at a selected one-third-octave mid-band frequency, minus the reference level difference, all input and output signals being relative to the same reference quantity

Note 1 to entry: The level non-linearity is expressed in decibels.

3.12
level range
setting of the controls provided in a measurement system for the recording and level measurement or spectral analysis of a sound pressure input signal

Note 1 to entry: The level range is expressed in decibels.

3.13
linear operating range
range of levels of steady sinusoidal electrical signals applied to the input of a measurement system exclusive of the microphone system, extending from a lower boundary to an upper boundary, over which the level non-linearity is within limits specified in 5.6.2

Note 1 to entry: The linear operating range applies to a stated level range and is expressed in decibels.

3.14
measurement system
combination of instruments used for the measurement of sound pressure levels, including a sound calibrator, microphone system, signal recording and conditioning devices, and one third octave band spectrum analysis or A-frequency-weighted, S-time-weighted sound level measurement as required for the aircraft type being evaluated

Note 1 to entry: The measurement system covered by this document does not include analysis means for computing metrics such as EPNL (EPNdB) or SEL (L_{AE}).

Note 2 to entry: Practical installations can include a number of microphone systems, the outputs from which are recorded simultaneously by a multi-channel recording device. The signal recording and conditioning devices and/or the spectrum analysis system can have separate channels in parallel, again with facilities for selection, either of the input or of the output. For the purposes of this document, each combination of a single microphone system and a single data-recording and data-analysis channel within the other instruments comprises a separate, complete measurement system, and the requirements apply accordingly.

3.15
microphone
electroacoustic transducer converting audio-frequency air pressure variations to AC voltage

Note 1 to entry: Microphones used for aircraft noise certification are typically of the electrostatic or "condenser" type which have an output impedance requiring a preamplifier to be located adjacent to the microphone rather than in external equipment connected to the microphone by a cable.

3.16
microphone system
components of the measurement system which produce an electrical output signal in response to a sound pressure input signal, and which generally include a microphone, a preamplifier, power supply, extension cables, and other devices as necessary

3.17
pressure sensitivity
<microphone system> quotient of the root-mean-square voltage at the output of a microphone system by the root-mean-square sound pressure, for sinusoidal sound pressure of specified frequency at the microphone diaphragm

Note 1 to entry: The pressure sensitivity is expressed in volts per pascal.

3.18
pressure sensitivity level
<microphone system> twenty times the logarithm to the base ten of the ratio of the pressure sensitivity to the reference sensitivity of one volt per pascal

Note 1 to entry: The pressure sensitivity level is expressed in decibels.

3.19
pressure type microphone
microphone having substantially uniform frequency response to sound pressure at the microphone diaphragm

Note 1 to entry: For frequencies whose wavelength is long compared to the diameter of the microphone diaphragm, pressure type microphones typically have uniform frequency response to plane progressive waves arriving at angles substantially in the plane of the microphone diaphragm, which is also described as grazing incidence.

3.20
principal axis
line through the centre of and perpendicular to the diaphragm of the microphone

3.21
reference flight path
intended path through space of the aircraft being tested, as defined by the relevant certification test protocol

3.22
reference frequency
specified frequency of the sinusoidal sound pressure signal produced by the sound calibrator

Note 1 to entry: The reference frequency is expressed in hertz.

3.23
reference level difference
level difference on the reference level range for a reference electrical input signal corresponding to the reference sound pressure level

Note 1 to entry: The reference level difference is expressed in decibels.

3.24
reference level range
level range for verifying the acoustical sensitivity of the measurement system, and containing the reference sound pressure level

Note 1 to entry: The reference level range is expressed in decibels.

3.25
reference sound pressure level
sound pressure level produced, under reference environmental conditions, in the cavity of the coupler of the sound calibrator that is used to verify the overall acoustical sensitivity of a measurement system

Note 1 to entry: The reference sound pressure level is expressed in decibels.

3.26
sound-incidence angle
angle between the principal axis of the microphone and a line from the sound source to the centre of the diaphragm of the microphone

Note 1 to entry: When the sound incidence angle is 0°, the sound is said to be received at the microphone at "normal incidence"; when the sound incidence angle is 90°, the sound is said to be received at "grazing incidence".

Note 2 to entry: The sound-incidence angle is expressed in degrees.

4 Purpose

The purpose of this document is to ensure that different measurement systems used for aircraft noise certification have the same electroacoustical characteristics within stated acceptance limits under specified reference environmental conditions. This document does not provide recommendations for installation of microphones or microphone windscreens, nor requirements for measurement and analysis procedures used in aircraft noise certification, but gives only the performance specifications for the measurement systems used to provide sound pressure levels over specific frequency ranges and weightings, averaged over a period of time.

Certain of the requirements apply to the complete measurement system, including any means of recording a time waveform of the sound pressure signal to be measured prior to analysis. Other requirements apply specifically to the microphone, which generates an electrical signal in response to the sound pressure received. Still further requirements apply only to the instruments used to operate on that signal in order to provide an output in the form of one-third-octave-band or weighted sound pressure levels.

The requirements of this document can be applied to the instruments used to measure the sound produced by each category of aircraft covered by certification protocols such as [1][1] (see Table 1). Three different measurement protocols are mentioned in [1] This document does not provide measurement recommendations for aircraft subject to certification requirements earlier than those in effect at the time of its publication.

Table 1 – ICAO measurement protocols (informative)

ICAO Annex 16 chapter	Aircraft category and mass	Microphone configuration	Noise metric	ICAO Annex 16 Appendix
3, 4 or 14	Subsonic jet, and propeller aircraft > 8 618 kg	Grazing incidence	EPNdB	2
8	Helicopters	Grazing incidence	EPNdB	2
10	Propeller aircraft ≤ 8 618 kg	Ground plane	L_{ASmax}	6
11	Helicopters ≤ 3 175 kg	Grazing incidence	L_{AE}	4
13	Tiltrotors	Grazing incidence	EPNdB	2

1 Numbers in square brackets refer to the Bibliography.

5 Requirements

5.1 General

5.1.1 Output data

The measurement system shall provide time-indexed one-third-octave-band or A-weighted sound level measurement values as appropriate for the analysis method specified.

For measurements to be used to calculate values in effective perceived noise level (EPNL), the measurement system shall provide time-average one-third-octave-band sound pressure levels covering at least the range of mid-band frequencies from 50 Hz to 10 kHz.

For L_{AE} or L_{ASmax} measurements, the measurement system shall provide either one-third-octave levels, or A-weighted sound pressure levels as provided by instruments conforming to IEC 61672-1. One-third-octave measurements can be converted to the required L_{AE} or L_{ASmax} values in subsequent data-analysis procedures not covered by this document.

5.1.2 Time-pressure history

The measurement system may record the unmodified time-pressure history at the microphone, allowing the original waveform to be reproduced at any time for subsequent processing and analysis, instead of storing the results immediately in one-third-octave or A-weighted values. Some certification requirements specify mandatory recording of time-pressure history along with integrated values. Even when such recording is not required, it is strongly recommended. When time-pressure history is recorded, it shall be an uncompressed, time indexed pulse-code modulation waveform file, along with recordings of calibration events, so that the measurement can be reconstructed in the future to accommodate other weighting or analysis protocols.

5.1.3 Measurements of sound from aircraft ground power units

Measurements of sound levels from aircraft ground power units shall be made with sound level meters in accordance with IEC 61672-1, with particular attention to calibration and the potential influence of the sound scattering properties of the user holding the sound level meter, if present.

5.1.4 Measurements of aircraft operations on the ground

Noise from aircraft operations on the ground, including testing of aircraft engines, is typically measured using grazing incidence microphone systems (see 5.5 for additional provisions) with the principal axis of the microphone oriented vertically, and evaluated using perceived noise level (PNL) or A-weighted sound pressure level (L_{ASmax}) to approximate human perception. Free-field microphones as typically provided with sound level meters may also be used, provided that the angle of sound arrival is within the angles for which free-field sensitivity is within the acceptance limits of 5.5.2.2.

5.2 Measurement uncertainty

5.2.1 Relationship with regulatory requirements

Measurements of acoustic emission for aircraft certification are made in accordance with regulatory requirements of ICAO Annex 16 or national certifying authorities, which establish a noise limit for particular aircraft. Certifying authorities can require documentation of measurement uncertainty to establish confidence that the noise measurement system complies with this document. See Annex B for a discussion of the principles used in establishing measurement uncertainty.

5.2.2 Performance verification

Each component of the system shall be calibrated, with traceability to relevant standards, including any accessories such as preamplifiers used in the measurement. Passive electrical accessories such as cables and connectors need not be included in the analysis. A description of the calibration procedure shall include each step used to derive free-field sensitivity in the directions over which measurements are made. The calibration record should include an analysis of the error margin or uncertainty expected based on manufacturers' data and the uncertainty of the calibrations employed, to a coverage level of 95 %.

5.2.3 Periodic tests

Methods for periodic tests of the electroacoustical performance of a measurement system giving results suitable for comparison with the requirements of this document are described in Annex A. The results of any such tests shall be adjusted to correspond to reference environmental conditions (see 5.3 for additional provisions).

5.3 Reference environmental conditions

Reference environmental conditions for specifying the performance of a measurement system are:

- air temperature 23 °C;
- static air pressure 101,325 kPa;
- relative humidity 50 %.

5.4 Sound calibrator

A sound calibrator compliant with at least the Class 1 or Class 1/C requirements of IEC 60942 shall be used to check the overall acoustical sensitivity of the measurement system. The reference sound pressure level produced in the cavity of the coupler of the sound calibrator shall be calculated for the reference environmental conditions of 5.3, using manufacturer-supplied information on the influence of atmospheric air pressure and temperature if required.

National aircraft certification authorities can permit the use of calibrators meeting lower accuracy requirements, if the additional uncertainty is stated.

5.5 Microphone system

5.5.1 Pressure and free-field type microphones

Microphones used for measurements in accordance with this document are omnidirectional pressure transducers, responding to an instantaneous difference between the incident pressure from the sound field and that of an internal volume of air which is coupled to the sound field through a long acoustic time constant. Microphones are typically referred to as "pressure type" when their transfer function is linear with respect to frequency for sound pressure at the diaphragm, or "free-field type" when the transfer function is linear with respect to frequency for an incident plane progressive wave, which is typically found in "free-field" conditions. Either pressure type or free-field type microphones can be found that meet the performance requirements of 5.5.2 and 5.5.3.

Microphones used in grazing incidence and ground plane microphone configuration are typically referred to as "pressure type" microphones, with substantially uniform frequency response to sound pressure integrated over the diaphragm surface.

Pressure type microphones have substantially uniform free-field sensitivity for distant sound arriving at 90° to the principal axis, and exhibit increased sensitivity at high frequencies for angles closer to normal incidence. Aircraft noise certification standards are based on these characteristics, so that corrections are not required for sound incidence angles within ± 30° of