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Acoustics — Unattended monitoring of aircraft sound in the vicinity of airports

Acoustique — Surveillance automatique du bruit des aéronefs au voisinage des aéroports

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20906 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Introduction

This International Standard specifies requirements for reliable measurements of aircraft sound.

This International Standard describes a threshold system of sound event recognition in a complex sound situation with multiple aircraft and other sound sources. A much more complex and sophisticated system may be needed to separate the aircraft sound events from each other and from other sound sources. Such methods — which may include radar location of sources, the addition of flight information systems, directional microphones, and other methods such as distribution of specific and residual sound or pattern recognition — are not described in this International Standard.

For political reasons, it is often necessary to install sound monitors in acoustically unsuitable places. For these situations, the operator of the sound-monitoring system should be aware of a potentially substantial increase of uncertainty in the results, as discussed in Annex B. In extreme situations, the uncertainty may become so large as to make an aircraft sound measurement meaningless.

Sound monitors installed in areas with usually low aircraft sound may be deployed to document noise levels where potential future airport operations might be considered: such sound monitors have to show that there is normally only low aircraft sound and hence no measured aircraft sound events — except in the case of extraordinary circumstances when an aircraft flies close to the sound monitor. Such sound monitors may be politically necessary.

Acoustics — Unattended monitoring of aircraft sound in the vicinity of airports

1 Scope

This International Standard specifies:

a) the typical application for a permanently installed sound-monitoring system around an airport;

b) performance specifications for instruments, and requirements for their unattended installation and operation, so as to determine continuously monitored sound pressure levels of aircraft sound at selected locations;

c) requirements for monitoring the sound of aircraft operations from an airport;

d) requirements for the quantities to be determined to describe the sound of aircraft operations;

e) requirements for data to be reported and frequency of publication of reports;

f) a procedure for determining the expanded uncertainty of the reported data in accordance with ISO/IEC Guide 98-3.

This International Standard does not provide

— a method for confirming or validating predicted sound contours;

— a method for determining, validating or confirming aircraft noise certification data;

— a method for describing the sound generated by aircraft while on the ground (including ground movements and the use of auxiliary power units), except while on the runway after start of roll for departures and between touchdown and leaving the runway for arrivals.

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.

ISO 1996-1, *Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 80000-8, *Quantities and units — Part 8: Acoustics*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement* (*GUM: 1995*)

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61672-1:2002, *Electroacoustics — Sound level meters — Part 1: Specifications*

IEC 61672-3, *Electroacoustics — Sound level meters — Part 3: Periodic tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 80000-8, IEC 61672-1 and the following apply.

3.1
aircraft operation
⟨acoustics⟩ movement (apart from taxiing) of an aircraft over or near to a sound monitor that can result in detection of the sound as an aircraft sound event

3.1.1
departure
⟨aircraft acoustics⟩ movement of an aircraft from the start of roll on take-off or from the moment when the sound can be distinguished above the residual sound (whichever is the last to occur) to when the sound becomes indistinguishable above the residual sound

3.1.2
approach
⟨aircraft acoustics⟩ movement of an aircraft from when the sound can be distinguished above the residual sound to the exit from the runway after landing or to the moment when the sound becomes indistinguishable above the residual sound (whichever is the first to occur)

3.2
sound monitor
⟨acoustics⟩ instruments and sound measuring equipment installed at a specified site for automatic and continuous measurements of the sound produced by aircraft flying over or near the microphone

3.3
sound-monitoring system
entire automatic continuously operating system deployed in the vicinity of an airport, including all sound monitors, the central station and all software and hardware involved in its operation

3.4
equivalent continuous sound pressure level
time-averaged sound pressure level
$L_{p,\mathrm{eq},T}$
ten times the logarithm to the base 10 of the ratio of the time average of the square of the sound pressure, p, during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0, expressed in decibels

$$L_{p,\mathrm{eq},T} = 10\lg\left[\frac{\frac{1}{T}\int_{t_1}^{t_2} p^2(t)\,\mathrm{d}t}{p_0^2}\right]\ \mathrm{dB} \qquad (1)$$

where the reference value, p_0, is 20 µPa

NOTE 1 Because of practical limitations of the measuring instruments, p^2 is always understood to denote the square of a frequency-weighted and frequency-band-limited sound pressure. If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts, e.g. $L_{p,\mathrm{A,oct,10\ s}}$ denotes the A-weighted time-averaged octave-band sound pressure level over 10 s.

NOTE 2 $L_{p,\mathrm{eq},T}$ can be interpreted as the sound pressure level of a stable and permanent sound that has the same average energy as the sound under study.

NOTE 3 Adapted from ISO/TR 25417:2007 [1], 2.3.

NOTE 4 $L_{p,\mathrm{eq},T}$ is mostly used in the following two applications: a) a series of $L_{p,\mathrm{eq},T}$, each averaged over a short time interval (typically 1 s, then called "one second equivalent continuous sound pressure level, $L_{p,\mathrm{eq,1\ s}}$", often abbreviated as "short L_{eq} ") to describe the level-time history of time-varying sound, and b) single $L_{p,\mathrm{eq},T}$, averaged over long times (e.g. 1 h or longer) to describe the overall (average) sound situation.

3.5
maximum one second equivalent continuous sound pressure level
$L_{p,\mathrm{eq,1\ s,max},T}$
maximum of the equivalent continuous sound pressure level averaged over the time interval of 1 s within a stated time interval T

3.6
AS-weighted sound pressure level
$L_{p,\mathrm{AS}}(t)$
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p, to the square of a reference value, p_0, expressed in decibels and measured with the frequency weighting A and time weighting S (slow) where the reference value, p_0, is 20 µPa

NOTE 1 For details see IEC 61672-1.

NOTE 2 Adapted from ISO/TR 25417:2007 [1], 2.2.

3.7
maximum AS-weighted sound pressure level
$L_{p,\mathrm{AS,max}}$
maximum of the AS-weighted sound pressure level within a stated time interval

3.8
N % exceedance level
N per cent exceedance level
$L_{p,\mathrm{AS},N,T}$
AS-weighted sound pressure level that is exceeded for N % of the time interval, T, considered

EXAMPLE $L_{p,\mathrm{AS,95,1\ h}}$ is the AS-weighted sound pressure level exceeded for 95 % of 1 h.

NOTE Adapted from ISO 1996-1:2003, 3.1.3.

3.9
aircraft sound event
data set of acoustical descriptors adequately describing a sound event produced by a single aircraft operation

NOTE Depending on the context, the words, "aircraft event" and "single event" mean an aircraft sound event.

3.10
threshold level
$L_{\mathrm{threshold}}$
any suitable user-defined sound pressure level used to optimize reliable event detection

NOTE This threshold level is different from the term to be used for calculating the exposure level.

3.11
sound exposure
E_T
integral of the square of the sound pressure, p, over a stated time interval or event of duration T (starting at t_1 and ending at t_2)

$$E_T = \int_{t_1}^{t_2} p^2(t)\,\mathrm{d}t \tag{2}$$

NOTE 1 The sound exposure is expressed in pascal squared seconds.

NOTE 2 Because of practical limitations of the measuring instruments, p^2 is always understood to denote the square of a frequency-weighted and frequency-band-limited sound pressure. If a specific frequency weighting as specified in IEC 61672-1 is applied, this is indicated by an appropriate subscript, e.g. $E_{\mathrm{A,1\,h}}$ denotes the A-weighted sound exposure over 1 h.

NOTE 3 When applied to a single event, the quantity is called “single event sound exposure” and the symbol E is used without subscript.

[ISO/TR 25417:2007 [1], 2.6]

3.12
sound exposure level
$L_{E,T}$
ten times the logarithm to the base 10 of the ratio of the sound exposure, E_T, to a reference value, E_0, expressed in decibels

$$L_{E,T} = 10 \lg \frac{E_T}{E_0}\ \mathrm{dB} \tag{3}$$

where the reference value, E_0, is $(20\ \mu\mathrm{Pa})^2\ \mathrm{s} = 4 \times 10^{-10}\ \mathrm{Pa}^2\ \mathrm{s}$

NOTE 1 If a specific frequency weighting as specified in IEC 61672-1 is applied, this is indicated by appropriate subscripts, e.g. $L_{E,\mathrm{A,1\,h}}$ denotes the A-weighted sound exposure level over 1 h.

NOTE 2 When applied to a single event, the quantity is called “single event sound exposure level” and the symbol L_E is used without further subscript.

[ISO/TR 25417:2007 [1], 2.7]

3.13 Sound designations

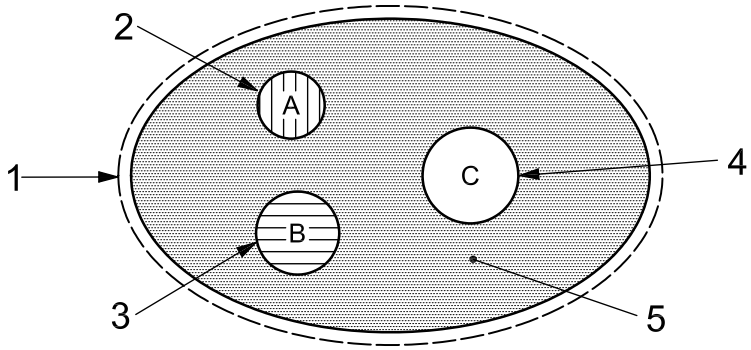
See Figure 1.

3.13.1
total sound
totally encompassing sound in a given situation at a given position and at a given time, usually composed of sound from many sources near and far

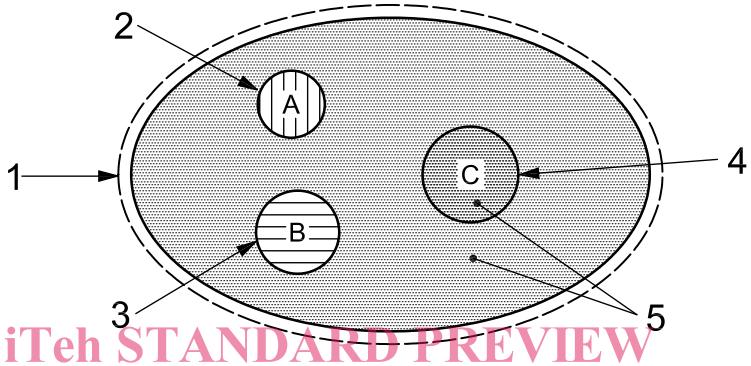
NOTE Adapted from ISO 1996-1:2003, 3.4.1.

3.13.2
specific sound
component of the total sound that can be specifically identified and which is associated with a specific source

[ISO 1996-1:2003, 3.4.2]



a) Three specific sounds under consideration, the residual sound and the total sound



b) Two specific sounds A and B under consideration, the residual sound and the total sound

Key

1 total sound
2 specific sound A
3 specific sound B
4 specific sound C
5 residual sound

NOTE 1 The lowest residual level is obtained when all specific sounds are suppressed.

NOTE 2 In a) the dotted area (5) indicates the residual sound when sounds A, B and C are suppressed.

NOTE 3 In b) the residual sound includes the specific sound C since it is not under consideration.

NOTE 4 Conceptually these specific sounds can be quite different from each other and distinct from the residual. In practice, however, it is often difficult to completely separate and measure one specific sound without any of the other specific sounds or any of the residual included, and, similarly, it is often difficult to measure the residual sound without any specific sounds included.

Figure 1 — Total, specific and residual sound designations

3.13.3
residual sound
total sound remaining at a given position in a given situation when the specific sounds under consideration are suppressed

[ISO 1996-1:2003, 3.4.3]

3.13.4
background sound
$L_{p,\mathrm{AS},\mathrm{res},T}$
indicator of residual sound

NOTE 1 Background sound may be estimated by the 95 % exceedance level of total sound ($L_{p,\mathrm{AS},95}$) (see 4.3.3).

NOTE 2 Some countries use $L_{p,\mathrm{AS},90}$ or $L_{p,\mathrm{AS},99}$ instead of $L_{p,\mathrm{AS},95}$ as the indicator of background sound.

3.14 Terms used for data processing

See Figure 2.

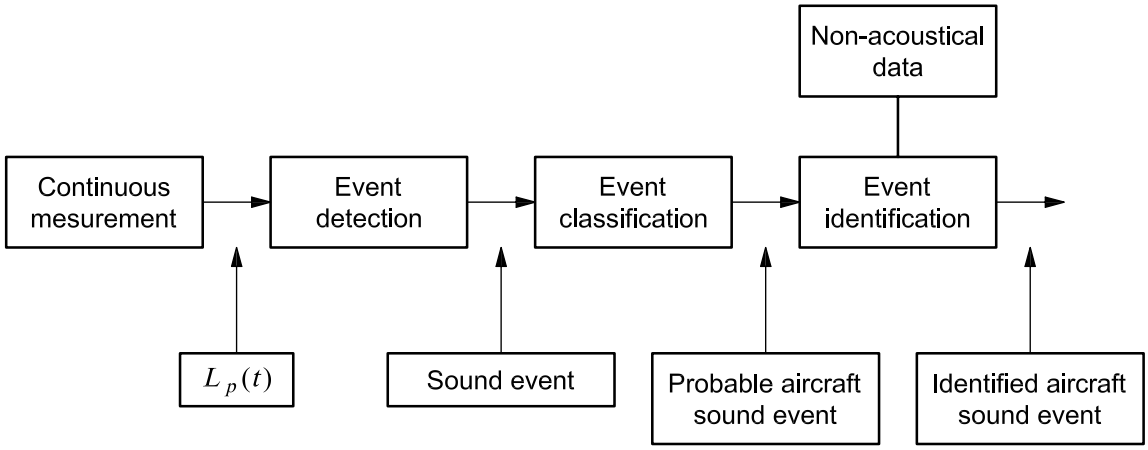


Figure 2 — Terms used for data processing

3.14.1
continuous sound measurement
uninterrupted measurement of a sound level meter (or equivalent instrument)

NOTE This measurement provides the continuous time-varying sound pressure level, $L_p(t)$.

3.14.2
event detection
extraction of discrete sound events based on acoustical criteria

3.14.3
sound event
data set containing at least the sound exposure level, the maximum sound pressure level, the duration of the event, and a time stamp

NOTE 1 To allow proper classification, the event can contain much more additional information.

NOTE 2 For the maximum short term equivalent continuous sound pressure level, see 3.5.

3.14.4
event classification
classification of sound events based primarily on acoustical knowledge

NOTE 1 Sound events can be classified into “aircraft sound events” or a “non-aircraft sound events”.

NOTE 2 Depending on the implementation, event detection and event classification can be combined in one stage.

3.14.5
non-acoustical data
〈acoustics〉 additional information on aircraft movements

EXAMPLE Operational information from the airport or information from systems that report aircraft position.

3.14.6
event identification
procedure for use of non-acoustical data to confirm the probable relationship of a sound event to a specific aircraft operation

3.14.7
identified aircraft sound event
aircraft sound event that is positively related to a specific aircraft operation

NOTE The data set of the identified aircraft sound event can include operational information like aircraft type, runway, and route.

4 Data acquisition

4.1 Instruments and equipment

4.1.1 General

For monitoring of aircraft sound, each measurement channel of the complete automated sound monitor, arranged as for normal use, shall conform to the electroacoustical performance specifications of IEC 61672-1 for a class 1 sound level meter. The sound monitor shall provide measurements of A-weighted measurement quantities. The frequency weighting shall conform to the specifications for response to plane progressive sound waves incident on the microphone from a reference direction representing normal (i.e. 0°) incidence on to the diaphragm of a microphone. This choice of reference direction shall be stated in the instruction manual provided by the manufacturer or supplier of the sound monitor.

For the purposes of this International Standard, a display need not be available at the sound monitor, but may take the form of a printed copy or other display method at the central station or elsewhere.

NOTE 1 For the additional requirement on extended temperature range, see 4.9.2, and for requirements concerning the instruction manual, see Clause 8.

NOTE 2 Optional one-third-octave band spectral sound measurements can be obtained.

4.1.2 Microphone assembly

The entire microphone assembly as used in normal operation (e.g. microphone, preamplifier, rain protection, windscreen, microphone device support, anti-bird devices, lightning conductor, and any calibration device) shall fulfil the following requirements: the lightning conductor shall be at least 0,5 m from the microphone; all other devices (e.g. anemometer) shall be at least 1 m below the microphone and at least 1,5 m horizontally distant from the microphone support mast.

If for practical reasons this arrangement is not possible, then the effects on the measurement uncertainty shall be documented.

4.1.3 Microphone windscreen

For all sound measurements, a suitable windscreen shall be installed around each microphone; the windscreen and its mounting are considered, for the purposes of this International Standard, as part of the microphone. The microphone-windscreen assembly should be tested to determine the A-weighted sound pressure level indication caused by a steady wind incident on the microphone at the speed of 10 m/s with the sound monitor assembled as recommended by the manufacturer or supplier. The results of this test shall be stated in the instruction manual. The A-weighted one-minute equivalent continuous sound pressure level resulting from wind sound with a wind speed of 10 m/s shall not exceed 65 dB.

4.2 Microphone mounting

4.2.1 Sound-monitoring site selection

Sites for unattended measuring microphones shall be chosen to minimize the effect of residual sound (e.g. from non-aircraft sound sources).