International Standard 5129

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Acoustics — Measurement of noise inside aircraft

Acoustique — Mesurage du bruit à l'intérieur des aéronefs

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5129 was developed by Technical Committee ISO/TC 43, *Acoustics,* and was circulated to the member bodies in September 1976.

It has been approved by the member bodies of the following countries :

Australia	Israel	South Africa, Rep. of
Austria	Italy	Spain
Belgium	Japan	Sweden
Brazil	Korea, Rep. of	Switzerland
Czechoslovakia	Mexico	Turkey
Denmark	Netherlands	United Kingdom
France	New Zealand	USA
Germany, F.R.	Norway	USSR
Hungary	Philippines	
Ireland	Poland	

No member body expressed disapproval of the document.

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Acoustics — Measurement of noise inside aircraft

1 Scope and field of application

This International Standard specifies the instrumentation and procedures for obtaining reproducible and comparable measurements of the noise inside all kinds of aircraft.

The results may be used for example :

— to determine compliance with maximum noise goals or specification requirements;

— to assess the noise exposure for hearing conservation purposes (see ISO 1999);

— to assess the degree of speech interference.

NOTES

1 An aircraft is defined as any machine that can derive support in the atmosphere from the reaction of the air other than directly against the earth's surface.

2 The test procedures described in this International Standard are comparable with engineering methods as defined in ISO 2204.

3 Measurements on sources emitting noise of an impulsive character may require the use of an impulse sound level meter (see 4.4).

4 When repeating a measurement following this International Standard with the same aircraft under nominally the same conditions, differences of the order of ± 2 dB may be observed in the test results of the A-weighted sound pressure level measurements.

2 References

ISO 1999, *Acoustics — Assessment of occupational noise exposure for hearing conservation purposes.*

ISO 2204, *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings.*

IEC Publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

IEC Publication 651, *Sound level meters.*

3 Nature of tests

3.1 type tests : Measurements performed to prove that the aircraft delivered by the manufacturer is in accordance with noise specifications.

Any variations from the prescribed test conditions shall be reported.

3.2 monitoring tests : Measurements performed in order to check that the noise of the aircraft is still within prescribed limits, and that noticeable changes have not occurred since the delivery or between the individual units of a consignment of aircraft.

For monitoring tests, slight deviations from the test conditions may be tolerated, for example the number of microphone positions and flight conditions may be reduced, and octave band analysis may be made instead of 1/3-octave band analysis. Any deviations shall be described in the test report.

4 Measured quantities

4.1 All values reported of A-weighted sound pressure levels are to correspond to the time weighting "S" (see IEC Publication 651).

4.2 During type tests, the values to be reported are

— octave band or 1/3-octave band sound pressure levels in decibels (dB) covering at least the frequency range from 45 to 11 200 Hz. 1/3-octave band sound pressure levels are preferred (see note 2 in clause 5);

— A-weighted sound pressure levels, L_{pA}, expressed in decibels (dB).

4.3 During monitoring tests, the values reported are

— A-weighted sound pressure levels, L_{pA}, expressed in decibels (dB);

— octave band or 1/3-octave band sound pressure levels in decibels (dB), if requested, covering preferably the frequency range from 45 to 11 200 Hz (see note 2 in clause 5). Octave band sound pressure levels are generally sufficient.

4.4 If an impulse sound level meter meeting at least the requirements of a type 1 instrument according to IEC Publication 651 is used to measure impulsive noise, it is recommended to state additionally the values read with the frequency weighting "A" and the time weighting "I", designated as L_{pAI} and expressed in decibels (dB).

5 Measuring equipment

Measuring equipment shall meet the following requirements over the range from 45 to 11 200 Hz.

NOTES

1 The directivity of the microphone may influence the measurements; therefore, omnidirectional microphones shall be used. The type of microphone shall be stated in the report.

2 If it is to be supposed that considerable low frequency noise is present, for example, in helicopters, the frequency range covered by the measuring equipment should be extended down to at least 2 Hz and recording by frequency modulation should be used.

5.1 Sound level meter

The sound level meter shall at least meet the requirements of a type 1 instrument according to IEC Publication 651.

5.2 Filters

For the measurement of noise spectra, the filters shall comply with IEC Publication 225.

5.3 Other systems

If alternative measuring equipment is used, including for example a tape recorder and/or level recorder, the tolerances of the several sections of the measuring chain shall not exceed the tolerances of the relevant clauses of IEC Publication 651.

NOTE — Microphones should be vented for pressure equalization, if of condenser type, and shall have known ambient pressure and temperature coefficients.

The microphone-amplifier specifications shall be compatible with those of the microphone and tape recorder.

5.3.1 Recording systems, when used, shall meet the following additional requirements :

At standard recording level (i.e. 10 dB below the 3 % harmonic distortion level) the frequency response shall be flat within ± 1,5 dB; the difference in response between adjacent 1/3-octave bands shall not exceed 1,5 dB. The performance of the system shall be such that the background noise in any 1/3-octave band or octave band is at least 35 dB below the standard recording level.

Each reel of tape shall in addition carry a calibration signal at its beginning and end which may be a pure tone signal in the range from 250 to 1 000 Hz or a broad-band noise. Data obtained from the tape can only be considered reliable if the level difference between the two signals (in the corresponding 1/3-octave band filtered level if broad-band noise is used) is no more than 1 dB, and the mean value of the two signals should be used for calibration purposes.

NOTES

1 With sharply falling spectra, appropriate pre-emphasis/de-emphasis networks may be needed to provide this signal-to-noise ratio.

2 Tape heads should be thoroughly cleaned before every series of measurements.

3 If an acoustic calibrator is used, it should meet the requirements of 5.4.2, and the sine wave should be recorded on all tapes under conditions of constant ambient pressure so that effects of pressure on calibrator and microphone response are minimized.

4 The tape recorder should not be moved while recording is in progress, unless it has been established previously that such movements will not change the tape recorder characteristics. Care should be taken that the recording is not affected by vibrations. Battery-driven tape recorders should be checked at frequent intervals during a test to ensure good battery condition and tape speed.

5.3.2 Data reduction shall be performed using octave band filters or 1/3-octave band filters having the characteristics specified in IEC Publication 225.

The analysers shall in principle be such that the filter outputs are squared, averaged, converted to logarithmic form and read-out. The averaging period shall be at least 8 s.

The detector(s) shall operate over a minimum dynamic range of 50 dB, with amplitude response linear within ± 0,5 dB over the upper 40 dB range.

The resolution of the read-out system shall be equal to or better than 0,5 dB.

5.4 Calibration and checking of measuring equipment

5.4.1 At time intervals no longer than 1 year, the sound level meter shall be calibrated for compliance with IEC Publication 651.

5.4.2 In other systems, before and after each series of tests, or at least less than 6 months prior to the date of the measurements :

— a calibration of the microphone frequency response shall be performed with additional calibrations made when shock or damage is suspected, and

— the frequency response, as well as the compliance with the relevant clauses of IEC Publication 651, of the overall system shall be determined using an insert voltage technique, to include all signal conditioning pre-amplifiers, networks and the tape recorder, if any.

5.4.3 If recording systems are used, a frequency response tape shall be recorded for later calibration of the data reduction system. A recording of at least 20 s shall be made with a "shorted" input connection as a check on the system dynamic range and background noise.

NOTE — Care should be taken to ensure that each reel of tape has the same response and background noise as the calibration tape. Preferably, the reels used in a series of measurements should come from the same production batch.

5.4.4 At appropriate intervals, and at least immediately before and immediately after each day's work, the response of the overall electro-acoustical system shall be checked using an acoustic calibrator generating a known sound pressure level at a known frequency in the range 250 to 1 000 Hz. It is desirable that this frequency corresponds to a preferred octave band centre frequency. The output of the acoustic calibrator shall be known within 0,5 dB.

This calibration shall be made on the ground at ambient atmospheric pressure and a barometric correction applied if necessary. The corresponding in-flight calibration shall be corrected for cabin pressure by use of manufacturers' data.

5.5 Correction for inherent noise

For all measurements of the sound pressure level of the aircraft noise which are less than 10 dB above the electrical noise floor, corrections shall apply as follows :

Difference between the sound pressure levels of the noise inside the aircraft and the inherent noise of the measuring equipment	Correction to be applied to the reading of the noise inside the aircraft
dB	dB
> 10	0
6 to 9	−1
4 to 5	−2
3	−3

No results shall be reported if the difference is less than 3 dB.

6 Test conditions

6.1 Noise measurements shall be performed during straight and level cruise conditions corresponding to specified requirements.

Additional measurements may be made for special purposes under different flight conditions, especially for stabilized climb and descent.

NOTE — In cases where steady operating conditions represent only a small percentage of the service of the aircraft, as for example in the case of sporting, agricultural or military aircraft, several operating conditions should be chosen for measurement. When the purpose of the measurements is to determine noise exposure, measurements should be taken under all normal operating conditions for the aircraft.

6.2 Measurements shall not be made while the aircraft is flying through turbulence or precipitation.

7 Aircraft internal configuration

7.1 The interior of the aircraft shall be in a fully furnished condition. Seat back-rests shall be set as near to the upright position as possible.

Pressurization and air conditioning should be operating in a steady-state mode typical of normal operation. The noise survey shall be performed with all individual passenger air outlets closed.

NOTE — Levels of interior noise will vary when passenger air outlets are open due to the number of outlets open, the degree of opening of each outlet, the directional orientation of each outlet and the position of the outlet relative to the microphone.

The public address system shall not be operating.

7.2 In crew compartments, the positions of the crew's working positions shall be noted.

7.3 In passenger compartments, the number of people present during measurements should be kept to the minimum required to conduct the tests. No persons should be located where they significantly affect the sound field at the microphone positions, and in particular no persons should be seated or standing within 1 m of the microphone.

8 Microphone positions

The level of the noise inside an aircraft may vary considerably with location. Therefore, sufficient measurement positions shall be selected so that the distribution of the level of the noise in the aircraft is adequately represented.

Measurement positions shall include the positions of each member of the crew. In passenger compartments the noise environment should be measured over the whole compartment, including the working places of the cabin crew.

Both seated and standing positions shall be included, if appropriate.

The exact position of the measurement positions shall be indicated on a plan.

The microphone shall be no closer than 0,15 m to walls, upholstery, baggage, etc.

The microphone shall be oriented vertically upwards.

8.1 In crew compartments, measurements shall be made within 0,1 m of the side of typical ear position of each member of the crew, and within 0,1 m in front of the microphone of any crew conversation recording system.

NOTE — The word "crew" covers the pilot of single seat aircraft.

For sitting positions, the height of the microphone shall be taken 0,65 ± 0,05 m above the unoccupied seat level with the seat at its mean position.

For standing positions, the microphone shall be 1,65 ± 0,1 m from the floor.

8.2 In passenger compartments, measurements should be made near the typical head position of a seated passenger. The microphone shall be placed on the seat centreline at a distance of 0,15 ±0,02 m from the head-rest and 0,65 ± 0,05 m above the unoccupied seat level. Seat number, or distance from wall and fuselage station, should be noted for each measurement position. Distribution of the measurement positions in the passenger cabin will depend on the seating configuration.

NOTE — The microphone should be held either in a portable bracket attached to the seat back or on an arm of about 1 m length in order to minimize the shielding effects of an operator holding the microphone.

In the case of passengers in prone position, for example, in ambulance aircraft, the microphone shall be placed 0,2 ± 0,02 m above the middle of the unoccupied pillow.

8.3 In freight compartments, measurements should be made to evaluate the noise environment when animals are to be carried.

9 Data recording

9.1 With sound level meters, at each microphone position and for each test condition three readings of the average sound pressure level shall be taken over at least 5 s. The mean value of these readings shall be retained as the test result and shall be rounded to the nearest integral decibel.

For monitoring purposes, it is sufficient to perform one measurement.

With recording systems, at each microphone position and for each test condition a recording of the noise shall be made for at least twice the duration of data reduction averaging period (see 5.3.2).

NOTE — Care must be taken that spurious signals are not induced on the microphone output by vibration, electromagnetic pick-up or other spurious influences. It is practical to check for all such signals by capping the microphone to ensure that all non-acoustically generated signals which may be present are at least 10 dB below the acoustic signal obtained with the uncapped microphone under the same flight conditions. This cap should be reasonably heavy and rigid and should form a good seal around the microphone.

9.2 Whenever the level of the noise fluctuates (for example, when it contains beats) the value shall be averaged over at least a three-beat period.

Occasional extreme peaks should be disregarded unless these are periodic.

NOTE — Complete information about the time history of the signal may, for example, be determined with a level recorder set to a response characteristic approximating that of a sound level meter set at time weighting characteristic F. Specific numerical values describing this time history may be

- long time average mean (effective) value;
- maximum and minimum values.

9.3 The presence of easily audible pure tone components or noise of a distinctly impulsive character should be stated additionally in the test report.

9.4 Whenever recordings are being made, at least the following flight data shall be recorded from cockpit instruments :

a) pressure altitude;

b) Mach number and/or speed;

c) engine conditions;

d) external ambient air temperature;

e) cabin pressure differential and temperature where relevant;

f) cabin systems operating modes where relevant;

g) position of landing gear;

h) position of flaps, spoilers and other control surfaces affecting interior noise;

j) position of operable canopies, windows, doors, speed brakes or other items which may affect the aerodynamic generation of noise discernible inside the aircraft.

10 Test report

The report shall include the following information :

a) measuring equipment and its calibration (see clause 5);

b) test condition (see clause 6);

c) aircraft internal configuration (see clause 7);

d) microphone positions (see clause 8), preferably on a plan;

e) data recording (see clause 9);

f) corrected octave band pressure levels (see clause 4) and A-weighted sound pressure level;

g) type and configuration of aircraft;

h) statement of the attained accuracy of the measurements, for example, by the use of confidence intervals.