SLOVENSKI STANDARD
oSIST prEN 12354-5:2007

01-julij-2007

Akustika v stavbah - Ocenjevanje akustiļ nih lastnosti stavb iz lastnosti sestavnih delov - 5. del: Zvoļ ne ravni obratovalne opreme

Building acoustics - Estimation of acoustic performance of building from the performance of elements - Part 5: Sounds levels due to service equipment

Bauakustik - Berechnung der akustischen Eigenschaften von Gebäuden aus Bauteileigenschaften - Teil 5: Schallpegel von haustechnischen Anlagen

Acoustique du bâtiment - Calcul de la performance acoustique des bâtiments a partir de la performance des éléments - Partie 5: Niveaux sonores dus aux équipements du bâtiment

Ta slovenski standard je istoveten z: **prEN 12354-5**

ICS:

91.120.20	Akustika v stavbah. Zvoļ na izolacija	Acoustics in building. Sound insulation

oSIST prEN 12354-5:2007 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 12354-5

March 2007

ICS

English Version

Building acoustics - Estimation of acoustic performance of building from the performance of elements - Part 5: Sounds levels due to service equipment

Acoustique du bâtiment - Calcul de la performance acoustique des bâtiments à partir de la performance des éléments - Partie 5: Niveaux sonores dûs aux équipements du bâtiment

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 126.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. prEN 12354-5:2007: E

Contents

Page

Foreword

This document (prEN 12354-5:2007) has been prepared by Technical Committee CEN/TC 126 “Acoustic properties of building elements and of buildings”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document is the first version of a standard, which forms a part of a series of standards specifying calculation models in building acoustics:

— *Part 1: Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms.*

— *Part 2: Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 2: Impact sound insulation between rooms.*

— *Part 3: Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 3: Airborne sound insulation against outdoor sound.*

— *Part 4: Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 4: Transmission of indoor sound to the outside.*

— *Part 5: Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 5: Sound levels due to service equipment.*

— *Part 6: Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 6: Sound absorption in enclosed spaces.*

Although this part covers the most common types of service equipment and installations in buildings, it cannot as yet cover all types and all situations. It sets out an approach for gaining experience for future improvements and developments.

The accuracy of this standard can only be specified in detail after widespread comparisons with field data, which can only be gathered over a period of time after establishing the prediction model. To help the user in the mean time, indications of the accuracy have been given, based on earlier comparisons with comparable prediction models. It is the responsibility of the user (i.e. a person, an organisation, the authorities) to address the consequences of the accuracy, inherent for all measurement and prediction methods, by specifying requirements for the input data and/or applying a safety margin to the results or applying some other correction.

Annex A forms an integral part of this part of EN 12354. Annexes B, C, D, E, F, G and H are for information only.

Introduction

The estimation of sound levels due to service equipment in buildings is a complex task and structure-borne sources and transmission are not completely understood. In addition there are large variations between different equipment and installations and an installation often comprises both airborne and structure-borne sources. This document contains a framework within which this subject can be treated. The main part (chapter 4) describes general models for the sound transmission and the related sources for ducts, airborne sound through buildings and structure-borne sound through buildings. For airborne and structure-borne sound transmission parts 1 and 2 of EN 12354 are used wherever possible.

In clause 5 the application of these models to the different types of service equipment in buildings is treated, specifying what is already known and available and what is not. In several annexes additional information is given on various aspects, related to sources and their sound production as well as to specific aspects of sound transmission through buildings.

For sound transmission through ducts there are standardized methods available to determine the sound power level of sources or the transmission loss of elements. Various handbooks are widely used for these estimations.

For airborne sound transmission through buildings there is existing information about sources and transmission, but some aspects that are particularly relevant to service equipment are less well known, such as the effect of acoustic near-fields, non-diffuse spaces and excitation and transmission at low frequencies. For these aspects some indications are given as to how they could be treated and also as an indicator for the direction of further research and future improvements to the models.

For structure-borne sound transmission similar solutions and problems exist as used for airborne sound. However, here the appropriate methods to characterize the sources for structure-borne sound excitation are not available, although there are various proposals in the literature and work has started within CEN (TC126/WG 7) Therefore in this document a choice has been made to use a general quantity in the models, called "the characteristic structure-borne sound power level" of sources, even though there is no practical measurement method available at the moment. This allows the estimation models to have a general form that could be developed and improved in the future. For some types of equipment indications are given in an informative annex as to how this quantity can be deduced or estimated from available and current measurement methods, like the ones already proposed by WG 7.

The aim of this document is to provide a general basis for a practical approach to the estimation of sound levels due to service equipment. It also clarifies the need for work on source characterisation with an indication of areas where further research work is needed.

1 Scope

This document describes calculation models to estimate the sound pressure level in buildings due to service equipment. As for the field measurement document (EN ISO 16032) it covers sanitary installations, mechanical ventilation, heating and cooling, service equipment, lifts, rubbish chutes, boilers, blowers, pumps and other auxiliary service equipment, and motor driven car park doors, but can also be applied to others equipment attached to or installed in buildings. The estimation is primarily based on measured data that characterises both the sources and the building constructions. The models given are applicable to calculations in frequency bands.

This document describes the principles of the calculation models, lists the relevant quantities and defines its applications and restrictions. It is intended for acoustical experts and provides the framework for the development of application documents and tools for other users in the field of building construction, taking into account local circumstances.

The calculation models described use the most general approach for engineering purposes, with a link to measurable quantities that specify the performance of building elements and equipment. The known limitations of these calculation models are described in this document. Users should, however, be aware that other calculation models also exist, each with their own applicability and restrictions.

The models are based on experience with predictions for dwellings and offices; they could also be used for other types of buildings provided the dimensions of constructions are not too different from those in dwellings.

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.

prEN 1151-2, *Pumps – Rotodynamic pumps — Circulation pumps having an electrical effect not exceeding 200 W for heating installations and domestic hot water installations — part 2: Noise test code (vibro-acoustics) for measuring structure- and fluid-borne noise*.

EN 12354-1, *Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms*.

EN 12354-2, *Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 2: Impact sound insulation between rooms*.

EN 12354-6, *Building Acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 6: Sound absorption in enclosed spaces*.

EN ISO 16032, *Acoustics — Measurement of sound pressure level from service equipment in buildings — engineering method*.

ISO 3740-3747, *Acoustics — Determination of sound power levels of noise sources — various methods*.

ISO 3822-1, *Acoustics — Laboratory tests on noise emission from appliances and equipment used in water supply installations — Part 1: Method of measurement*.

ISO 3822-2, *Acoustics — Laboratory tests on noise emission from appliances and equipment used in water supply installations — Part 2: Mounting and operating conditions for draw-off taps and mixing valves*.

ISO 3822-3, *Acoustics — Laboratory tests on noise emission from appliances and equipment used in water supply installations — Part 3: Mounting and operating conditions for in-line valves and appliances*.

ISO 3822-4, *Acoustics — Laboratory tests on noise emission from appliances and equipment used in water supply installations — Part 4: Mounting and operating conditions for special appliances*.

ISO 5135, *Acoustics — Determination of sound power levels of noise from air terminal devices, air-terminal units, dampers and valves by measurements in a reverberation room*.

ISO 5136, *Acoustics — Determination of sound power radiated into a duct by fans — In-duct method*.

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

ISO 9611, *Acoustics — Characterization of sources of structure-borne sound with respect to sound radiation from connected structures — Measurement of velocity at the contact points of machinery when resiliently mounted*.

ISO 10846-1, *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements — Part 1: Principles and guidelines*.

ISO 10846-2, *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements — Part 2: Dynamic stiffness of elastic supports for translatory motion — Direct method.*

ISO 10846-3, *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements — Part 3: Method for determination of the dynamic stiffness of resilient supports for translatory motion*.

ISO 10846-4, *Acoustics and vibration — Laboratory measurement of vibro-acoustic transfer properties of resilient elements — Part 4: Dynamic stiffness of elements other than resilient supports for translatory motion*.

ISO 11546-1, *Acoustics — Determination of sound insulation performances of enclosures — Part 1: Measurements under laboratory conditions (for declaration purposes)*.

ISO 11691, *Acoustics — Measurement of insertion loss of ducted silencers without flow — Laboratory survey method.*

EN 13141-1, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 1: Externally and internally mounted air transfer devices*.

EN 13141-2, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 2: Exhaust and supply air terminal devices*.

ISO 13141-3, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 3: Range hoods for residential use*.

ISO 13141-4, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 4: Fans used in residential ventilation systems*.

ISO 13141-5, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 5: Cowls and roof outlet terminal devices*.

ISO 13141-6, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 6: Exhaust ventilation system packages used in a single dwelling*.

ISO 13141-7, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings*.

EN 14366, *Building Acoustics — Laboratory measurement of noise from waste water installations*.

3 Relevant quantities

3.1 Quantities to express building performance

The protection against sound from equipment and machinery according to EN ISO 16032 can be expressed in sound pressure levels in various ways. These quantities are determined in octave bands as maximum level using time weighting "S" or time weighting "F" or as equivalent level; in all cases normalization to a reference equivalent absorption area or standardization to a reference reverberation time can be applied. The building performance is normally expressed in an A-weighted or C-weighted sound pressure level that is to be calculated from these octave band levels.

NOTE The octave band levels are also used to determine the so-called NC, NR or RC ratings, as described in many textbooks. This is especially the case for buildings such as offices, commercial buildings, schools and performance spaces.

3.1.1 A-weighted maximum sound pressure level $L_{\mathrm{A,max}}$, The A-weighted maximum sound pressure level in a room, due to the sound produced by equipment or machinery in the building.

NOTE This sound pressure level is obtained from the maximum sound pressure level in octave bands from 63 Hz to 4 kHz using time weighting "S" ($L_{\mathrm{S\,max}}$) or time weighting "F" ($L_{\mathrm{F\,max}}$). The sound pressure levels in octave bands can also be normalized ($L_{\mathrm{S\,max,n}}$, $L_{\mathrm{F\,max,n}}$) or standardized ($L_{\mathrm{Smax,nT}}$, $L_{\mathrm{F\,max,nT}}$).

3.1.2 A-weighted equivalent sound pressure level $L_{\mathrm{A,eq}}$. The equivalent A-weighted sound pressure level in a room, due to the sound produced by equipment or machinery in the building.

NOTE This sound pressure level is obtained from the equivalent sound pressure level in octave bands (L_{eq}) from 63 Hz to 4 kHz. The sound pressure levels in octave bands can also be normalized ($L_{\mathrm{eq,n}}$) or standardized ($L_{\mathrm{eq,nT}}$).

3.1.3 C-weighted maximum sound pressure level $L_{\mathrm{C,max}}$, The C-weighted maximum sound pressure level in a room, due to the sound produced by equipment or machinery in the building.

NOTE This sound pressure level is obtained from the maximum sound pressure level in octave bands from 31,5 Hz to 4 kHz using time weighting "S" ($L_{\mathrm{S\,max}}$) or time weighting "F" ($L_{\mathrm{F\,max}}$). The sound pressure levels in octave bands can also be normalized ($L_{\mathrm{S\,max,n}}$, $L_{\mathrm{F\,max,n}}$) or standardized ($L_{\mathrm{S\,max,nT}}$, $L_{\mathrm{F\,max,nT}}$).

3.1.4 C-weighted equivalent sound pressure level L_{Ceq}. The equivalent C-weighted sound pressure level in a room, due to the sound produced by equipment or machinery in the building.

NOTE This sound pressure level is obtained from the equivalent sound pressure level in octave bands (L_{eq}) from 31,5 Hz to 4 kHz. The sound pressure levels in octave bands can also be normalized ($L_{\mathrm{eq,n}}$) or standardized ($L_{\mathrm{eq,nT}}$).

3.1.5 Relation between quantities

The A-weighted and C-weighted quantities are all obtained from the sound pressure levels in octave bands.

These sound pressure levels (L) are depending on the applied time weighting, i.e. "S", "F" or integration over a cycle (equivalent). The level with these various time weightings depends on the type of sound and cannot be deduced from each other in general. Hence, the estimated octave band level will have to relate to the same time weighting as the specified quantity.

In all cases there is a direct relation between the sound pressure level (L), the normalized sound pressure level (L_n) and the standardized sound pressure level (L_{nT}) in octave bands. These relations are given by:

$$L = L_n + 10 \lg \frac{A_{ref}}{A} \text{ dB} \tag{1a}$$

$$L_{nT} = L_n + 10 \lg \frac{A_{ref} T_{ref}}{0{,}16\, V} \text{ dB} \tag{1b}$$

where

A is the equivalent absorption area in the room, in square metres;

A_{ref} is the reference equivalent absorption area (A_{ref} = 10 m^2), in square metre;

T_{ref} is the reference reverberation time (T_{ref} = 0,5 s), in seconds;

V is the volume of the room, in cubic metres.

In this document the normalized sound pressure level L_n in octave bands, with the appropriate average and time weighting, is chosen as the prime quantity to predict. The other quantities can be obtained from this directly.

3.2 Quantities to express product performance

The quantities to express the performance of products relate on the one hand to the sources of sound and on the other hand to the transmission of sound. In general this concerns both air-borne and structure-borne sound.

The relevant sound sources differ for the various equipment and installations considered. Therefore the relevant quantities to express the performance of sound sources will be dealt with in the appropriate sections. However, the quantities for the sources must in all cases relate to the same time weighting as the quantity to be estimated for the building performance.

The relevant elements in the sound transmission are partly those from other documents in this series, like EN 12354-1 and EN 12354-2 where the related quantities are specified, and partly specific for the considered service equipment. Therefore also here the relevant quantities will be indicated in the appropriate clause.

4 Calculation models

4.1 General principles

In general a mixture of air-borne and structure-borne sound transmission causes the sound level in a room due to service equipment. Which of those is dominant depends on the type of equipment and installation as well as on the type of building construction. Furthermore, service equipment and installations often consist of several sound sources and several connection points between the installation and the building structure. This makes a general prediction method rather complicated.

NOTE An additional problem is that there are only a few well-established measurement methods to quantify the strength of the equipment. Especially in the field of structure-borne sound these methods, and the quantities, have been missing, though now work has started in CEN/TC126/WG7. Indications are given in Annex B, C and D.

It is assumed that a complete installation can be divided in several of air-borne and/or structure-borne sound sources that can be considered independent from each other. Such a source can be a physical object, a partial source or a combination of various partial sources or connection points, depending on the type of equipment or installation considered. The model approach is to consider one such a source at the time and apply a one-dimensional model, where the most relevant model is chosen for the considered type of source. The resulting sound pressure level in a room follows from the addition of the contribution of each of such sources.

In general three principally different transmission situations are considered:

— air-borne sound transmission through pipes and/or ducts;

— air-borne sound transmission through a building construction;

— structure-borne sound transmission through a building construction.

For each of these situations a general approached will be described in the next subclause of this clause. For several types of service equipment and installations, the most appropriate applications of these general models will be specified in clause 5.

The resulting normalized sound pressure level in a room in octave bands, L_{n}, follows from the addition of the transmitted sound from all relevant sources and transmission situations for the considered installation or service equipment:

$$L_{\mathrm{n}} = 10 \lg \left[\sum_{i=1}^{m} 10^{L_{\mathrm{n,d,i}}/10} + \sum_{j=1}^{n} 10^{L_{\mathrm{n,a,j}}/10} + \sum_{k=1}^{o} 10^{L_{\mathrm{n,s,k}}/10} \right] \mathrm{dB} \qquad (2)$$

where

L_{n} is the total normalized sound pressure level in a room due to the sound source i, j and k, in decibels;

$L_{\mathrm{n,d,i}}$ is the normalized sound pressure level due to sound transmission through a pipe or duct for source i, in decibels;

$L_{\mathrm{n,a,j}}$ is the normalized sound pressure level due to air-borne sound transmission through the building structure for source j, in decibels;

$L_{\mathrm{n,s,k}}$ is the normalized sound pressure level due to structure-borne sound transmission through the building structure for source k, in decibels;

m is the number of sound sources related to duct transmission;

n is the number of air-borne sound sources;

o is the number of structure-borne sound sources.

In case the building performance is to be expressed by the maximum level, especially with time weighting "F", the results from Equation 2 can be considered as an estimate of the upper limit. An estimate of the lower limit would than be the maximum value of all the sources considered separately.

The models can be used to calculate the building performance in octave bands, based on acoustic data for the sound sources and building elements in octave bands. The calculations are to be performed for the octave bands from 63 Hz to 4000 Hz, unless a more limited range is sufficient for the considered type of equipment. From these the single number rating for the building performance (A- or C-weighting) can be deduced as for the measurement results in accordance with EN ISO 16032.

NOTE The calculations can be extended to higher or lower frequencies if acoustic data are available for such a larger frequency range. However, especially at the lower frequencies no information is currently available on the accuracy of such calculations (see also Annex G).

The models assume a diffuse sound field in the receiving room. Though often a sufficiently realistic assumption, large deviations may occur at low frequencies. Since sound from some service equipment will be dominated by low frequencies, such deviations cannot be neglected. Special attention will be given to this aspect for the application of the models to specific service equipment and installations. General information on this aspect is given in Annex G.

4.2 Air-borne sound transmission through pipes and ducts

4.2.1 General

Each element of a duct system can be a transmission element as well as a sound source. In the predictions each sound source is considered separately and the sources and elements are considered to be independent, thus interference between elements, modal effects and resonances are neglected.

The normal quantity to express the source strength is the air-borne sound power level L_W, injected into the duct. The sound transmission through the duct is described by the sound power level reduction ΔL_W occurring in each distinguishable element of the duct. The resulting sound pressure in a receiving room is either caused by sound radiating at the duct opening (room a) or by sound radiating by the duct itself (room b). The resulting sound pressure level depends on the absorption in that room, which is normalized to A_{ref} = 10 m^2.

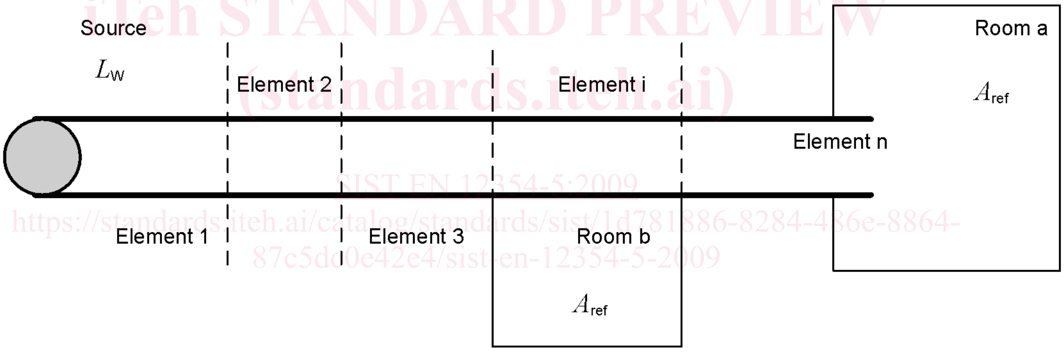

Figure 1 – System of a pipe with a sound source, transmission elements and receiving rooms (a and b)

The resulting normalized sound pressure level in a room, $L_{n,d}$, due to a sound source in a duct follows from:

$$L_{n,d} = L_W - \sum_{i=1}^{e} \Delta L_{W,i} + 10 \lg \frac{4}{A_{ref}} \text{ dB} \tag{3}$$

where

L_W is the sound power level of the source, in decibels;

$\Delta L_{W,i}$ is the sound power level reduction by element i, in decibels;

e is the number of elements between source and receiving room;

A_{ref} is the reference absorption area (= 10 m^2) , in square metres.

NOTE 1 This relation assumes a diffuse sound field in the room. However, that is often not the case. In EN 12354-6 indications are given of the effect of non-diffuse spaces on the resulting sound levels. These indications can be used to correct the estimation of the sound pressure level in the room.

NOTE 2 If not the room average is of interest but the sound pressure level at a specific position in the room, this level may be influenced or even dominated by the direct sound of the sound-radiating element in the room. For a position at distance r of that element with a directivity factor Q, the last term in Equation (3) is to be replaced by: $10 \lg \left[\frac{Q}{4\pi / r^2} + \frac{4}{A_{\text{ref}}} \right]$.

The radiated sound power into a room is influenced by the position of the radiating element (last element in the chain, i = e) in the room with respect to its boundaries. This effect shall be included in the sound power level reduction of that last element. For some elements this is already included through the applied measurement method, but if that is not the case it shall be added to the sound power level reduction of the radiating element; see Annex E.

If the considered source is the sound field in a room the performance of the duct system can also be expressed as the normalized level difference of the transmission system $D_{\text{n,s}}$ as treated in EN 12354-1. This level difference follows from:

$$D_{\text{n,s}} = \sum_{\text{i}=1}^{\text{e}} \Delta L_{\text{W,i}} + 10 \lg \frac{A_{\text{ref}}}{S_1} \text{ dB} \tag{4}$$

where

$D_{\text{n,s}}$ is the normalized sound level difference for indirect transmission through a system s, in decibels;

S_1 is the area of the first element (i=1) of the transmission system in the source room, i.e an opening, duct section or air terminal device, in square metres.

NOTE For air transfer devices or a pair of air terminal devices with a simple ventilation systems for dwellings, this quantity is also directly measured and expressed as the $D_{\text{n,e}}$, see EN 13141-1 and EN 13141-2. Equation. (4) could than be used also to deduce the sound power level reduction for such (combination of) elements.

4.2.2 sources

The sources can be elements of the system which produce sound themselves, as an air moving device or a burner, sound created at or by elements of the system, such as flow-generated sound from grids, bends and silencers or sound injected into the duct from outside.

In all cases the strength of these air-borne sound sources will be given by the sound power level L_{W}, as it is propagating into the duct in one - considered - direction or as it its radiated directly into the surrounding space. The sound power level should relate to the appropriate operating conditions of the considered system. The sound power level of sources is primarily based on the results of standardized measurement methods.

4.2.2.1 Air moving device

For a ducted air moving device we normally distinguish between the inlet sound power level, $L_{\text{W,in}}$, outlet sound power level, $L_{\text{W,out}}$, and unit sound power level, $L_{\text{W,unit}}$, in which "inlet" and "outlet" refer to the flow direction and 'unit' to the radiated structure-borne sound by the device itself. The sound power level of these sources is primarily based on standardized measurements; see also Annex B.

4.2.2.2 Flow-generated sound

For the sources as flow-generated sound from grids, bends, flow rate controllers, fire dampers, multi-leaf-dampers and silencers the sound power level can be determined directly by measurements. Estimations can be deduced from empirical relations, see Annex B.

4.2.2.3 Sound entering through openings and devices

For the source as the sound entering the duct from the outside through a duct opening, inlet or outlet devices, the sound power level can be determined indirectly from the measured transmission loss of that opening or device. The sound power level for transmission into the duct, L_{W}, follows from the transmission loss $D_{\mathrm{t,oi}}$ of the device from outside to inside (see 4.2.3) as:

$$L_{\mathrm{W}} = L_{\mathrm{o}} - D_{\mathrm{t,oi}} + 10\lg\frac{S_{\mathrm{co}}}{4}\ \mathrm{dB} \qquad (5)$$

where

$D_{\mathrm{t,oi}}$ is the sound power transmission loss for a duct opening or device for transmission from outside to inside, in decibels;

L_{o} is the sound pressure level in the source room, in decibels;

S_{co} is the area of the cross section of the duct opening, in square metres.

NOTE The transmission loss of the opening device can be based on direct measurements. Since there is by definition a relation between the transmission loss of an air-terminal device, i.e an opening, from outside to inside the duct and vice versa, the one can be deduced also from the other; see Annex E.

Since this sound transmission is also influenced by the position of the opening or device with respect to the room boundaries, this effect shall be included in the sound power transmission loss of the considered element. For some elements this is already included through the applied measurement method, but if that is not the case it shall be added to the sound power transmission loss of the considered element; see Annex E.

4.2.2.4 Sound entering through duct wall

For the sources as the sound entering the duct from outside (breaking in), the sound power level can be determined indirectly from the measured transmission loss of the duct. The sound power level for transmission up or downstream the duct, L_{W}, follows from the sound reduction index R_{oi} (transmission loss from outside to inside) of the duct as:

$$\begin{aligned} L_{\mathrm{W,u}} &= L_{\mathrm{o}} - R_{\mathrm{oi}} + 10\lg S_{\mathrm{d}} - 6 - 10\lg\frac{S_{\mathrm{cd,u}} + S_{\mathrm{cd,d}}}{S_{\mathrm{cd,u}}}\ \mathrm{dB} \\ L_{\mathrm{W,d}} &= L_{\mathrm{o}} - R_{\mathrm{oi}} + 10\lg S_{\mathrm{d}} - 6 - 10\lg\frac{S_{\mathrm{cd,u}} + S_{\mathrm{cd,d}}}{S_{\mathrm{cd,d}}}\ \mathrm{dB} \end{aligned} \qquad (6)$$

where

L_{o} is the sound pressure level in the room outside the duct, in decibels;

R_{oi} is the sound reduction index of the duct for transmission from outside to inside, in decibels;