

# INTERNATIONAL STANDARD

# ISO 11820

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## **Acoustics — Measurements on silencers *in situ***

*Acoustique — Mesurages sur silencieux in situ*

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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.

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 11820 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annexes A to C of this International Standard are for information only.

## Introduction

This International Standard gives a method for evaluating the acoustic performance of silencers under plant-operating conditions. The attenuation losses determined express the extent to which the level of sound power passing through a duct, or across the internal cross-section of an aperture or opening (e.g. in an enclosure or a building) is reduced by the use of a silencer. Sound transmission via flanking elements is attributed to the silencer performance unless the flanking element is not a part of the silencer or of the related duct walls. The influences of flow noise and of alterations to the operating conditions with and without a silencer are included.

In laboratory measurements on ducted silencers in accordance with ISO 7235, insertion losses, static pressure losses and regenerated sound (flow noise) are determined under well-defined conditions. In practical applications both the sound field and flow field are less uniformly distributed. This can lead to different attenuations and greater pressure losses. In addition, sound levels and rates of flow are mutually dependent. Therefore, in this International Standard the regenerated sound is not measured separately but is treated as a property of the silencer in its operating installation which limits the degree of attenuation in the particular application.

# Acoustics — Measurements on silencers *in situ*

## 1 Scope

**1.1** This International Standard specifies measurements on silencers *in situ*. It is applicable to measurements on silencers in practical applications for acoustic analysis, acceptance tests and similar evaluations. Results obtained in accordance with this International Standard cannot be compared to performance data obtained from laboratory measurements on ducted silencers in accordance with ISO 7235, partly because of different test conditions (such as sound field distribution, flow, temperature and mounting conditions) and partly because of different definitions.

Depending on the method used, the measurement is either of

- insertion loss  $D_{is}$ , or
- transmission loss  $D_{ts}$ .

The measurement method depends upon the type of silencer and the installation conditions (e.g. insertion loss measurements must be carried out for blowdown silencers).

**NOTE 1** The subscripts denote the practical application of the silencer and the particular installation and operating conditions: "s" stands for "*in situ*", "t" for transmission, and "i" for insertion.

Additional characteristic quantities, which could include measurements taken using artificial sound sources or measurements taken to determine the directivity of sound propagation from the silencer, may be agreed upon in accordance with this International Standard.

**1.2** This International Standard is applicable to

- a) silencers which are installed either as a whole or in the form of individual baffles in the propagation path of sound (e.g. openings of ducts) originating from a sound source (machine, building, plant

such as a gas turbine generator, scrubbing plant, cooling tower, heating ventilation and air conditioning (HVAC) plant, exhaust stack, air intake duct, weapon, internal combustion engine, compressor, etc.);

- b) all types of passive silencers (absorptive, reactive, reflection and blowdown silencer);
- c) active silencers (involving amplifiers and loudspeakers) as far as the insertion loss of passive silencers is equivalent to the off/on conditions of active devices; and
- d) other measures or means of effecting acoustic attenuation in air or other gases (e.g. components installed in ducting, louvres, grilles and deflector hoods).

Additionally, this International Standard is applicable to the determination of the effect of cleaning or refurbishing silencers.

This International Standard is not applicable to closed high-pressure systems (e.g. silencers in closed pipes) since measurements of structure-borne sound are not anticipated.

**1.3** Quantities to be measured include the following:

- a) sound pressure levels in octave bands with centre frequencies at least from 63 Hz to 4 kHz and, if possible and required, from 31,5 Hz to 8 kHz or in one-third-octave bands with centre frequencies from 50 Hz to 5 kHz and, if possible and required, from 25 Hz to 10 kHz
  - at a point or points on the source side of a silencer,
  - at a point or points on the receiver side of a silencer;
- b) static and dynamic pressures, flow velocities and temperatures at selected positions.

Operating data to be determined include flow rate, pressure and speed, which define the operating conditions of the machine or plant to be silenced.

## 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 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 5221:1984, *Air distribution and air diffusion — Rules to methods of measuring air flow rate in an air handling duct*.

IEC 651:1979, *Sound level meters*.

IEC 651:1979/Amd.1:1993, *Amendment No. 1*.

IEC 804:1985, *Integrating-averaging sound level meters*.

IEC 804:1985/Amd.1:1989, *Amendment No. 1*.

IEC 804:1985/Amd.2:1993, *Amendment No. 2*.

## 3 Definitions

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

**3.1 transmission sound pressure level difference,  $D_{tps}$ :** Difference, in decibels, between the mean sound pressure levels on the source and receiver side of a silencer:

$$D_{tps} = \overline{L_{p2}} - \overline{L_{p1}} \quad \dots (1)$$

where

$\overline{L_{p1}}$  is the mean sound pressure level (ref. 20  $\mu$ Pa), in decibels (in one-third-octave or octave bands, see IEC 1260), on the receiver side of the silencer, for all measuring points used to determine the airborne sound within the duct or propagated from the aperture and external surfaces of the silencer;

$\overline{L_{p2}}$  is the mean sound pressure level (ref. 20  $\mu$ Pa), in decibels (in one-third-octave or octave bands), on the source side of the silencer, for all measuring points used to determine the airborne sound reaching the silencer.

NOTE 2  $D_{tps}$  is not self-standing but is an intermediate step towards determining the transmission loss (see 9.1.3).

Mean sound pressure levels  $\overline{L_p}$  are defined by

$$\overline{L_p} = 10 \lg \left( \frac{1}{N} \sum_{j=1}^N 10^{0,1L_{pj}} \right) \text{ dB} \quad \dots (2)$$

where

$L_{pj}$  is the individual level;

$N$  is the number of measuring points.

**3.2 insertion sound pressure level difference,  $D_{ips}$ :** Difference, in decibels, in sound pressure levels measured at a point or averaged over a small measurement area before and after installation of a silencer:

$$D_{ips} = L_{pII} - L_{pI} \quad \dots (3)$$

where

$L_{pI}$  is the sound pressure level (ref. 20  $\mu$ Pa), in decibels (in one-third-octave or octave bands, see IEC 1260), of the sound source(s) measured at a point or averaged over a small measurement area, after installation of the silencer;

$L_{pII}$  is the sound pressure level (ref. 20  $\mu$ Pa), in decibels (in one-third-octave or octave bands), occurring at the same measuring point or over a small measurement area due to the sound source(s) to which the silencer is to be attached, before installation of the silencer.

NOTE 3 As opposed to  $D_{tps}$ ,  $D_{ips}$  is restricted to a point or a small area where certain directivity indices of sound radiation with and without the silencer are effective. The reference to a small area with a diameter of about half a wavelength rather than a point may be useful to avoid strong effects of interference between direct and reflected waves which may occur at certain points.

**3.3 transmission loss,  $D_{ts}$ :** Difference, in decibels, between the levels of the sound power incident upon and transmitted from the silencer:

$$D_{\text{ts}} = L_{W2} - L_{W1} \quad \dots (4)$$

where

$L_{W1}$  is the level (ref. 1 pW), in decibels (in one-third-octave or octave bands), of the sound power propagated through the silencer into an attached duct, into a room or into free space, to be determined from

$$L_{W1} = \overline{L_{p1}} + 10 \lg (S_1/S_0) \text{ dB} + K_1 \quad \dots (5)$$

in which, depending on the installation conditions (see clause 5 and 9.1):

$S_1$  is the area of the measurement surface on the receiver side of the silencer corresponding to the mean sound pressure level  $\overline{L_{p1}}$ , or

$S_1$  is one-quarter of the absorption  $A$  in a reverberant receiving room, where Sabine's formula applies so that

$$S_1 = (6 \ln 10)V/(cT_1) \quad \dots (6)$$

in which

$V$  is the volume of the room;

$c$  is the speed of sound (for air at room temperature  $c = 340 \text{ m/s}$ );

$T_1$  is the reverberation time;

$$S_0 = 1 \text{ m}^2;$$

$K_1$  is the correction, in decibels, for the field distribution in the transmitted sound field on the receiver side of the silencer (see annex A);

$L_{W2}$  is the level (ref. 1 pW), in decibels (in one-third-octave or octave bands), of the sound power incident upon the silencer, to be determined from

$$L_{W2} = \overline{L_{p2}} + 10 \lg (S_2/S_0) \text{ dB} + K_2 \quad \dots (7)$$

in which, depending on the installation conditions (see clause 5 and 9.1):

$S_2$  is the area of the measurement surface on the source side of the silencer corresponding to the mean sound pressure level  $\overline{L_{p2}}$ , or

$S_2$  is one-quarter of the total silencer intake area in a reverberant source room, where Sabine's formula applies and sound pressure levels  $L_{p2}$  are measured at various positions in the room but not very close to the silencer or to any sound source;

$$S_0 = 1 \text{ m}^2;$$

$K_2$  is the correction, in decibels, for the field distribution in the incident and reflected sound field on the source side of the silencer (see annex A).

NOTE 4 The definitions of the areas  $S_1$  and  $S_2$  include basic field corrections so that the corrections  $K_1$  and  $K_2$  are generally small, typically less than 3 dB in absolute value.

**3.4 insertion loss,  $D_{\text{is}}$ :** Difference, in decibels, between the levels of the transmitted sound power with and without a silencer:

$$D_{\text{is}} = L_{W\text{II}} - L_{W\text{I}} \quad \dots (8)$$

where

$L_{W\text{I}}$  is the sound power level (ref. 1 pW), in decibels (in one-third-octave or octave bands) with the silencer installed, to be determined from

$$L_{W\text{I}} = \overline{L_{p\text{I}}} + 10 \lg (S_{\text{I}}/S_0) \text{ dB} + K_{\text{I}} \quad \dots (9)$$

in which

$\overline{L_{p\text{I}}}$  is the mean sound pressure level (ref. 20  $\mu\text{Pa}$ ), in decibels (in one-third-octave or octave bands) with the silencer installed, averaged over all measurement points for airborne sound carried by the duct or propagated from the aperture; and depending on the installation conditions (see clause 5 and 9.1):

$S_{\text{I}}$  is the area of the measurement surface behind the silencer corresponding to the mean sound pressure level,  $\overline{L_{p\text{I}}}$ , or

$S_{\text{I}}$  is one-quarter of the absorption  $A$  in a reverberant receiving room, where Sabine's formula applies so that

$$S_{\text{I}} = (6 \ln 10)V/(cT_1) \quad \dots (10)$$

in which  $T_1$  is the reverberation time, and  $V$  and  $c$  are as defined in 3.3;

$$S_0 = 1 \text{ m}^2;$$

$K_{\text{I}}$  is the correction, in decibels, for the sound field distribution behind the silencer (see annex A);

$L_{W\text{II}}$  is the sound power level (ref. 1 pW), in decibels (in one-third-octave or octave