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Acoustics — Measurement of insertion loss of ducted silencers without flow — Laboratory survey method

Acoustique — Détermination de la perte d'insertion de silencieux en conduit sans écoulement — Méthode de contôle en laboratoire

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 11691:1995), which has been technically revised. The main changes compared to the previous edition are as follows:

— a modal filter has been inserted after the source to bring the standard more in line with the corresponding arrangements in ISO 7235:2003[5], and

— in this edition, test ducts and test object should, if possible, have the same cross-sections.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The insertion loss of absorbent silencers is generally not affected by the air flow, provided that the flow velocity does not exceed approximately 20 m/s in the narrowest cross-section of the silencer. In practice, non-uniform flow distributions must be considered, therefore the limit velocity of 20 m/s corresponds to a design velocity of 10 m/s to 15 m/s.

Acoustics — Measurement of insertion loss of ducted silencers without flow — Laboratory survey method

1 Scope

This document specifies a laboratory substitution method to determine the insertion loss without flow of ducted, mainly absorbent, circular and rectangular silencers, as well as other duct elements for use in ventilating and air-conditioning systems.

NOTE Laboratory measurement procedures for ducted silencers with superimposed flow are described in ISO 7235[5].

This document is applicable to silencers where the design velocity does not exceed 15 m/s. As the method does not include self-generated flow noise, this document is not suitable for tests on silencers where this type of noise is of great importance for the evaluation of the silencer performance. As most silencers, particularly in offices and dwelling, have design velocities below 15 m/s, this document can often be a cost-efficient alternative to ISO 7235[5].

The insertion loss determined according to this document in a laboratory is not necessarily the same as the insertion loss obtained in an installation in the field. Different sound and flow fields in the duct yield different results. In this document, the sound field is dominated by plane wave modes. Due to the use of regular test ducts, the results can include some flanking transmission via structural vibrations in the duct walls that sets an upper limit to the insertion loss that can be determined.

This document is intended to be used for circular silencers with diameters of 80 mm to 2 000 mm or for rectangular silencers with cross-sectional areas within the same range.

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.

ISO 3741, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61183, *Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters*

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

IEC 61672-1, *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 following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
insertion loss
D
reduction in level of sound power propagating through a duct due to the insertion of a silencer into the duct system in place of a *substitution duct* (3.3)

Note 1 to entry: Insertion loss is expressed in decibels.

3.2
test duct
straight *standard ducts* (3.5) of constant cross-section in front of and behind the silencer under test

Note 1 to entry: The purpose of the test ducts is to separate the test object from the sound source and the reverberation room.

3.3
substitution duct
standard duct (3.5) element having, if possible, the same length and same connecting cross-sections as the test object

3.4
transition element
element which fits and connects the duct of the sound source to the *test duct* (3.2) and, in some cases, the test duct to the silencer

3.5
standard duct
sheet metal duct commercially available directly from stock and normally used in practical applications together with the silencer under test

Note 1 to entry: Normal wall thicknesses for standard ducts lie in the range from 0,4 mm for small circular ducts to 1,25 mm for large circular ducts. A common thickness for rectangular ducts is 0,9 mm.

4 Test facility and arrangement

4.1 General

The test facility shall consist of the equipment shown in Figure 1 and shall contain the following:

— the sound measuring equipment (see 4.2);

— the sound source equipment (see 4.3);

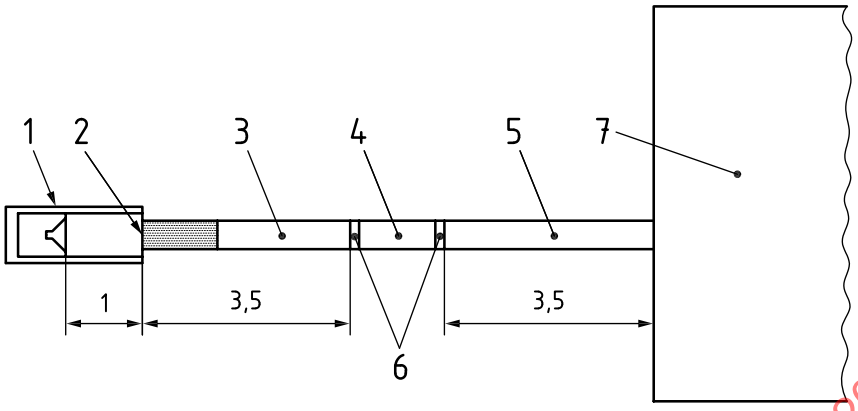
— the transition element (see 4.4);

— the test ducts (see 4.5);

— the substitution duct (see 4.5);

— the measurement environment appropriate to the standard used to determine the sound power level. (If ISO 3741 is used to determine the sound power level, a reverberation room is used, see 4.6. This is the preferred method.)

Dimensions in metres



Key

1	loudspeaker	5	test duct
2	transition element	6	transition element (if any)
3	test duct	7	reverberation room
4	substitution duct/test object		modal filter

Figure 1 — Test setup

4.2 Sound measuring equipment

The instrumentation system, including the microphone and cable, shall meet the requirements for a class 1 instrument according to IEC 61672-1. Filters shall meet the requirements for a class 1 instrument according to IEC 61260-1.

Before and after each series of measurements, a class 1 sound calibrator complying with IEC 60942 with a maximum permitted error of ±0,3 dB shall be applied to the microphone for verifying the calibration of the entire measuring system at one or more frequencies within the frequency range of interest.

Conformance of the sound pressure level measuring instrument, including the microphone, the filters and the sound calibrator, with the relevant requirements shall be verified by the existence of a valid certificate of conformance for the measurement parameters and the environmental conditions specified in the test method. For conformance with IEC 61672-1, conformance testing in accordance with IEC 61672-3 is required for all parameters required for the application for everything except that the manufacturer's specifications can be used in place of the instruction manual. State this when full IEC 61672-1 conformance is not available. If applicable, random incidence response of the microphone shall be verified by a procedure from IEC 61183.

All conformance testing shall be conducted by a laboratory operated in accordance with ISO/IEC 17025[8] and that meets the maximum permitted uncertainty defined in IEC 61672-1.

The sound calibrator should be calibrated at intervals not exceeding 1 year, the conformance of the reference sound source with the requirements of ISO 6926[4] should be verified at intervals not exceeding 2 years, the conformance of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding 2 years, and the conformance of the filters with the requirements of IEC 61260-1 should be verified at intervals not exceeding 2 years or whenever the algorithms associated with the filters are changed.

NOTE IEC 61672-3 is only applicable to devices which have been pattern approved in accordance with IEC 61672-2[9].

4.3 Sound source equipment

4.3.1 General

The sound-source equipment is used to excite a sound field with dominating plane-wave mode in front of the test object, and shall comprise

— electronic equipment and a loudspeaker unit (see 4.3.2),

— a modal filter (see 4.3.3), and

— a transition element between the loudspeaker and the test object (see 4.3.2).

Resonances in the duct in front of the test object shall be avoided (see 4.3.3).

4.3.2 Electronic equipment, loudspeaker unit and transition element

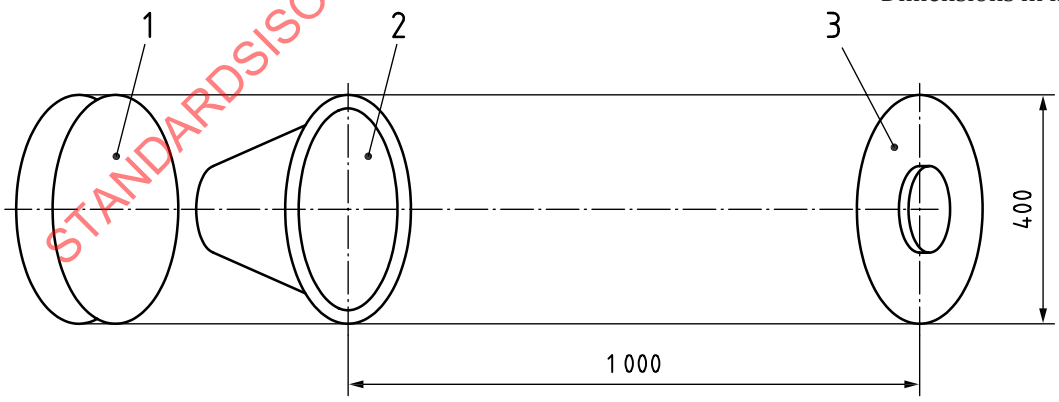
A random-noise generator and an amplifier shall drive one loudspeaker in an acoustically sealed circular duct (see Figure 2). Care shall be taken to ensure that the loudspeaker unit does not transmit unwanted structure-borne sound to the connected duct, e.g. by using a viscoelastic ring around the speaker frame rim, and that the transmission of airborne sound through the walls of the box is sufficiently low. As shown in Figure 2, the loudspeaker unit shall consist of a 0,3 m (12 in) loudspeaker element mounted at the end of a 1,0 m long circular duct with a diameter of 0,4 m. The back of the loudspeaker shall be enclosed in a sealed cabinet filled with mineral wool. The loudspeaker unit is coupled to the test duct with a transition element.

4.3.3 Modal filter

In principle, the modal filter is an extra silencer. It provides for a small attenuation of the fundamental mode and for a substantial attenuation of higher order modes of axial sound propagation. In addition, the modal filter is employed to decouple the sound source from the test object/substitution duct. For this purpose, the modal filter shall provide a minimum insertion loss of 3 dB in the 50 Hz and 63 Hz and of 5 dB in the 80 Hz to 10 000 Hz mid-band frequencies of the one-third-octave bands in the connected ducts.

NOTE For example, a short silencer similar to the test object can often be used as a modal filter. More detailed guidance for modal filters is found in ISO 7235[5].

Dimensions in millimetres



Key

1 mineral wool
2 loudspeaker [30 cm (12”)]
3 transition element

Figure 2 — Sound source

4.4 Transition element

The transition element which connects the source to the test duct shall have an abrupt change in area, that is a flare angle of approximately 180°. There is no limit on the ratio of the cross-sectional areas of the sound source duct and the test duct.

4.5 Test ducts and substitution duct

There shall be 3,5 m of duct and duct plus modal filter respectively on each side of the silencer. On the source side of the test object, the modal filter shall be considered to be part of the test duct. The same test ducts shall be used both with the silencer and the substitution duct.

Whenever insertion loss values higher than the limiting insertion loss as defined in ISO 7235[5] with standard ducts are to be measured, it is necessary to reduce the structure-borne and the parasitic airborne noise. Possible ways are to mount elastic gaskets before and after the silencer, to line the external duct walls with materials having high internal losses, such as sandwich structures, or to use heavier duct walls.

4.6 Reverberation room

The reverberation room shall comply with the requirements of ISO 3741.

4.7 Other measurement environments

Although a reverberation room is the preferred measurement environment for the method in accordance with this document, other environments complying with the following documents are allowed:

— free field over one or more reflecting planes in accordance with ISO 3744[2];

— hard-walled room in accordance with ISO 3743-1[1];

— any environment complying with ISO 9614-2[6].

5 Test procedure

The measurements shall be carried out in one-third-octave bands in the frequency range from 50 Hz to 10 000 Hz. If the measurement environment is not qualified for the whole frequency range, the results may still be reported as long as frequencies outside the range of qualification are clearly indicated in the test report.

The insertion loss, D, shall be determined from spatially averaged sound pressure levels L_{p1} and L_{p2}, which are determined from measurements of local sound pressure levels in two series at identical points or paths in the reverberation room.

The emitted sound signal shall be the same with respect to the sound power spectrum for the two tests. This is assumed to be fulfilled if the voltage across the loudspeaker is kept constant. The measurements and the averaging shall be in accordance with ISO 3741.

If test environments other than a reverberation room are used, average the results according to the instructions given in the standard used. The measurement surface or microphone positions shall then be as for the corresponding sound power determination for the opening of the transmission element.

In the first test series, L_{p1} shall be determined with the test object substituted by the substitution duct.

In the second test series, L_{p2} shall be determined with the test object being mounted between the test ducts.

The insertion loss, D, shall be determined from Formula (1):

$$D = L_{p1} - L_{p2} \tag{1}$$

If the sound absorption of the reverberation room changes between the tests, corrections shall be made in accordance with ISO 3741.

If the insertion loss is reported in octave bands, the octave-band values shall be calculated from the one-third-octave-band values, assuming the sound pressure levels of each one-third-octave band within the octave band are equal for measurements with the substitution duct. Thus, the insertion loss of an octave band is given by Formula (2):

$$D_{\text{oct}} = -10\lg\left[\frac{1}{3}\left(10^{-\frac{D_1}{10}} + 10^{-\frac{D_2}{10}} + 10^{-\frac{D_3}{10}}\right)\right]\text{dB} \tag{2}$$

where D_1, D_2 and D_3 are the numerical values of the insertion losses of the one-third-octave bands within the octave.

6 Measurement uncertainty

Due to lack of knowledge, the determination of the uncertainty of results obtained from measurements according to this document does not comply with ISO/IEC Guide 98-3[7]. Exact information on the precision of the method cannot be given at this time. Therefore, this document is defined as a survey method. However, due to a simpler and more narrowly defined test setup, it is estimated that this method will have a standard deviation of reproducibility, σ_R, as defined in ISO 5725-2[3], which is equal to or better than that of ISO 7235[5] (see Table 1).

Table 1 — Estimated values of the standard deviation of reproducibility

Mid-band frequencies of the one-third-octave band Hz	**Standard deviation of reproducibility, σ_{Ri}, of the insertion loss** dB
50 to 100	1,5
125 to 500	1
630 to 1 250	2
1 600 to 10 000	3

Unless more knowledge is available, the expanded measurement uncertainty for a stated coverage probability of 95 % according to ISO/IEC Guide 98-3[7] shall be given as two times the standard deviation of reproducibility in a test report, if requested.

7 Information to be recorded

7.1 General

The following information, when applicable, shall be compiled and recorded for all measurements made in accordance with the requirements of this document.

7.2 Description of the silencer under test

a) Type of silencer and its application;

b) dimensions of the inlet and outlet cross-sectional areas;

c) overall dimensions and weight of silencer;