APPLICATION NOTE

About this document

Content

This document is the third part of a series of application notes on the sound energy quantities *sound power* and *sound intensity*. It contains information on the determination of sound power on the basis of sound pressure measurements.

Target group

This application note is intended for acousticians who are interested in the basics of determining sound power from sound pressure measurements with microphones.

Questions?

Do you have questions? Your feedback is appreciated!
For question on the content of this document: Imke.Hauswirth@head-acoustics.com
For technical questions on our products: SVP-Support@head-acoustics.com

Sound Power and Sound Intensity – Part 3

Determination of Sound Power from Sound Pressure Measurements

Definition of the measurement surface

To determine the sound power based on sound pressure measurements, a measurement surface must first be defined. The measurement surface is a hypothetical surface on which the sound pressure measurements are performed. It surrounds the measurement object completely or envelops the measurement object in conjunction with a sound-reflecting closed surface[1]. Theoretically, the distance between the measurement surface and the measurement object is irrelevant. The larger the distance to the measurement object, the larger the measurement surface, which, in turn, is taken into consideration when calculating the sound power.

Different measurement surfaces are possible, e.g., cubic, hemispheric, and a measurement surface following the contour of the object under examination.

To determine the sound power by means of sound pressure measurements in the free field, a hemisphere is often used. The hemisphere has the advantage that the sound power can be determined by using relatively few measuring points. According to ISO 3744, it is recommended to start with 10 measurement points. The microphones are positioned with each microphone assigned an equal portion on the surface of the hemisphere.

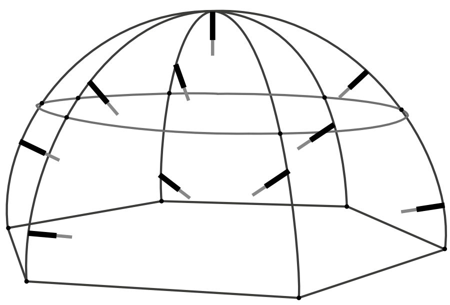


Figure 1: Microphone hemisphere

[1] If the floor is assumed to be sound reflective (e.g., a concrete floor), it does not have to be included in this surface.

If the sound pressure levels at the different measurement points differ too much, the number of microphones must be increased.

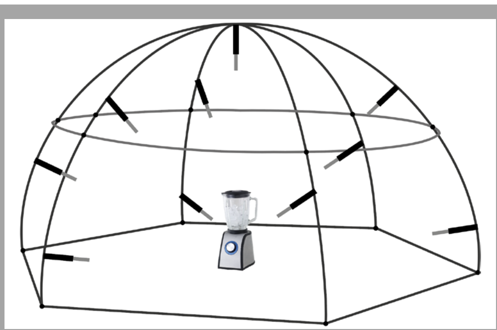
Determination of sound power

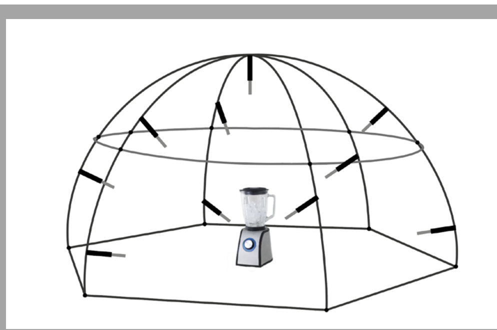
To determine the sound power, the sound pressure level L_P is first determined at several points (*1* to *N*) on a measurement surface *S* enveloping the sound source in the free field. These measurements can then be used to calculate the sound power level L_W:

$$L_W = 10 \cdot log\left[\frac{1}{N}\sum_{i=1}^{N} 10^{0,1L_{Pi}}\right] + 10 \cdot log\left[\frac{S}{S_0}\right]$$

The formula consists of two sections: In the first term, the contributions of the different measurement microphones are averaged energetically and a total sound pressure level in dB is determined. Averaging the sound pressures at the various measurement positions yields a sound pressure that is representative of the entire measurement object, irrespective of the position of the individual measurement microphones. In the second term, the size of the measurement surface S is related to the reference surface S_0 and is also converted into a dB value. Considering the size of the measurement surface makes the calculation of the sound power level independent of the distance between the measurement microphones and the measurement object:

Effect of the size of the measurement surface





A larger measurement surface means that the distance between the measurement object and the measurement microphone becomes larger. This leads to a lower measured sound pressure and thus to a lower value for the first term of the equation. However, this is compensated by the second term, which becomes larger for a larger measurement surface.

$$L_W = 10 \cdot log\left[\frac{1}{N}\sum_{i=1}^{N} 10^{0,1L_{Pi}}\right] + 10 \cdot log\left[\frac{S}{S_0}\right]$$

becomes smaller with a larger measurement surface

becomes larger with a larger measurement surface

A smaller measurement surface means that the distance between the measurement object and the measurement microphone becomes smaller. This leads to a higher measured sound pressure and thus to a higher value for the first term of the equation. However, this is compensated by the second term, which becomes smaller for a smaller measurement surface.

$$L_W = 10 \cdot log\left[\frac{1}{N}\sum_{i=1}^{N} 10^{0,1L_{Pi}}\right] + 10 \cdot log\left[\frac{S}{S_0}\right]$$

becomes larger with a smaller measurement surface

smaller with a smaller measurement surface

→ L_W remains constant

Accuracy classes

The exact procedure is specified in various standards (e.g., ISO 3744). Depending on the measuring equipment available and the measurement conditions existing during the measurements, the measurement can be carried out according to different accuracy classes. The procedure according to accuracy class 1 (Precision) is the one with the most requirements. Measurements performed according to class 3 (Survey) serve as control measurements.

Correction values

To make sound power measurements comparable and to eliminate external influences, correction factors may have to be used in the calculation. In this way, background noise and room influences can be corrected. Furthermore, the existing environmental conditions (e.g., low temperatures) may have to be considered. The correction factors K_0, K_1 and K_2 used in ISO 3744 serve this purpose, for example:

Correction factors K_0, K_1, K_2

Atmosphere correction K_0	This correction factor allows unfavorable atmospheric influences to be corrected. For this purpose, both the barometric pressure and the temperature prevalent during the measurement must be measured. A value for K_0 in dB is then determined from the measurement results.
Background noise correction K_1	To determine the frequency-dependent correction factor K_1, a measurement at rest must be performed during which the test object is not in operation. Such a measurement is used to determine the background noise or extraneous noise level. If this value is too high compared to the level during operation, the correction value K_1 must be used. The extraneous noise can be composed of airborne noise, structure-borne noise, and electrical noise of the measuring device.
Environmental correction K_2	The frequency-dependent correction factor K_2 considers ambient influences that falsify the sound pressure measurement (e.g., undesired room influences such as reflections and absorptions).

➜ *Proceed to the fourth application note on sound power providing information on the determination of sound power on the basis of sound intensity measurements.*