Eurovent Industry Recommendation / Code of Good Practice

Eurovent 16/3 - 2023

Air curtain unit: Acoustic performance and calculations

First Edition

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Document history

This Eurovent Industry Recommendation supersedes all of its previous editions, which automatically become obsolete with the publication of this document.

Modifications

This Eurovent publication was modified as against previous editions in the following manner:

Modifications as against	Key changes
1st edition	Present document

Preface

In a nutshell

This Eurovent Recommendation provides manufacturers with helpful guidelines on how to measure and state the sound emitted by an air curtain. After a first introduction to acoustics, the document focuses on the sound emitted from an air curtain and provides a template with all the data to be measured and declared by manufacturers in order to help give customers' confidence.

Authors

This document was published by Eurovent and was prepared in a joint effort by participants of the Product Group 'Air Curtains and Fan Heaters (PG-CUR), which represents a vast majority of all manufacturers of these products active on the EMEA market.

Copyright

Suggested citation

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Important remarks

Eurovent does not grant any certification based on this document. All certification-related issues are managed by the association's independent subunit Eurovent Certita Certification in Paris. For more information, visit www.eurovent-certification.com.

Contents

Eurovent 16/3 - 2023 ____ 1
Document history ____ 2
  Modifications ____ 2
Preface ____ 2
  In a nutshell ____ 2
  Authors ____ 2
  Copyright ____ 2
    Suggested citation ____ 2
  Important remarks ____ 2
Sound Measurement ____ 4
  Introduction ____ 4
  Basics ____ 4
    Sound pressure ____ 4
    Sound power ____ 4
    Frequency ____ 5
    Direction diagram ____ 5
  Sound emitted from an air curtain ____ 5
    Adaption on the human ear ____ 6
    Several sound sources ____ 6
    Sound power level and sound pressure level in situ ____ 7
    Calculation of sound pressure level ____ 8
    Measured Product Values ____ 9
    Standards ____ 9
About Eurovent ____ 11
  Our Member Associations ____ 11

Sound Measurement

Introduction

Noise is determined as sound which causes harm to the health and is estimated negatively. The harmful influence on the human organism is very different. The long influence of an intensive noise (over 80 dBA) on the human ear can cause partial or full loss of hearing. The influence of the noise is not limited only to the loss of hearing through the hearing nerves. Noise has influence on the human nervous system and even on human internal organs. For impulse and nonregular noises, the influence is even more. For this reason, acoustics appear – to measure the levels of noise and to defend people's health.

Basics

To determine the levels of noise, people introduced several physical quantities, the main ones are - sound pressure, sound power and frequency.

Sound pressure

Sound pressure is the pressure waves with which the sound moves in a medium, for instance, air.

The human ear interprets these pressure waves as sound. They are measured in Pascal [Pa].

The weakest sound pressure that the ear can interpret is 0,00002 Pa (p_0), which is the threshold of hearing. The strongest sound pressure which the ear can tolerate without damage is 20 [Pa], referred to as the upper threshold of hearing.

The large difference in pressure, as measured in [Pa], between the threshold of hearing and the upper threshold of hearing, makes the figures difficult to handle. So a logarithmic scale is used instead, which is based on the difference between the actual sound pressure level (p) and the sound pressure at the threshold of hearing. This scale uses the decibel (dB) unit of measurement, where the threshold of hearing is equal to 0 [dB] and the upper threshold of hearing is 120 [dB].

To recalculate [dB] from [Pa] you can use the following formula:

$$L = 20 \cdot \log(p/p_0)\ [dB]$$

The sound pressure reduces as the distance from the sound source increases and is affected by the room's characteristics and the location of the sound source. Sound pressure can be measured by the microphone.

Sound power

Sound power is the energy per time unit (Watt) that the sound source emits.

The sound power is not measured, but it is calculated from the sound pressure. There is a logarithmic scale for sound power similar to the scale for sound pressure.

The sound power is not dependent on the position of the sound source or the room's sound properties, and it is, therefore, easier to compare between different objects. Sound power is not measured directly, it is calculated from the sound pressure.

Frequency

Frequency (f) is a measurement of the sound source's periodic oscillations.

Frequency is measured as the number of oscillations per second, where one oscillation per second equals 1 Hertz (Hz).

More oscillations per second, i.e. a higher frequency, produces a higher tone.
In the range 16 [Hz]-20.000 [Hz] these oscillations are called sound.

Lower than 16 [Hz] they are called infrasound and higher than 20000 [Hz] ultrasound. Frequencies are often divided into 8 groups, known as octave bands: 63 [Hz], 125 [Hz], 250 [Hz], 500 [Hz], 1.000 [Hz], 2.000 [Hz], 4.000 [Hz] and 8.000 [Hz]. Knowing frequency, you can calculate the length of the sound wave:

$$\lambda = c/f\ [m]$$

where c is the speed of sound [m/s].

Direction diagram

Usually, sound sources are not emitting sound in all directions in the same way. You can compare the sound source with the lantern. Lantern power is the analogue to the sound power of the sound source and illumination is the analogue to the intensity of the sound. Illumination is decreasing in the same way as the intensity of the sound when the distance to the source increases.
The lantern is shining not equally in all directions and in the same way, the sound source does.

This is called direction diagram and that is why it is usually necessary to measure sound pressure in several points and using this measurement to calculate sound power:

$$W = \int \frac{\overline{\mathrm{p}}^{2}}{\rho c} ds$$

$$L_w = 10 \cdot \log(W/W_0)\ [dB]$$

Where $W_0=10^{-12}$[W]

Sound emitted from an air curtain

Sources of sound can be very different. But the main types are mechanical, aerodynamic, hydrodynamic, and electrical sounds.

Mechanical sounds are usually presented in production plants or in places where there are a lot of machines, so not by an air curtain. The electrical sound can be attributed to the magnetic sound of electric motors, the sound of electrical components of the control system, etc.

Aerodynamic sound is usually divided into broadband sound and discrete sound.

Broadband sound is connected to the turbulence near the solid boundaries (vortex sound, boundary layer sound) and separation of flow.

Discrete sound is connected to the heterogeneity of the flow and interaction of the various elements in the flow path. Discrete sound has usually greater input into the sound power. When we are talking about the air curtains, their discrete sound frequencies relate to the speed of rotation (n) of the fan and the type of selected fan.

Adaption on the human ear

Because of the ear's varying sensitivity at different frequencies, the same sound level in both low and high frequencies can be perceived as two different sound levels. As a rule, we perceive sounds at higher frequencies more easily than at lower frequencies. For that reason, there is a Filter to evaluate the noise in the human ear.

Filter A

The sensitivity of the ear also varies in response to the sound's strength. Several so-called weighting filters have been introduced to compensate for the ear's variable sensitivity across the octave band.

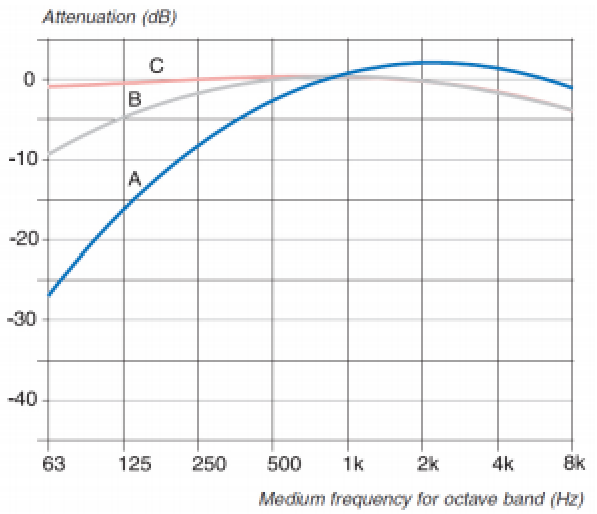

Figure 1: Different filters

A weighting filter A is used for sound pressure levels below 55 [dB]. Filter B is used for levels between 55 and 85 [dB], and filter C is used for levels above 85 [dB]. The A filter, which is commonly used in connection with air curtains, has a damping effect on each octave band as shown:

[Hz]	63	125	250	500	1k	2k	4k	8k
[dB]	-26,2	-16,1	-8,6	-3,2	0	+1,2	+1	-1,1

The resultant value is measured in [dB(A)]. There are other ways of compensating for the ear's sensitivity to different sound levels, apart from these filters. A diagram with NR curves (Noise Rating) shows sound pressure and frequency (per octave band). Points on the same NR curve are perceived as having the same sound levels, meaning that 43 [dB] at 4.000 [Hz] is perceived as being as loud as 65 [dB] at 125 [Hz].

Several sound sources

We have different sound sources in an air curtain due to the different amounts of fans. In addition to that, in one Installation there is the possibility to install an air curtain on the left and on the right side of the entrance.

To establish the total sound level in a room, all the sound sources must be added together logarithmically.

Sound power level and sound pressure level in situ

There is a link between a sound source's sound power level and the sound pressure level. If a sound source emits a certain sound power level, the following factors will affect the sound pressure level: The position of the sound source in the room, including the direction factor (1), the distance from the sound source (2) and the room's sound-absorbing properties, referred to as the room's equivalent absorption area (3).

Direction factor, Q

The direction factor shows the sound's distribution around the sound source. Distribution in all directions, spherical, is measured as Q = 1. Distribution from a diffuser positioned in the middle of a wall is hemispherical, measured as Q = 2.

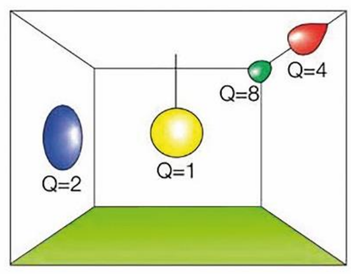

Figure 2: Distribution of sound around the sound source ©Systemair

- Q = 1 In the centre of the room
- Q = 2 On wall or ceiling
- Q = 4 Between wall or ceiling
- Q = 8 In a corner

Distance from the sound source, r

Where r indicates the distance from the sound source in meters.

The room's equivalent absorption area, A_{eqv}

A material's ability to absorb sound is indicated as an absorption factor α. The absorption factor can have a value between '0' and '1', where the value '1' corresponds to a fully absorbent surface and the value '0' to a fully reflective surface. The absorption factor depends on the qualities of the material and the tables available, which indicate the value of different materials.

A room's equivalent absorption area is measured in [m²] and is obtained by adding together all the different surfaces of the room multiplied by their respective absorption factors. In many instances, it can be simpler to use the mean value for sound absorption in different types of rooms, together with an estimate of the equivalent absorption area (see Fig. 2).

Equivalent absorption area based on an estimate

If values are not available for the absorption factors of all the surfaces, and a more approximate value of the room's total absorption factor is quite adequate, an estimate can be calculated in accordance with the diagram below. The diagram is valid for rooms with normal proportions, for example 1:1 or 5:2. Use the diagram as follows to estimate the equivalent absorption area: calculate the room's volume and read off the equivalent absorption area with the correct mean absorption factor, determined by the type of room.

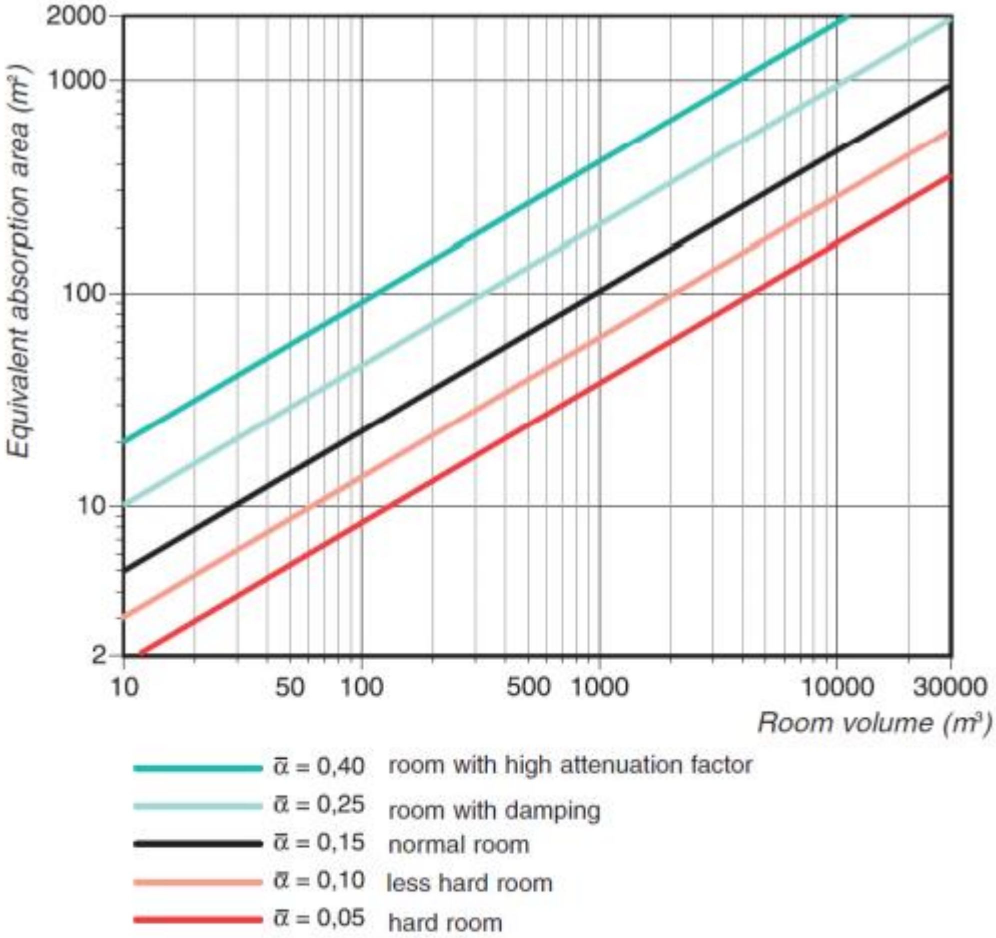

Figure 3 Estimation of equivalent absorption area

Calculation of sound pressure level

$$L_{pA} = L_{wA} + 10 \cdot \log\left[\frac{Q}{4\pi r^2} + \frac{4}{A_{eqv}}\right]$$

Where:

- L_{pA} = sound pressure level [dB]
- L_{wA}= sound power level [dB]
- Q = direction factor
- r = distance from sound source [m]
- A_{eqv} = equivalent absorption area [m² Sabine]

Measured product values

In order to give the customer confidence, the following data shall be measured and made available (the numbers are given as examples):

Air flow product:	XYZ		
Air flow [m^3/h]	1.800	1.450	1.150
Minimum (highest/lowest airflow in [m^3/h]	1.800		1.150
Sound data			
Sound level [dB(A)]	52	48	40
Sound power level LWA [dB(A)]	XX		
Sound power (LWA) measurements according to ISO 27327-2: 2014, installation type E			
Sound pressure [dB(A)]	52		40
Sound pressure (LpA) Conditions: Distance to the unit 5 meters Directional factor: 2 (on the wall) Equivalent absorption area: 200 m^2 at lowest/highest air flow			X

Standards

The values stated should reference a measurement method as defined by a European or international standard listed here:

- **ISO 27327-2: 2014**, Fans – Air curtain units – Part 2: Laboratory methods of testing for sound power

Data obtained in accordance with ISO 27327-2 can be used for the following purposes, amongst others:

a) Comparison of air curtain units which are similar in size and type
b) Comparison of air curtain units which are different in size, type, design, speed, etc.
c) Determining whether an air curtain unit is suitable for a specified upper limit of sound emission
d) Scaling air curtain unit noise from one size and speed to another size and speed of the same type of air curtain unit
e) Prediction of sound pressure level in application of the air curtain unit
f) Engineering work to assist in developing machinery and equipment with lower sound emissions

In addition, there are other standards that should be considered when assessing the acoustic performance of units:

- **ISO 266:1997**, Acoustics – Preferred frequencies
- **ISO 3740:2019**, Acoustics – Determination of sound power levels of noise sources — Guidelines for the use of basic standards
- **ISO 3741:2010**, Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms
- **ISO 3743-1:2010**, Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for small movable sources in reverberant fields – Part 1: Comparison method for a hard-walled test room
- **ISO 3743-2:2018**, Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms
- **ISO 3747:2010**, Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering/survey methods for use in situ in a reverberant environment
- **ISO 5801:2017**, Industrial fans – Performance testing using standardised airways
- **ISO 6926:2016**, Acoustics – Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels
- **ISO 13347-1:2004**, Industrial fans – Determination of fan sound power levels under standardised laboratory conditions – Part 1: General overview
- **ISO 13347-2:2004**, Industrial fans – Determination of fan sound power levels under standardised laboratory conditions – Part 2: Reverberant room method
- **ISO 13349-1:2022**, Fans – Vocabulary and definitions of categories – Part 1: Vocabulary
- **ISO 13349-2:2022**, Fans – Vocabulary and definitions of categories – Part 1: Categories
- **ISO 27327-1:2009**, Fans – Air curtain units – Part 1: Laboratory methods of testing for aerodynamic performance rating

About Eurovent

Eurovent is Europe's Industry Association for Indoor Climate (HVAC), Process Cooling, and Food Cold Chain Technologies. Its members from throughout Europe represent more than 1.000 organisations, the majority small and medium-sized manufacturers. Based on objective and verifiable data, these account for a combined annual turnover of more than 30bn EUR, employing around 150.000 people within the association's geographic area. This makes Eurovent one of the largest cross-regional industry committees of its kind. The organisation's activities are based on highly valued democratic decision-making principles, ensuring a level playing field for the entire industry independent from organisation sizes or membership fees.

Our Member Associations

Our Member Associations are major national sector associations from Europe that represent manufacturers in the area of Indoor Climate (HVAC), Process Cooling, Food Cold Chain, and Industrial Ventilation technologies.

The more than 1.000 manufacturers within our network (Eurovent 'Affiliated Manufacturers' and 'Corresponding Members') are represented in Eurovent activities in a democratic and transparent manner.

→ For in-depth information and a list of all our members, visit www.eurovent.eu