INTERNATIONAL STANDARD

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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 mesurage en laboratoire

Reference number
ISO 11691:1995(E)

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.

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.

International Standard ISO 11691 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annex A of this International Standard is for information only.

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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.

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

1 Scope

1.1 General

This International Standard 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 1 Laboratory measurement procedures for ducted silencers with superimposed flow are described in ISO 7235.

This International Standard 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 International Standard is not suitable for tests on silencers where this type of noise is of great importance for the evaluation of the silencer performance.

The insertion loss determined according to this International Standard in a laboratory will not necessarily be the same as the insertion loss that will be obtained in an installation in the field. Different sound and flow fields in the duct will yield different results. As this International Standard requires regular test ducts, the results may include some flanking transmission via structural vibrations in the duct walls, that sets an upper limit to the insertion loss that can be determined.

NOTE 2 ISO 7235 gives methods for determining this limit.

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

1.2 Measurement uncertainty

Exact information on the precision of the method cannot be given at this time. Therefore this International Standard is denoted a survey standard.

Interlaboratory tests are necessary for the determination of the standard deviation of reproducibility, σ_R, of the method (relevant terms and methods are given in ISO 5725-1). It is, however, estimated that this method will have a σ_R which is comparable to that of ISO 7235. See table 1.

Table 1 — Estimated values of the standard deviation of reproducibility

Midband frequencies of one-third-octave band Hz	Standard deviation of reproducibility, σ_R dB
50 to 1 250	2
1 600 to 10 000	3

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3741:1988, *Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-band sources in reverberation rooms.*

ISO 3743-1:1994, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields — Part 1: Comparison method for hard-walled test rooms.*

ISO 3744:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane.*

ISO 7235:1991, *Acoustics — Measurement procedures for ducted silencers — Insertion loss, flow noise and total pressure loss.*

ISO 9614-1:1993, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points.*

IEC 651:1979, *Sound level meters,* and Amendment 1:1993.

IEC 804:1985, *Integrating-averaging sound level meters,* Amendment 1:1989 and Amendment 2:1993.

IEC 942:1988, *Sound calibrators.*

IEC 1260:—[1], *Electroacoustics — Octave-band and fractional-octave-band filters.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

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. It is expressed in decibels.

3.2 test duct: Straight standard duct of constant cross-section in front of and behind the silencer under test. 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 element having, if possible, the same length and same connecting cross-sections as the test object. It is conical if the cross-sectional areas of the entrance and exit of the silencer are different from each other. If the planes of the connections of the silencer are not parallel to each other, the connections shall be made with smooth curved ducts with a bend radius of the walls as large as possible.

3.4 transition element: Element which fits and connects the duct of the sound source to the test duct 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 3 Normal wall thicknesses for standard ducts lie in the range 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

4.1 General

The test facility shall consist of the equipment shown in figure 1. It contains the following:

— the sound measuring equipment (see 4.2);

— the sound source equipment (see 4.3);

— the transition element(s) (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.

NOTE 4 If ISO 3741 is used to determine the sound power level, a reverberation room is used (see 4.6). This is the preferred method.

4.2 Sound measuring equipment

The instrumentation system, including the microphone and cable, shall meet the requirements for a type 1 instrument specified in IEC 651 or, in the case of integrating-averaging sound level meters, the requirements of IEC 804. Filters shall meet the requirements of IEC 1260.

Before and after each series of measurements, a class 1 sound calibrator complying with IEC 942 with a tolerance of ± 0,3 dB shall be applied to the microphone for verifying the calibration of the entire measuring system at one or more frequencies over the frequency range of interest.

1) To be published. (Revision of IEC 225:1966.)

The compliance of the calibrator with the requirements of IEC 942 shall be verified once a year and the compliance of the instrumentation system with the requirements of IEC 651 (and IEC 804 in the case of integrating systems) shall be verified at least every 2 years in a laboratory making calibrations traceable to appropriate standards.

The date of the verification of the compliance with relevant IEC standards shall be recorded.

4.3 Sound source equipment

The sound source equipment shall be connected to the test duct in front of the test silencer. It shall consist of a noise generator, an amplifier and a loudspeaker unit.

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.

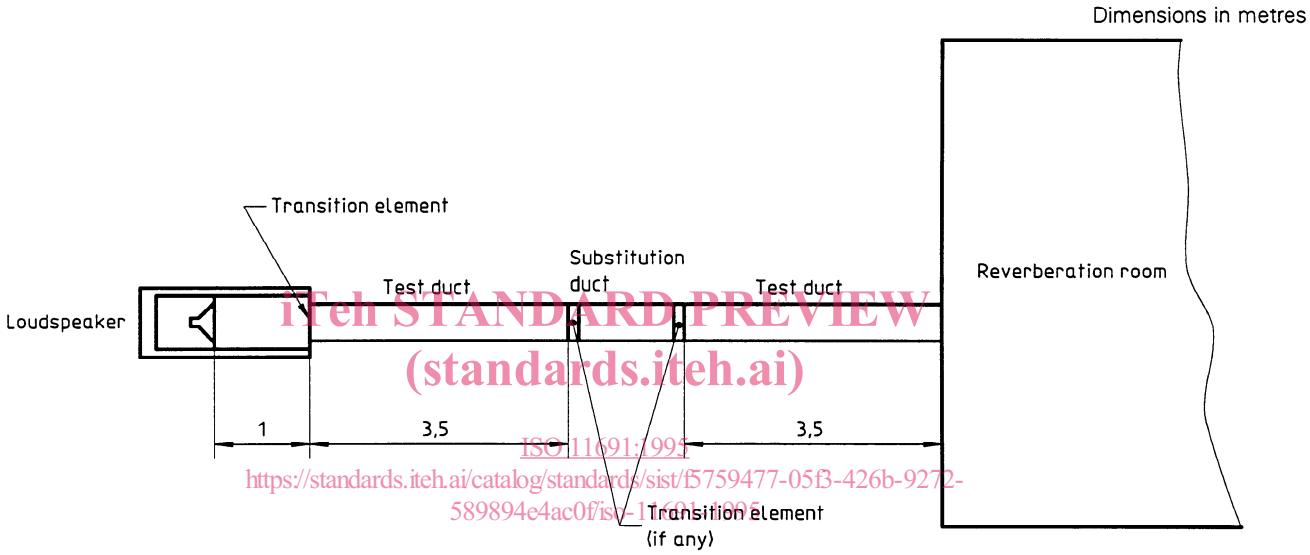

Figure 1 — Test facility

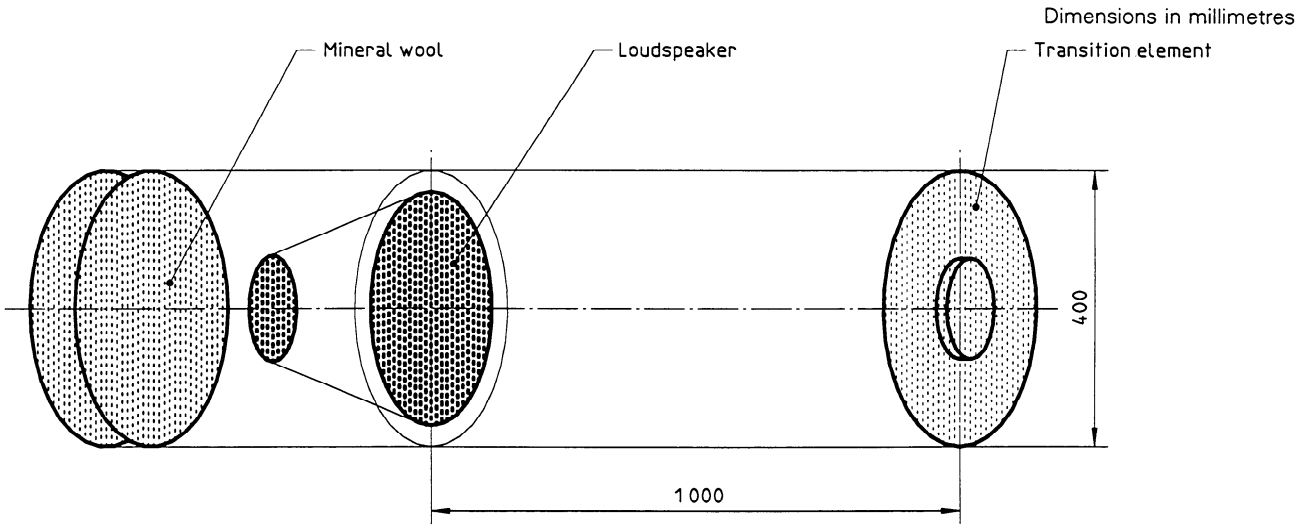

Figure 2 — Sound source

NOTE 5 The different dimensions have been standardized in detail in order to reduce reproducibility errors between different laboratories.

Care shall be taken that the loudspeaker unit does not transmit disturbing vibrations and that the transmission through the walls of the housing is sufficiently low.

4.4 Transition elements

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°, and there is no limit on the ratio of the cross-sectional areas of the sound source duct and the test duct.

Transition elements, if any, between the test ducts and the silencer to be tested shall not exceed 0,6 m in length.

4.5 Test and substitution ducts

The test ducts may be either circular or rectangular. The cross-dimensions of the ducts should be as close as possible to those of the inlet or outlet of the silencer. The ratio of the cross-sectional area of the test duct to that of the silencer or substitution duct shall be within the range 0,6 to 1,7. Within this range, transition elements between the duct and the silencer may be used. There shall be 3,5 m of duct on each side of the silencer. The same test ducts shall be used both with the silencer and the substitution duct. (See note 5 in 4.3.)

Whenever insertion loss values higher than the limiting insertion loss as defined in ISO 7235 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 International Standard, other environments complying with the following International Standards are allowed:

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

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

— any environment complying with ISO 9614-1.

5 Test procedure

Carry out the measurements in one-third-octave bands in the frequency range 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.

Determine the insertion loss, D, 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, determine L_{p1} with the test object substituted by the substitution duct.

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

Calculate the insertion loss, D, from

$$D = L_{p1} - L_{p2} \qquad \ldots (1)$$

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, calculate the octave-band values 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 substi-

tution duct. Thus the insertion loss of an octave band is given by

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

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

6 Information to be recorded

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

6.1 Description of the silencer under test

a) Type of silencer and its application.

b) Dimensions of the inlet and outlet cross-sectional areas.

c) Length and weight of silencer.

d) Dimensions of the narrowest free cross-sectional area(s) within the silencer.

e) Thickness, separation and surface of splitters, if any.

f) Material, thickness, distance and covering, including perforation ratio, of sound-absorbent linings.

g) Any further construction parameters that may have affected the result.

6.2 Description of test arrangement

a) Description of the test environment in accordance with the basic International Standard used for the determination of the sound power level (see 4.7). In the case of the reverberation room in accordance with ISO 3741, indication of the volume of the room is sufficient.

b) Position of the duct outlet in the reverberation room or a description of microphone position(s) in accordance with the basic International Standard, if not ISO 3741, used for the determination of the sound power level (see 4.7).

c) Type of coupling between the sound source and the test duct.

d) Wall thickness, material and structure of the test ducts.

e) Measuring equipment, including type and serial number.

6.3 Acoustical test results

The insertion loss shall be presented in tabular and preferably also in graphical form as a function of frequency. For graphs with the insertion loss in decibels plotted against frequency in hertz on a logarithmic scale, the length for a 10:1 frequency ratio shall be equal to the length for 25 dB on the ordinate scale.

For results in accordance with this International Standard, it is preferred that one octave corresponds to 15 mm and 10 dB to 20 mm.

7 Information to be reported

a) Date and time when the measurements were performed.

b) At least the information in accordance with 6.1 a), 6.1 b), 6.1 c) and 6.3.

c) The report shall contain the statement that the test results have been obtained in full accordance with this International Standard with an indication of frequencies outside the range of qualification.

d) The basic standard, if not ISO 3741, used for the averaging of the sound pressure level or the sound intensity outside the transmission element shall be given.