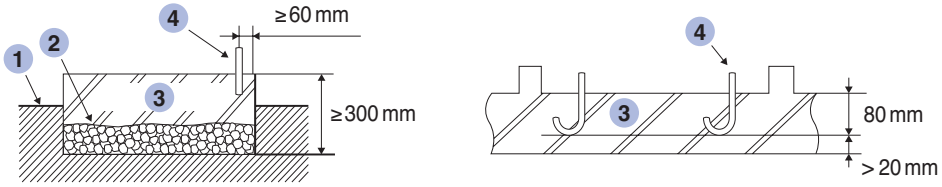
Fastening of the compact unit

The compact unit must be mounted on one level, horizontal and on a solid surface. Besides the weight of unit, also the weight of water must be considered. Four anchoring bolts M12 are needed for fastening, where the tightening force is minimum 15,000 N.

1. Ground
2. Stone quarry
3. Concrete and / or floor slab
4. Anchor bolt



Minimum requirements for anchoring the compact unit on the floor above a foundation (left) or directly in the floor plate (right).

5.10 Acoustics

5.10.1 Sound pressure level

Sound occurs when air vibrates. This vibration propagates in air as pressure waves and reaches the ear drum of the human ear. Independent of the type of noise (speech or motor noise) the sound can be measured as sound pressure. The larger the sound pressure, the louder the noise is perceived. The human ear can perceive a range from 20 × 10-6 Pa (hearing threshold) up to 20 Pa (threshold of pain). This range that corresponds to a ratio of 1:1,000,000 is not perceived by the human ear linearly, but rather logarithmically. For this reason the sound pressure is not specified as pressure, but rather as sound pressure level in decibel (dB). Values of sound pressure level for typical situations are:

Noise	Sound pressure level in dB(A)	Sound pressure in µPa	Perception
Forest	20	100	very quiet
Library	40	1,000	quiet
Speech	55	10,000	normal
Street	80	100,000	loud
Pneumatic hammer	100	1,000,000	very loud

Typical noise situations and occurring sound pressure levels and sound pressures

The non-linear perception of sound pressure leads to a state where two equally loud sound sources are not perceived as double as loud as one sound source but only 3 dB louder. Doubling of the volume of a noise source is associated with a sound pressure level increase by 10 dB.

The effect of other nearby noise influences will alter the perceveid noice limit values. The following table can therfore only act as a guide of noise limits for each type of area:

Industrial areas	Day and night	70 dB(A)
Commercial areas	Day time	65 dB(A)
	Night time	50 dB(A)
Core areas	Day time	60 dB(A)
	Night time	45 dB(A)
General residential areas	Day time	55 dB(A)
	Night time	40 dB(A)
Pure residential areas	Day time	50 dB(A)
	Night time	35 dB(A)
Health resort areas, hospitals	Day time	45 dB(A)
	Night time	35 dB(A)

The values are based on the measurable value 0.5 m in front of the middle of an opened window of the affected room to be protected. They are only valid as mean values and may be exceeded by temporary noise peaks.

The measurable sound pressure level is dependent on the distance to the sound source and decreases with increasing distance.

5.10.2 Sound power levels for estimation of sound pressure level

The sound power level is a quantity for evaluating the sound source independently of distance and direction of sound propagation. It is a calculable quantity that is determined for individual units in laboratory measurements under defined conditions. Based on the sound power level of a specific unit the sound pressure level can be estimated at a certain distance and for corresponding sound propagation conditions for a certain case.

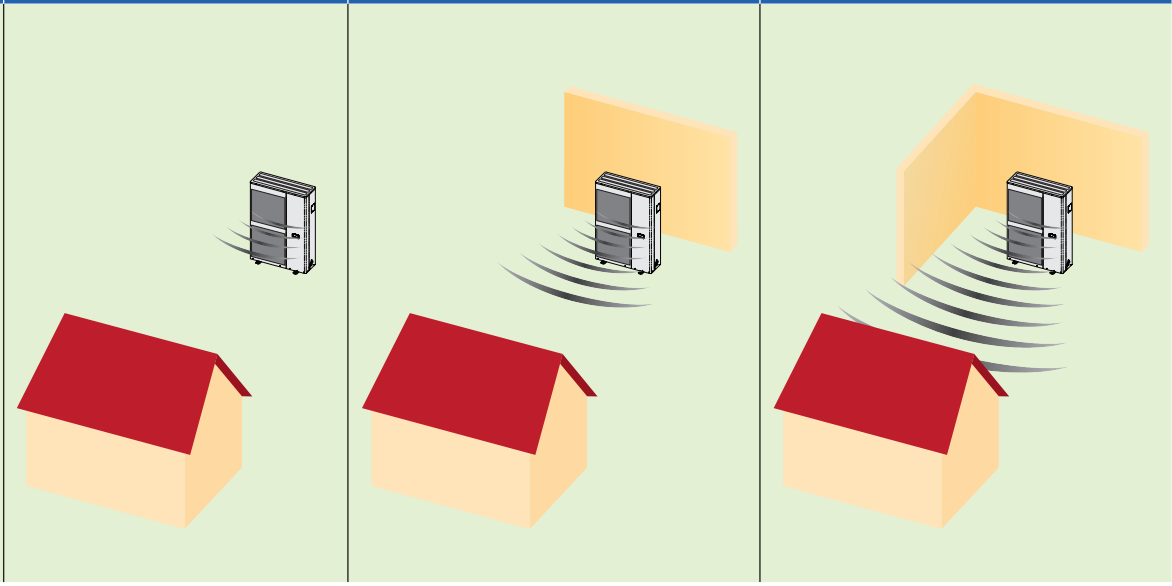
Sound propagates in all directions equally with the sound power from the sound source. With an increasing distance to the sound source, the area through which the sound penetrates expands in proportion to the distance from the sound source. This leads to a continuous decrease of the sound pressure level for a constant sound power. During sound propagation the sound pressure level is moreover influenced by the following factors:

- Interruption by obstructions like buildings, walls or landscape formations
- Reflection from surfaces such as walls, glass facades, buildings or asphalt-covered areas as well as areas made of stone
- Absorption of sound on e.g. grass, bark-chip mulch, leaves or fresh-fallen snow
- Wind can increase or decrease the sound pressure level (depending on wind direction).

An estimation of the sound pressure level L_{Aeq} at a certain place with a distance r from the heat pump can be calculated with the following formula based on the sound power level L_{WAeq}:

$$L_{Aeq} = L_{WAeq} + 10 \times \log \left(\frac{Q}{4 \times \pi \times r^2} \right)$$

For this, one additionally needs the direction factor Q, which considers the spatial radiation conditions of the sound source:

Sound propagation	Half space	Quarter space	Eighth space
Q=	2	4	8
Arrangement			

Directional factor Q for different arrangements of the sound source

Example

The outdoor unit WH-UD12CE5-A of a split system has a sound power level of 67 dB(A) and is installed such that the sound can propagate into the quarter space (Q = 4). The sound pressure level as 10 m distance results in:

$$L_{Aeq}\,(10\,m) = 67\,dB\,(A) + 10 \times \log\left(\frac{4}{4 \times \pi \times 10^2}\right) = 42\,dB\,(A)$$

For a distance of 20 m the sound pressure level is still:

$$L_{Aeq}\,(20\,m) = 67\,dB\,(A) + 10 \times \log\left(\frac{4}{4 \times \pi \times 20^2}\right) = 36\,dB\,(A)$$

The sound pressure level can be determined roughly from the following table, in that the table value is subtracted from the unit specific sound power level (see technical data).

Directivity factor Q	Distance from the sound source in m								
	1	2	4	5	6	8	10	12	15
2	-8	-14	-20	-22	-23,5	-26	-28	-29,5	-31,5
4	-5	-11	-17	-19	-20,5	-23	-25	-26,5	-28,5
8	-2	-8	-14	-16	-17,5	-20	-22	-23,5	-25,5

Table for rough calculation of the sound pressure level based on the sound power level.

Note

Through the selection of the installation location, the sound pressure level can be increased or decreased. Installation on reflective floor surfaces should be avoided. Sound pressure level can be reduced further by constructing obstructions, whereby the air flow itself should not be obstructed.

The sound output direction of outdoor and/or compact units should be selected if possible towards the street, since neighbouring rooms to be protected are seldom oriented in this direction.

In case of doubt, an acoustic engineer must be consulted.