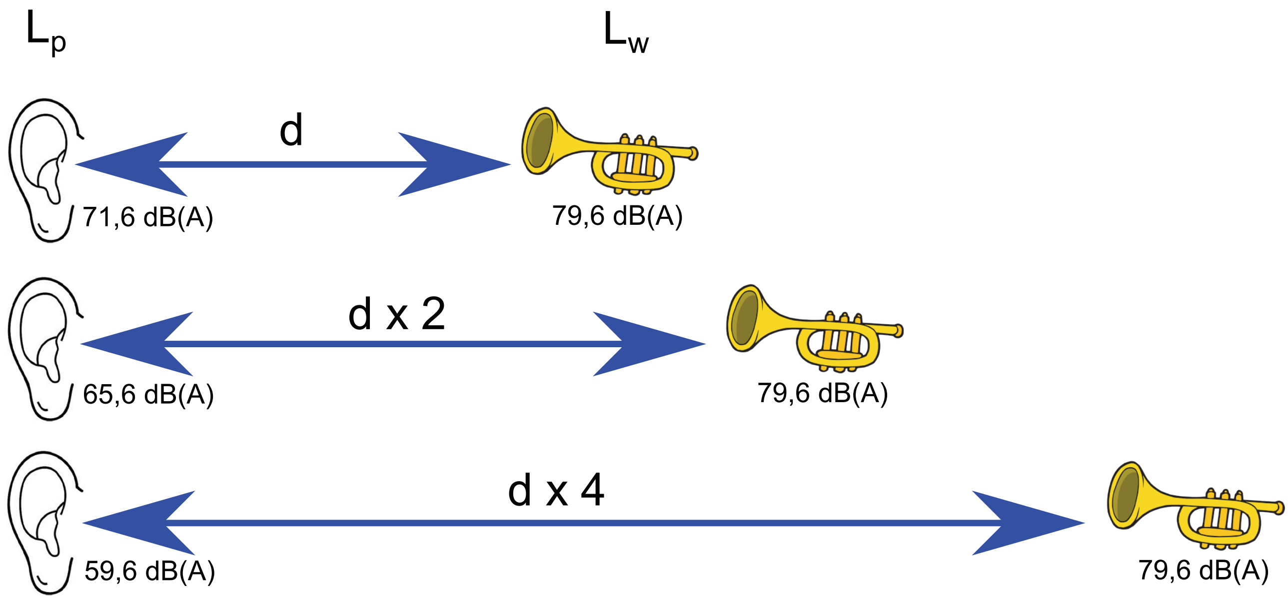
1 ACOUSTIC ISSUES

For all aerothermal appliances for which only outdoor installation is possible, it is essential to assess the acoustic aspects related to the positioning of the units, both for the verification of compliance with any regulatory limits on noise emissions, and for the assessment of the acoustic comfort of the users surrounding the installation site.

2 DEFINITIONS

The measurement unit usually used to express acoustic quantities in the HVAC sector is the dB(A), which is a measurement of sound intensity weighted according to the sensitivity of the human ear (which is higher at low frequencies than at high frequencies).
This is a logarithmic scale, so for example an increase of 3 dB(A) translates into a doubling of the perceived sound intensity.
It is essential to remember the distinction between sound power Lw and sound pressure Lp.
Figure 2.1 *p. 1* lets you intuitively appreciate the difference between sound power Lw and sound pressure Lp.

Figure 2.1 *Sound power and pressure*



d distance of the measuring point from the sound source
Lw [dB(A)] Sound power
Lp [dB(A)] Sound pressure at distance d, with precise positioning of the source

2.1 SOUND POWER LW

Sound power Lw expressed in dB(A) characterises the overall sound emission capacity of the source: it is an intrinsic property of the sound source, independent of the distance from the measuring point.
This value is usually measured in appropriately equipped laboratories and makes it possible to compare different emission sources (appliances).

2.2 SOUND PRESSURE LP

Sound pressure Lp, also expressed in dB(A), on the other hand, is an index of the sound level perceived at a given location and therefore depends on several factors:
- distances of the different sound sources
- directivity factors
- environmental conditions (reverberation)
- background noise

Being a local parameter, it is usually measured on site with a sound level meter.

3 ACOUSTIC ASSESSMENT

Acoustic assessment cannot disregard correct appliance positioning, also in connection with the installation context and the level of naturally occurring background noise (which is higher e.g. in urban settings than in rural settings).
Table 3.1 *p. 2* shows a generic indication of the background noise levels naturally present in some reference environments, expressed as Level of equivalent continuous sound pressure (Leq), which is an average of the sound energy level.
This type of table is established by national and/or local regulations, since they are necessarily affected by lifestyles, climate and architecture of the buildings.

Table 3.1 *Example of background noise levels in reference environments - Leq [dB(A)]*

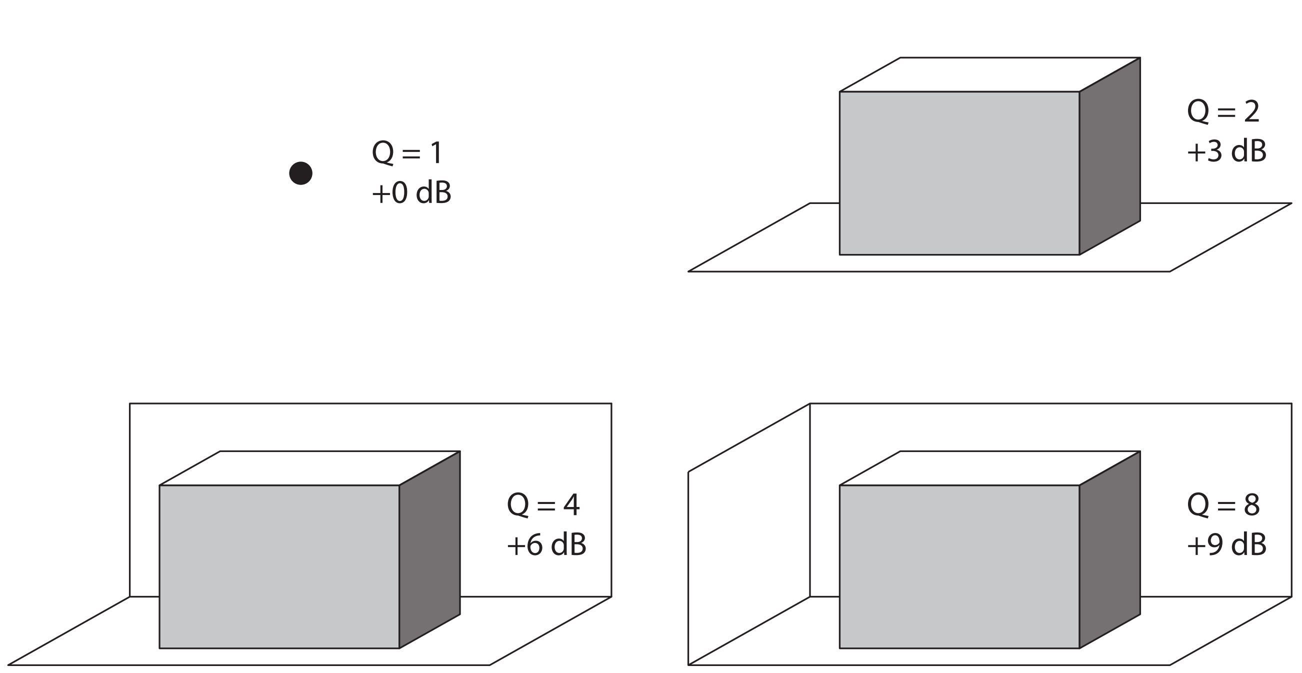
Type of area	Day	Medium	Night
Hospitals, rest areas, protected natural areas	45	40	35
Rural or peripheral residential areas, with low traffic (vehicular/aircraft)	50	45	40
Urban residential areas	55	50	45
Residential and retail areas with medium-high traffic (vehicular/aircraft)	60	55	50
Retail and industrial areas (light industry)	65	60	55
Industrial areas (heavy industry)	65	65	65

Figure 3.1 *p. 2* sets out the sound pressure increase depending on source positioning with respect to any obstacles able to reflect sound.
A sound source sufficiently distant from any obstacle (point source, i.e. directivity factor Q equal to 1) is taken as a reference, which is, however, an absolutely unrealistic case in relation to the actual positioning of the appliances, as they are always at least resting on a flat surface (i.e. directivity factor Q equal to 2 and sound pressure increase of 3 dB(A)).

Sound pressure values for Robur appliances

All sound pressure values published in the technical data tables for Robur appliances (Section B) refer to installation with directivity factor 2, i.e. they already include the 3 dB(A) increase due to positioning the appliance on a flat surface. When comparing with sound pressure values of other manufacturers' appliances, it is essential to check that the directivity factor and the distance to which the sound pressure value refers are the same.

Figure 3.1 *Sound reflection factors*



Q. Directivity factor

It should be considered that acoustic shielding can be combined with visual shielding, which is sometimes required regardless of whether the acoustic aspects are critical or not.

4 OVERALL RESULTING SOUND PRESSURE

The overall sound pressure resulting from the simultaneous presence of several sound sources may be calculated either in a simplified or analytical manner.
In no case, since the dB(A) scale is logarithmic, the calculation can be performed by simply adding up the sound pressure values of the individual appliances, due to the simplifications it implements.
The difference between the sound pressures Lp between the appliances (both at the same distance and under the same measurement conditions) is taken into account, and based on this, the value indicated in Table 4.1 *p. 3* is added to the highest Lp value.

4.1 SIMPLIFIED CALCULATION

Simplified calculation may only be used if there are two

Table 4.1 *Simplified calculation table of the resulting Lp value*

Difference in dB(A) between L_p figures	dB(A) to be added to the highest L_p value
0÷1	3
2÷3	2
4÷6	1
>6	0

Example of calculation with identical units

Two identical GAHP A HT (sound pressure Lp at 5 metres (max) 57,6 dB(A)) give a resulting total sound pressure Lp of (57,6 + 3 = 60,6 dB(A)) because the difference between the Lp values of the two sound sources is 0 dB and therefore the value to be added to the higher Lp value is 3 dB(A). This in fact, since the dB(A) scale is logarithmic, correctly translates into a doubling of the perceived sound intensity.

Example of calculation with different units

A GAHP A HT S1 (sound pressure Lp at 5 metres (max) 52,0 dB(A)) operating together with a ACF60-00 (sound pressure Lp at 5 metres (max) 57,6 dB(A)) gives a resulting total sound pressure Lp of (57,6 + 1 = 58,6 dB(A)) because the difference between the Lp values of the two sound sources is between 4 and 6 dB(A) and therefore the value to be added to the higher Lp value is 1 dB(A).

4.2 ANALYTICAL CALCULATION

The following formula is to be used for the analytical calculation of the resulting overall sound pressure:

$$L_p = 10\log_{10}\left(\sum_{i=1}^{n} 10^{\frac{(L_p)_i}{10}}\right)$$

Lp is the overall resultant sound pressure level and $(Lp)_i$ is the sound pressure level of the individual sources (all at the same distance and under the same measurement conditions).

Example of calculation

Two GAHP-AR S (sound pressure Lp at 5 metres (max) 53,0 dB(A) each) operating with one GAHP A HT S1 (sound pressure Lp at 5 metres (max) 52,0 dB(A)) lead, applying the above formula, to a total resulting sound pressure of 57,5 dB(A):

$$L_p = 10\log_{10}\left(10^{\frac{53}{10}} + 10^{\frac{53}{10}} + 10^{\frac{52}{10}}\right)$$