Technology Collaboration Programme
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Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

Annex 51

Acoustic Signatures of Heat Pumps

Final Report – Part 13

7.1 Educational material, guides & guidelines

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Preface

This project was carried out within the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP), which is a Technology Collaboration Programme within the International Energy Agency, IEA.

The IEA

The IEA was established in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster cooperation among the IEA participating countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development (R&D). This is achieved, in part, through a programme of energy technology and R&D collaboration, currently within the framework of nearly 40 Technology Collaboration Programmes.

The Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

The Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) forms the legal basis for the implementing agreement for a programme of research, development, demonstration, and promotion of heat pumping technologies. Signatories of the TCP are either governments or organizations designated by their respective governments to conduct programmes in the field of energy conservation.

Under the TCP, collaborative tasks, or “Annexes”, in the field of heat pumps are undertaken. These tasks are conducted on a cost-sharing and/or task-sharing basis by the participating countries. An Annex is in general coordinated by one country which acts as the Operating Agent (manager). Annexes have specific topics and work plans and operate for a specified period, usually several years. The objectives vary from information exchange to the development and implementation of technology. This report presents the results of one Annex.

The Programme is governed by an Executive Committee, which monitors existing projects and identifies new areas where collaborative effort may be beneficial.

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A central role within the HPT TCP is played by the Heat Pump Centre (HPC).

Consistent with the overall objective of the HPT TCP, the HPC seeks to accelerate the implementation of heat pump technologies and thereby optimize the use of energy resources for the benefit of the environment. This is achieved by offering a worldwide information service to support all those who can play a part in the implementation of heat pumping technology including researchers, engineers, manufacturers, installers, equipment users, and energy policy makers in utilities, government offices and other organizations. Activities of the HPC include the production of a Magazine with an additional newsletter 3 times per year, the HPT TCP webpage, the organization of workshops, an inquiry service and a promotion programme. The HPC also publishes selected results from other Annexes, and this publication is one result of this activity.

For further information about the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) and for inquiries on heat pump issues in general contact the Heat Pump Centre at the following address:

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Acoustic Signatures of Heat Pumps

IEA HPT Annex 51

7.1: Educational material, guides & guidelines

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Date: July 2021	Final Version, Review: 04

Index

1 Introduction

In this document, four guides are included:

- Control the noise – a guide for installing air for water heat pumps
- Heat pumps & environment acoustics
- Heat pumps & recommendations for installation
- Heat pumps - study of the risk of noise pollution in the vicinity

The first guide is based on a documentation produced for the Danish Energy Agency. The three consecutive documents are based on fiche technquies from AFPAC, the French heat pump association. The original documents are available on the Annex 51 Website https://heatpumpingtechnologies.org/annex51/.

Control the noise – a guide for installing air for water heat pumps covers an introduction to heat pumps discussing noise/sound authority, noise from air to water heat pumps (noise creation, noise measurement, influence of operation conditions, noise regulations), noise distribution (outdoor noise, indoor noise), calculation models (noise data, operating conditions, sound calculation tool), noise reduction, good installation (vibration sources and distribution cannels, rules of thumb regarding vibration isolation), control measurements, npise reduction (noise shields, noise gates, cabinet vibrations, cabinet noise) and examples (unappropriate placement, good and bad placements, control measurment of noise).

Heat pumps & environment acoustics covers definitions of sound power and sound pressure, the calculation method of adding sound sources, recommendations for the implementations (location, reflection of emitted noise, reflection of received noise, directivity of ventilations, distance to property lines, installation under windows), reminder on the regulation of neighbourhood noise, application examples and emergence calculation (outdoor measurement, measurement inside buildings.

Heat pumps & recommendations for installation covers supports (concrete base, metal frame), network design rules (design principles, wall crossings), the pipes (direct expansion, water pipes), air networks (vibration transmission through ducts, noise transmission through ducts, radiation of noise through the walls of the duct, design principles), acoustic attenuation devices (absorbers on walls, sound barrier, enclosures) and maintenance.

Heat pumps - study of the risk of noise pollution in the vicinity covers measurements of residual noise without heat pumps, acoustic emergence, manufacturer documentation, conversion of acoustic power / pressure, place of installation (location, reflection of emitted noise), location of measurement and the measurement of acoustic emergence (absorbent on wall, sound barrier, enclosure).

2 Control the noise – a guide for installing air for water heat pumps

This is a translation by Svend Vinther Pedersen (Teknologisk Institut Kongsvang Allé 29, 8000 Aarhus C) from the original which was prepared by Grontmij A/S Granskoven 8 2600 Glostrup Danmark, T +45 4348 6060, F +45 4348 6660 www.grontmij.dk, CVR-nr. 48233511´for the Danish Energy Agency in 2012. The Danish Original is available on the Annex 51 Website https://heatpumpingtechnologies.org/annex51/

Preface

This guide has been prepared for the Danish Energy Agency in order to provide a simple tool to limit the noise nuisance from heat pumps. A large number of heat pumps are expected to be established in Denmark - including some based on extracting heat from the outdoor air. If noise considerations are not taken into account when these types of heat pumps are installed, there is a risk of unnecessary noise nuisance for the neighbors.

The guide is therefore designed to provide a planning tool for future heat pump owners, installers and municipalities that can be used with a modest knowledge regarding sound conditions. This includes especially the calculation program, which can be used via the Danish Energy Agency's home page (www.ens.dk). In addition to the description of the use and the basis for the calculation tool, the guide also contains various instructions for good assembly, noise reduction, etc. These instructions are particularly aimed at the installers and the understanding of these parts of the guide is not necessary for the use of the calculation program.

The primary purpose of the calculation program is that heat pumps are placed regarding noise are placed as optimally on the building plot as possible. Furthermore, it is illustrated how quiet the heat pump should be in each case. In an effort to make the use of the calculation program easy, a number of simplifications have been made of the Danish Environmental Protection Agency's exact calculation model for noise propagation. The simplifications mean that the results of the calculation program cannot be used for formal documentation of compliance with noise limits, but the results will in the vast majority of cases give a good and true picture of the noisy consequences of a given heat pump placement.

The preparation of the guide and the calculation program was carried out with assistance of a number of companies in the Danish Heat Pump Manufacturers' Association, suppliers of noise reduction equipment and others. The Danish Energy Agency and the Danish Environmental Protection Agency have also made significant contributions. We thank everyone for good contributions.

Grontmij A/S

2.1 Introduction

This guide is designed to help you in the selection of good noise solutions when you want to install a heat pump. This applies both when you choose a suitable product and especially when you choose the location where the heat pump is going to be installed.

A heat pump is often a good solution if you want to save energy. However, when installing a heat pump, it is important that you relate to the noise nuisance it can cause to both yourself and your neighbor. In the worst case scenario, your neighbor may require that your heat pump to be removed if it is too noisy.

This guide provides you with tools and recommendations on how to get an indication in advance of whether the heat pump you are planning to install is causing unnecessary noise nuisance. The guide deals with air-water type heat pump systems. For other heat pump types, not everything in the guide is relevant, but a number of the recommendations can also be followed for these.

The guide provides a calculation tool on the Danish Energy Agency's website (www.ens.dk) this tool gives an illustration of the noise consequences in the surroundings if you install the heat pump in a given place. However, the guide cannot be used as a documentation of the noise load of neighbors. This requires that the noise in the specific situation is measured or calculated using the Environmental Protection Agency's guidelines on noise ([1], [2], [3] and [4]).

In the following you can read about air to water heat pumps, where the heat is extracted from the outside air and transferred to a water-based radiator system, underfloor heating system or domestic hot water system. The guide is developed for heat pumps with a heat output of less than 200 kW.

2.2 Heat pumps

Air to water heat pumps consist of three components:

a) An outdoor evaporator, which is always equipped with a fan which increases the heat absorption from the outdoor air.

b) A compressor that produces the pressure changes that allow heat energy to be extracted from the outside air.

c) A fluid-based piping system that sends water through a radiator or a floor heating system.

The compressor is usually located in the outdoor heat pump unit. However, in some heat pump systems, the compressor is placed indoors, which can reduce the outdoor noise, but in return gives indoor noise.

The liquid-based heat pump system is equipped with a circulation pump and a heat exchanger.

2.3 Noise/sound Authority

The municipality is the environmental authority when it comes to neighboring noise from heat pumps. In addition, the municipality is the authority in relation to the fulfillment of the building and installation regulations.

You do not need to apply for approval when you install an air to water heat pump, but you must of course comply with the noise level requirements. The municipality will therefore only be involved if it is made known to a problem, e.g. if it receives a complaint about the noise.

2.4 Noise from Air to water Heat Pumps

2.4.1 What creates the noise?

The outdoor heat pump unit has two dominant noise sources:

- The fan which sucks air over an evaporator surface

- The compressor which compresses the refrigerant

The noise from the fan is buzzing and may in some cases contain a tone that can be clearly heard in between the other noise. The noise is caused by the air turbulence around the wings of the fan and it increases very sharply as the speed of rotation increases. As the evaporator power also increases with the speed of rotation, the manufacturer must consider these considerations. A small fan that rotates fast is more noisy than a large one that rotates slowly.

In most heat pumps, the compressor is less noisy than the fan. The noise from the compressor is typically deeper in tone than the noise from the fan and may have a slightly throbbing nature. In some cases, the noise from the compressor may give a low frequency sound, ie. a very deep tone.

Both the fan and the compressor cause vibrations in the heat pump's bearing frame structure. From here, the vibrations are transmitted to the one carrying the heat pump (the support), but most often also to the housing of the heat pump (the cabinet plates). The cabinet plates can function in the same way as a loadspeaker. However, this noise is usually included in the supplier's noise declaration, but errors in the heat pump can increase the noise compared to the stated.

If a good vibration insulation is not established in relation to the support, the heat pump can make more noise than the supplier has stated. This is especially the case if the heat pump is installed on a light structure such as a roof or wooden wall that the heat pump's vibrations inadvertently make it seem like a big speaker. In these cases, vibration isolators (rubber feet) only work very poorly. The heat pump should therefore be fitted in accordance with the recommendations in section 2.8.

2.4.2 How is noise measured ?

Noise is measured with a sound pressure gauge. A sound pressure gauge measures all the sound at the point where the microphone is located. The microphone cannot distinguish the sound from all the other sound that is in the environment, ie. background noise. It is therefore important that you make sure that the heat pump makes the dominant sound when you make a control measurement. This is typically achieved by measuring relatively close to the heat pump, preferably at a quiet time of the day. The background noise can be measured by turning off the heat pump and immediately measuring the remaining noise. The background noise should preferably be at least 10 dB lower than the noise from the heat pump. If this is not the case, a correction must be made for background noise (cf. [2]).

The sound pressure of the noise is measured in decibels (dB) and is usually expressed as 'dB (A)', where the A indicates a frequency weighting that makes the measured sound resemble what our ears perceive. One cannot add two decibel values as a simple calculation, so for example, 40 dB (A) + 40 dB (A) = 43 dB (A) and not 80 dB (A).

You do not need to know the decibel calculation to use the corresponding calculation program. However, it is important to know that getting a few decibels difference covers a big difference in sound pressure. When the decibel number is increased by 6-10 dB, the sound is perceived twice as high.

You must know the noise level of the heat pump in the surroundings before you install it - or you may need to remove it again. You cannot measure the noise for good reasons until you have installed the heat pump, but you can calculate the expected noise. To calculate the noise, use the method given in the Environmental Protection Agency's Guide No. 5, 1993 "Calculation of external noise from companies" [3]. However, in connection with this guide, a simplified calculation model has been developed, which is described in section 6. However, this method is for information purposes only and you cannot therefore use the results as documentation to the municipality. On the other hand, you can use the calculation model to select a good location for your heat pump regarding noise.

In order to calculate the noise at the neighbor, you need to know the sound energy emitted by the heat pump, also called the 'sound power level' (in the Environmental Protection Agency's instructions it is also called 'source power level'). The sound power level is also measured in dB, which can be confusing as the sound pressure and sound power level are far from the being same.

Sound power level and sound pressure level are directly related - but in a slightly complicated way. It may be easier to understand the difference between sound pressure and sound power level by comparing with temperature and heat power (see Figure 2-1). A radiator is described by the heat output it can emit. The heat effect is completely independent of the location of the radiator. The temperature achieved by the use of the radiator, on the other hand, depends a lot on the space in which the radiator is placed. The same applies to sound. The sound power level is independent of the location of the heat pump, but the noise (sound pressure) that arises during the operation of the heat pump depends on the environment in which the heat pump is set up.

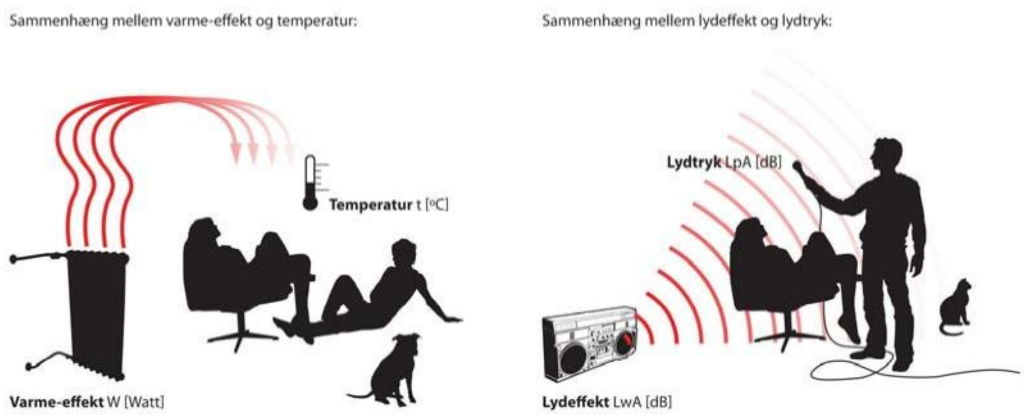


Figure 2-1: Relationship between power and temperature/sound pressure

The noise at the neighbor should be measured as a mean value over at least half an hour (valid for the period between 10 pm and 7 am). If the noise is constant, you can measure for a shorter time, but if the heat pump is at a standstill within half an hour, then the standstill period must be corrected. It is easiest to measure for a full half hour (start time is completely optional). If the heat pump runs only during the day and evening periods, it must be averaged over a longer period (from 1 hour to 8 hours), but this is rarely the case.

To determine the mean, use an integrating sound pressure gauge that measures the noise over the measurement period. The sound pressure gauge measures a value called Leq or LAeq, which are international designations.

In the Environmental Protection Agency's guidelines, the term 'Lr' is used in relation to noise limits. 'Lr' is equal to LAeq plus a supplement. The supplement is 5 dB if there is a clear tone in the noise or if the noise has significant impulses. In other cases, the supplement is 0 dB.

2.4.3 The influence of the operating conditions

Noise data is typically given for a normal operating situation and corresponds to the typical noise level in general use. The following operating situations may occur:

- Normal operation
- Maximum Operating
- Silent mode (for some models)
- Defrost

The difference in noise emission in the four operating situations depends on the design of the heat pump, but there can be relatively large differences:

Maximum Operating:

At maximum operation, noise can increase significantly, typically up to about 5 dB compared to normal operation. The increase in particular depends on how the normal operation is compared to the maximum operation. This depends on the make and model of the heat pump.

Silent mode:

In silent mode is he noise lower than in normal operation, but the difference is usually only slightly lower, ie. 1-2 dB less. For heat pumps where the compressor sits indoors, silent mode can be even more silent, often 4-5 dB lower. These figures should be stated in the supplier's sales material.

Defrosting:

The heat pump has a function that automatically defrosts it when the evaporator surface freezes. During defrosting, the noise changes remarkably in comparison to normal operation. Most often, will the noise level not rise - although it may be perceived as such.

2.4.3.1 Control of the operation Noise data is typically given for a normal operating situation and

There are various ways to control a heat pump. Some models run on/off. That means, a buffer tank heats up while the heat pump runs and the stored heat is used while the pump is in off mode. This means that the heat pump runs at full capacity when it is in operation, thus having the optimum effect. Unfortunately, on/off controlled heat pumps happen to be installed without the necessary buffer tank, resulting in many short operating periods and with a more annoying noise.

Other heat pumps can reduce the output via speed controlled compressors and possibly speed controlled fans. Such a regulation would mean that the heat pump runs for a longer period of time with a lower average noise level. The regulation may be more neighbor frindly, but it should be borne in mind that the noise level at full load - ie. a frosty winter morning - will be maximal regardless of the control strategy. If the municipality has ordered to comply with a noise limit, this will usually apply to the noisiest operating mode.

You should also be aware of that especially at a low heat consumption, the energy efficiency of a heat pump can be relatively poor. This is especially important for new houses with low energy consumption during the spring and autumn transition seasons.

2.4.4 Noise regulations

2.4.4.1 Noise by the neighbour

You should position your heat pump in a place that annoys your neighbour and yourself as little as possible. The noise from the heat pump is particularly annoying at windows to bedrooms and living rooms as well as on terraces. This applies regardless of whether it is your neighbor's or your own. The location is significant importance for the noise level at the exposed locations. Greater distance decreases the noise level, but e.g. a building can also reduce the noise. A low-noise heat pump also helps keep the noise level down.

Heat pumps shall fulfill the environmental law in the same way as companies. This means that your heat pump must adhere to some noise limits at the neighbors. It is the municipality that determines the noise limit that the heat pump must adhere to at the neighbor. Normally, it is the Danish EPA's recommended noise limits that should be applied. The noise limits are stated in the Environmental Protection Agency's instructions, which you can find at www.mst.dk. The most important guide is "External noise from companies" (no. 5/1984) [1]

Noise limits varies during the day. The night period will always have the lowest noise limit. In particular, heat pumps must produce heat in the early morning hours, where it is coldest outside and water is used for bathing, etc. As the night period runs until 7 am, it is usually the noise limit for the night period, which, in environmental terms, determines how what the noise level from a heat pump must be.

The noise limits also vary with the nature of the area, ie. depending on whether you live in a detached, building block, industrial or a fourth area. Reference is made to the Environmental Protection Agency's Guide No. 5/1984 [1] for the different area types. In most cases where heat pumps are installed, one of the noise limits you can see in Table 1 applies.

Dayperiode	Holiday house area	Noise L_r for dense low building area (detached houses semidetached houses and others.)	Blocks of flats Mixed living and business areas, Open land (detached houses)
Working days 07 – 18 Saturdays 07 – 14	$Lr \leq 40$ dB	$Lr \leq 45$ dB	$Lr \leq 50\text{-}55$ dB
Working days 18 – 22 Saturdays 14 – 22 Sundays 07 – 22	$Lr \leq 35$ dB	$Lr \leq 40$ dB	$Lr \leq 45$ dB
All days 22 – 07	$Lr \leq 35$ dB	$Lr \leq 35$ dB	$Lr \leq 40$ dB

Table 7-1 – EPA recommended noiselimitations

The noise limit (L_r) applies to the sound pressure level (meanvalue over a period of time, which is 30 minutes at night) anywhere at the neighbor. It will often be the noise at the borderline of the plot to the neighbor that is most noise-laden, but elsewhere - e.g. at a window on the first floor – can sometimes be noisier. For single-family dwellings in the open country (eg agricultural properties), the noise limit applies only close to the dwelling (up to 15 meters from the dwelling).

If the noise from the heat pump contains a clear howl or hum, the noise is added 5 dB. That means, 5 dB is added to the noise level being measured or calculated before comparing the result to the limit value.

In special cases, the compressor noise is so dominant that the noise is perceived as bass-like (called "low frequency noise"). The Danish Environmental Protection Agency has established special criteria for the assessment of low frequency noise (cf. [4]). A special feature of these noise rules is that the noise must be measured indoors by the neighbors. The conditions for low-frequency noise are so complicated that it requires professional assistance (see the Environmental Protection Agency's list of laboratories approved for "Environmental measurement - external noise"). It is recommended that heat pumps that does not have a low frequency character. are selected.

2.4.4.2 Noise by the owner

It is the Building Regulations that set requirements for the noise conditions that are allowed in the house of the user of the heat pump, ie. by you.

Building regulations 2010 for the outdoor noise impose the same noise requirements for own windows and outdoor living areas as the Environmental Protection Agency's guide noise limits for the noise at the neighbors. That means, Table 6-1 also applies to the same ground on which the heat pump is installed.

For windows, however, it is only windows for living rooms where the noise requirement applies. Windows for secondary rooms such as utility rooms, toilets, outbuildings, etc. is not covered. Outdoor living areas include balconies, terraces and similar places on the grounds where the home's users can reasonably be expected to stay for "relaxation" purposes.

Building Regulations 2010 also imposes requirements for the indoor noise level from the heat pump. The noise requirement is $L_{Aeq} \leq 30$ dB. For air to water heat pumps, this is rarely a problem if the system is installed reasonably. See section 8, which describes good assembly practices.

2.5 Noise distribution

2.5.1 Outdoor Noise

The noise from the outdoor heat pump unit is normally distributed by the ambient air. The distribution of the sound can be illustrated by balls that are constantly forming and moving away as they grow and grow (see Figure 2-2). For example, if a part of the sound bullet strikes a wall, the sound is reflected away again. The reflected sound lays on top of the second noise so that the sound level increases (see Figure 2-3). How much the sound level increases depends on the surface's ability to absorb sound.

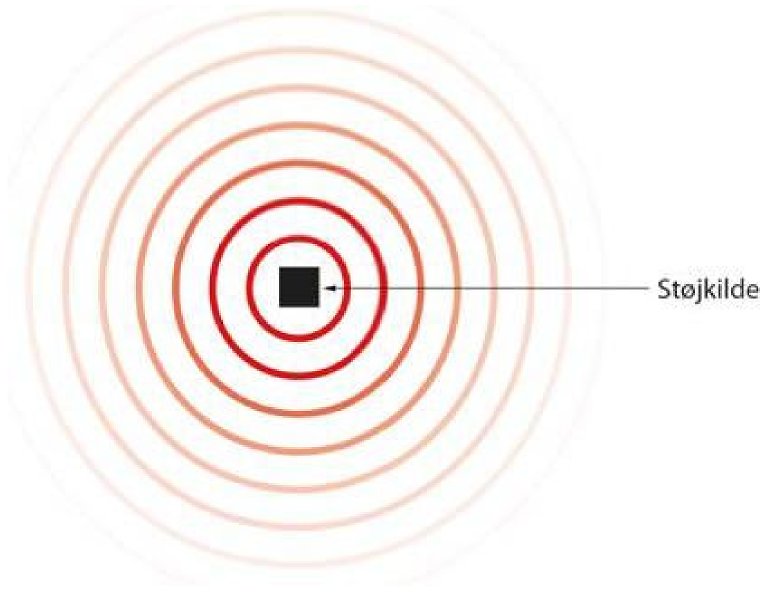


Figure 2-2: Outdoor sound propagation - free radiation

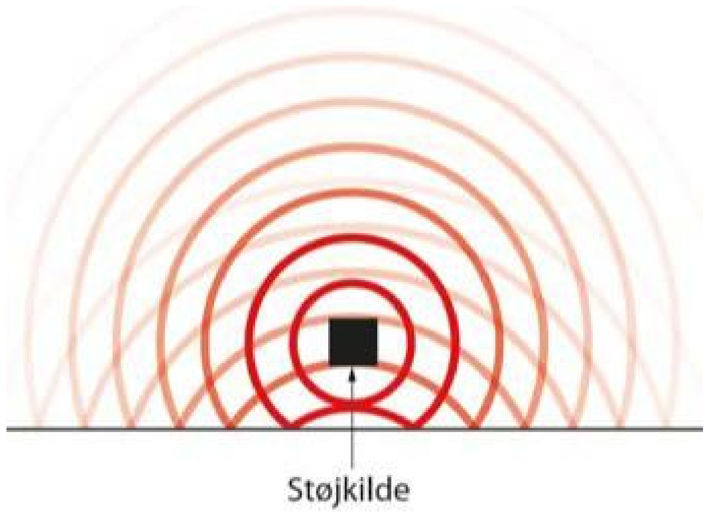


Figure 2-3: Outdoor sound propagation - reflective surface

The sound-absorbing ability depends on the nature of the surface. The terrain is a surface that always appears. The sound-absorbing ability depends on whether there are tiles, asphalt or similar hard surfaces or soil, grass or loose gravel. The hard surfaces reflect almost all the noise that strikes while grassland, etc. absorbs much of the sound that strikes.

The terrain between the heat pump and the neighbor is therefore of great importance for the noise level reaching the neighbor.

The housing that the heat pump is typically set up reflects the sound. It is the surface of the house (bricks, wood paneling, eternite, concrete, etc.) that reflects the sound. This means that in the directions where the heat pump and the reflective wall are free of sight, the noise will be approx. 2 dB higher. The noise can be reduced by mounting an sound absorbing material on the housing wall behind the heat pump. The absorbent may e.g. be constructed as shown in Figure 2-19 - preferably without the dense plate.

In addition to the terrain and the house on which the heat pump stands, other buildings and similar vertical surfaces can reflect the sound, and increase the noise exposure of the neighbor. However, it is a bit complex where reflection becomes important. However, if noise screens are used at the heat pump, it is always important that the screen is sound absorbing on the surface towards the heat pump.

A correct calculation of noise propagation is made using the method described in the Environmental Protection Agency's Guide No. 5, 1993 "Calculation of external noise from companies" [3]. There are various calculation programs which have the calculation method incorporated, but they are usually relatively expensive and require a good acoustic understanding to use. In connection with this guide, a calculation tool has been made based on the correct calculation method, but which in simplified form allows you to assess the noise propagation without having knowledge of acoustics.

2.5.2 Indoor Noise

The indoor sound propagation is basically the same as the outdoor, there are just many more reflective surfaces. However, for water-based systems, the noise emitted from the installation is rarely annoying. It is, on the other hand, vibrations from the installation, which are transmitted via the suspensions in the walls of the housing. From here, the vibrations are radiated like noise in the neighboring rooms. See section 2.8 on how to avoid this.

Indoor noise can also come from the outdoor heat pump unit if it is installed improperly on the walls or the roof of the house. If the heat pump is mounted on the building, vibrations transmitted through the installation's suspension can cause noise emitted from the interior building parts.

2.6 Calculation model

The calculation model on the Danish Energy Agency's website is a tool you can use to find a good location for your heat pump and assess how quiet the heat pump should be to avoid unnecessary noise nuisance for you and your neighbor. The model cannot calculate the exact noise level at the neighbor – in this case you are referred to the Danish Environmental Protection Agency's calculation model (see the Danish Environmental Protection Agency's Guide No. 5/1993 "Calculation of external noise from companies" [3]). The model is intended as a planning tool that you can use to select the right heat pump with the right noise level and place it with the fewest noise nuisance for both yourself and your neighbor.

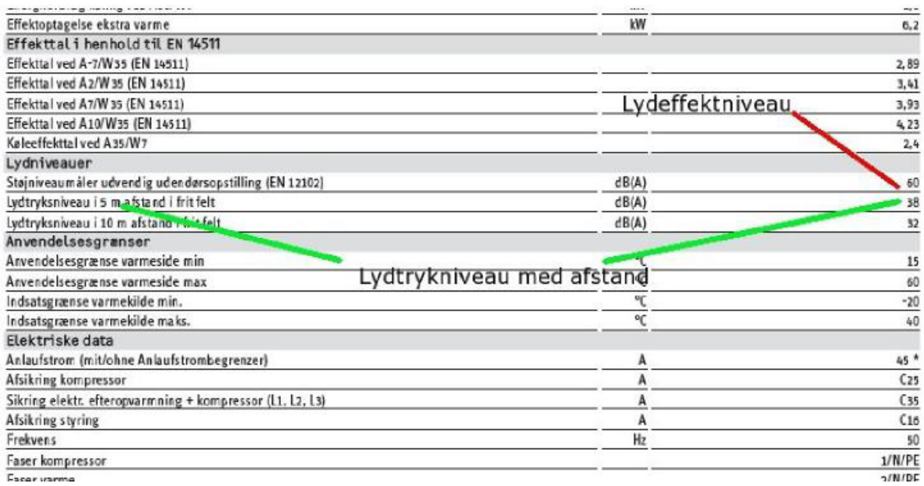
The calculation model is limited to heat pumps with a heat output of less than 200 kW. For larger systems, the extent and noise emission of the system becomes so complicated that accurate noise calculations should be made with respect to the specific sound conditions.

The calculation model draws different noise curves depending on where you place your heat pump on the map. The noise curves show where the noise is above and below the 35 dB and 40 dB, respectively, which are typical noise limits (cf. section 2.4). Furthermore, the model draws a 45 dB curve for orientation. In principle, the noise limit must be observed at all places, but it is especially important that the noise is low at bedroom windows and terraces.

2.6.1 Noise data

A crucial starting point for a noise calculation is the sound energy (= sound power level, cf. section 2.4.2) emitted by the heat pump's outdoor unit. This data is usually found in the supplier's or manufacturer's sales material.

For some heat pumps, the sound power level ('Sound Power Level') is not stated. Instead, a sound pressure level is specified at a certain distance from the heat pump. The calculation model can also handle noise data in this form, but if the sound power level is specified, then this is what you need. Figure 2-4 shows an example of noise data from a sales specification. The figure shows an atypical designation 'Noise level for exterior outdoor installation'. Based on the size of the figure, it must be considered the sound power level of the outdoor unit. These kinds of imprecise terms often appear in the suppliers' sales material. In case the sound pressure is specified, some suppliers forget to state the distance at which the sound pressure is measured.



Effektoptagelse ekstra varme	kW	6,2
Effekttal i henhold til EN 14511		
Effekttal ved A-7/W35 (EN 14511)		2,89
Effekttal ved A2/W35 (EN 14511)		3,41
Effekttal ved A7/W35 (EN 14511)		3,93
Effekttal ved A10/W35 (EN 14511)		4,23
Køleeffekttal ved A35/W7		2,4
Lydniveauer		
Støjniveaumåler udvendig udendørsopstilling (EN 12102)	dB(A)	60
Lydtryksniveau i 5 m afstand i frit felt	dB(A)	38
Lydtryksniveau i 10 m afstand i frit felt	dB(A)	32
Anvendelsesgrænser		
Anvendelsesgrænse varmeside min	°C	15
Anvendelsesgrænse varmeside max	°C	60
Indsatsgrænse varmekilde min.	°C	-20
Indsatsgrænse varmekilde maks.	°C	40
Elektriske data		
Anlaufstrom (mit/ohne Anlaufstrombegrenzer)	A	45 *
Afsikring kompressor	A	C25
Sikring elektr. efteropvarmning + kompressor (L1, L2, L3)	A	C35
Afsikring styring	A	C16
Frekvens	Hz	50
Faser kompressor		1/N/PE

Figure 2-4: Example of brochure with noise data

The international standard DS / ISO 13261-1 describes under which operating conditions, etc. the sound power level must be determined. The measurement itself is carried out according to a standard in the ISO 3740 series (different methods depending on the measurement conditions). In a number of cases, reference is made to other standards (for example, in Figure 2-4), which is not formally correct, but it can usually produce useful results nonetheless.

2.6.2 Operating Conditions

As a starting point for the noise calculation, noise data corresponding to normal operation is used. Here, make sure that the heat output of the heat pump you want to install matches the actual heating demand - even on a cold winter morning. If the heat pump has too little power, it will run at its maximum performance for long periods and therefore it will be noisier than in the normal operation mode.

Some heat pumps have a so-called silent mode. This setting rarely makes noise much less than in normal operation mode. You may well make noise calculations with the silent mode value, but it only makes sense if the heat pump is physically limited to being able to run only in this mode, which is often not economically optimal.

2.6.3 How to use the noise calculation model

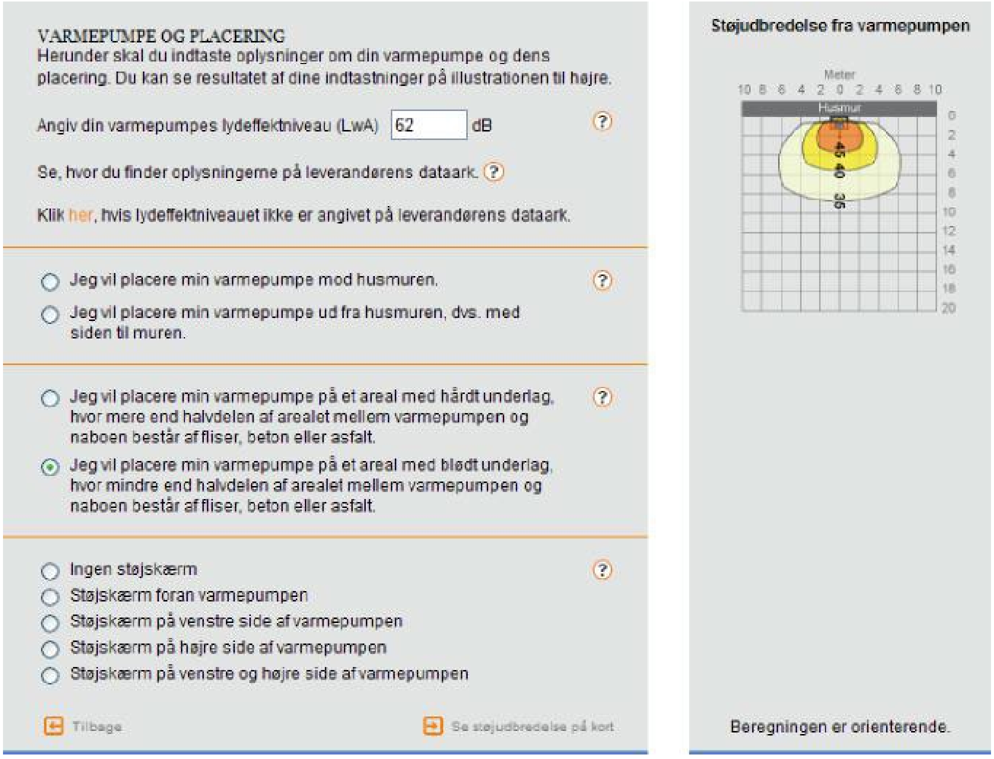


Figure 2-5: Start image in calculation program

When you start the program, you will see a screen where you need to enter information about your heat pump and its location.

Specify the sound power level of your heat pump

You need to know the sound energy your heat pump emits to calculate the noise level at your neighbor. Sound energy is called the 'sound power level' and is shortened to 'L_{WA}'. The sound power level is usually indicated on the supplier's data sheet. If the sound power level does not appear in the supplier's datasheet, you can calculate it from a specified sound pressure at a given distance by clicking the "here" link in the upper left of the page.

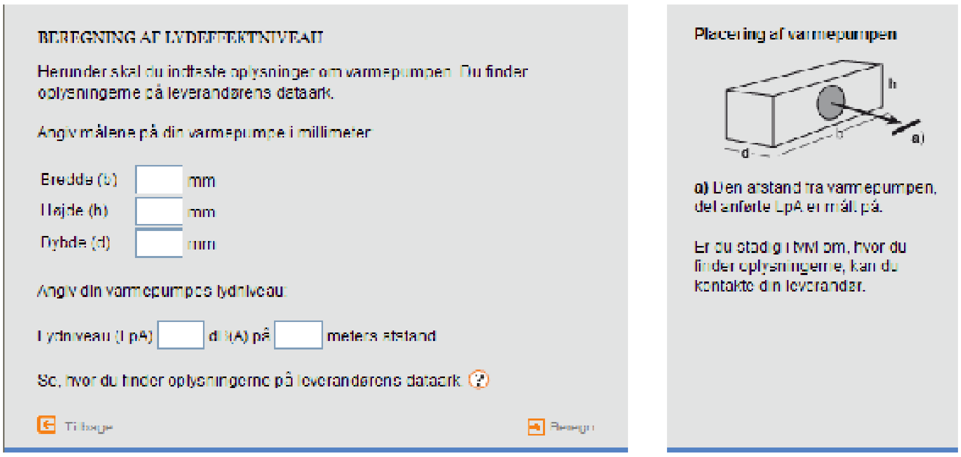


Figure 2-6: Calculation of sound power level from sound pressure level at given distance

Sound power level calculation

You will now be taken to the Sound Power Level Calculation page where you will need to enter information about the heat pump. First, specify the height, width and depth of your heat pump in millimeters, then the sound level of the heat pump as well as the distance at which the sound level is measured. You will find the information on the supplier's data sheet (eventually available on the supplier's website).

If the measurement distance does not appear in the supplier's data sheet, you should contact them and get it informed. A measuring distance of 1 meter is most often used, so you can try with this value. However, it is important that before the final choice of location and heat pump you are informed of the correct measuring distance. The result will be completely wrong if the noise is actually measured at a different distance.

Once you have entered the information, click 'Calculate'. You will then return to the 'Heat pump and location' page.

Now indicate whether you want to place your heat pump against the house wall or from the house wall. It is very important for the noise distribution how to place your heat pump in relation to the house wall.

Location of the heat pump

Next, choose whether to place your heat pump on a hard or soft surface (see section 2.5.1). The surface on which you place your heat pump upon is decisive for how much noise it makes at your neighbor. In the calculation model, two cases are used. In one case, there are only tiles around the heat pump and grass (soil, gravel) the rest of the way over to the neighbor. In the second case, there are tiles at least half the distance from the heat pump to the neighbor.

Noise screen setup

Next, select whether you want to set up the noise screen. You can reduce the noise of your neighbor by 5-10 dB by setting up one or more noise screens around your heat pump. You can set up noise screens on two sides of the heat pump.

Remember that buildings can act as noise screens (see section 2.10.1 for extension requirements).

Once you have entered all the information about your heat pump, click the arrow 'View noise propagation map'.

This will open a new window where you will need to enter the address you want to install your heat pump on. After entering the address, click the arrow.

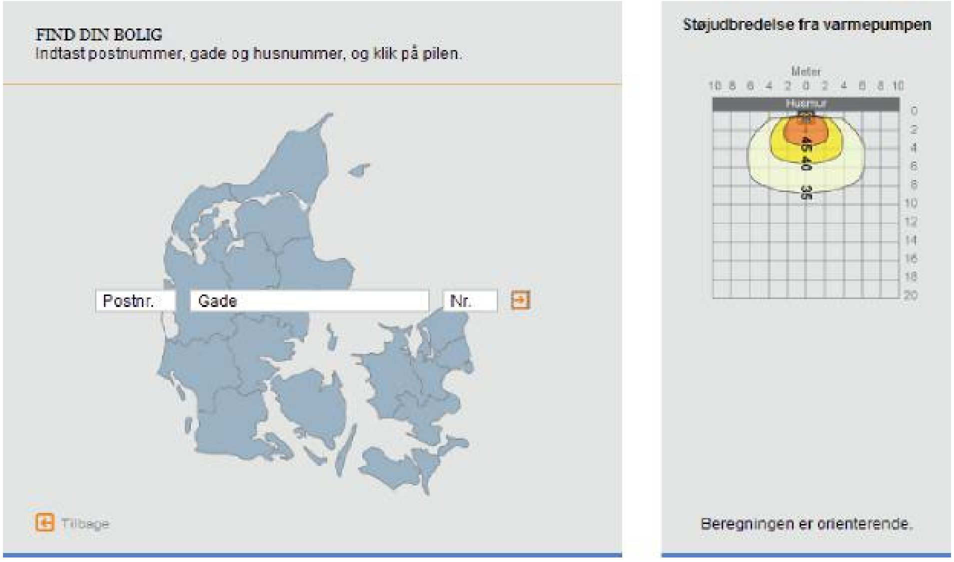


Figure 2-7: Choice of location for the heat pump

You will then see an aerial view of the address. Hold down the left mouse button, drag the heat pump to the location where you want to place it next to your home[1], and then release the mouse button. Then hold down the 'Shift' key at the same time as the left mouse button to turn the heat pump. The heat pump must be positioned so that none of the noise curves goes over the building it is set up. Then you can see the noise distribution in the aerial photo. Find out if the location of the heat pump provides an acceptable noise load in yourself and your neighbor.

[1] The calculation program assumes that the heat pump is installed on a wall.

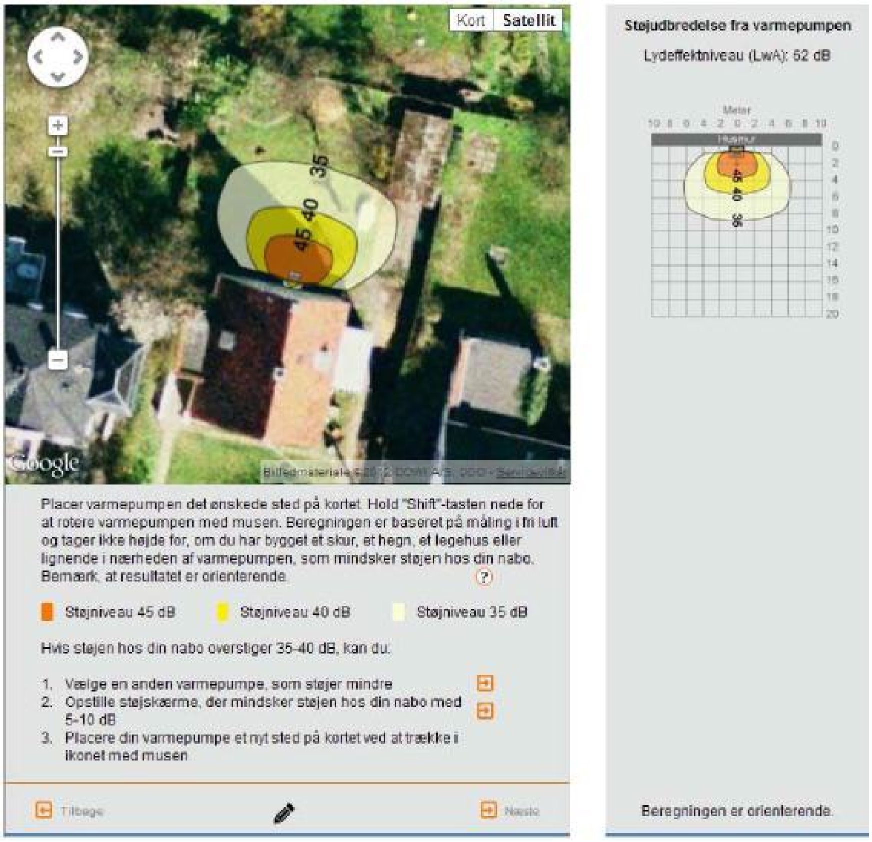


Figure 2-8: Calculation result

If the sound conditions are not acceptable, you have the following options:

1. You can choose a different heat pump which is less noisy - or the same with a "noise reduction kit" if it is offered by the supplier. It takes place in the noise data entry window. Then place your heat pump again on the aerial photo and do the noise level calculation.

2. You can choose to set up the noise screen on 1-2 sides of the heat pump. The screen must meet the requirements specified in Section 2.10.1. A noise shield may well be a building such as a garage or a shed. You can select different combinations of screen layouts in the same menu as under a) in the above mentioned. You cannot normally set up noise screens on all three sides of the heat pump as it will not get enough air. In the 'location selection' menu, select a location of the heat pump. A new calculation is made.

3. You can place the heat pump somewhere on the map. The program saves the selected heat pump data and goes to the location selection menu (address data is preserved). A new calculation is made.

2.7 Noise reduction

The noise load can be reduced in various ways:

a) Increase the distance if possible

b) Select a less noisy heat pump

c) Get the heat pump muted. Many suppliers offer a "noise cancellation kit" that dampens the noise without major loss of energy performance

d) Shield the heat pump. This can possibly be done by "hiding" the heat pump behind a building such as a an outhouse. Otherwise, you can set up an actual noise shield at the heat pump. It is important that the distance between the heat pump and the noise shield is so large that adequate ventilation is ensured (see the supplier's installation instructions).

See section 2.9 for detailed examples of noise canceling measures.

2.8 Good installation

The noise load can be reduced in various ways:

The location of the heat pump is very important, but also the way it is mounted affects the noise. The calculation model described in section 2.6 assumes that no noise is emitted from other than the parts of the heat pump.

As mentioned, air to the water heat pump consists of an outdoor installation (heat pump) and an indoor installation (heat exchanger and circulation pump), see Figure 2-9. When the heat pump operates, vibrations occur in the various parts of the pump. The same occurs for the indoor unit. It is important that these vibrations only to a very small extent are transmitted to the environment, as they can be emitted as noise here. The vibrations can be transmitted both via the mounting points of the units and via the pipe connections.

In order to limit the noise in the surroundings, it is important that all parts are provided with good vibration insulation during installation / assembly. Note that most operating instructions do not relate to good installation regarding noise. In this section you will find general guidelines for a good sound installation. If the mounting conditions are particularly complicated, contact a consultant who is experienced in noise and vibration conditions.

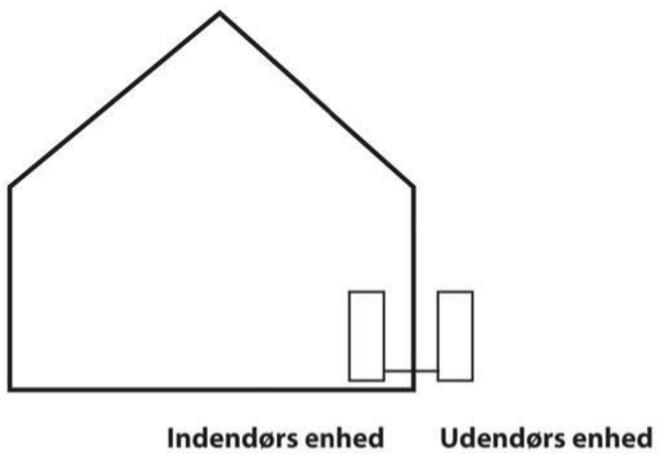


Figure 2-9: Example of the location of the heat pump units

2.8.1 Vibration sources and distribution channels

The most common sources to vibration are:

- Outdoor unit: Compressor, possibly circulation pump and fan

- Indoor unit: Heat exchanger and circulation pump

- Pipe joints: Wall fixings and pipes

The vibrations do not damage buildings, but they can cause noise nuisance.

2.8.1.1 Outdoor unit

The heat pump is best placed on the terrain. From this, however, vibrations can be propagated through the ground to surrounding buildings, where they are emitted via the building foundation as noise from floors and walls.

If it is not possible to install the heat pump on terrain, it is important that you install the pump on a structure that is as rigid and heavy as possible. Walls and roofs move easily, creating noise. You should therefore avoid mounting your heat pump on lightweight walls of plaster, wood and the like.

2.8.1.2 Indoor unit

Vibrations from the indoor unit can be transmitted to the floors and walls of the building via the mounting connections. You should avoid mounting your heat pump on the wall - at least on light walls. Similarly, you should not install the heat pump on a lightweight floor structure (such as wood flooring on beams or beams). Vibrations from the indoor unit can be highly troublesome to the property's occupants - especially as low-frequency noise.

If it is necessary to support the indoor heat pump unit on a light wall or floor, it is recommended that you lay a thick concrete tile or similar. under the vibration dampers of the unit.

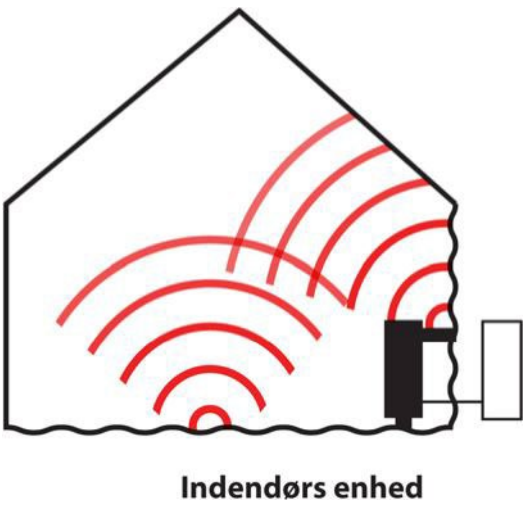


Figure 2-10: – Importance of rigid mounting of indoor units

2.8.1.3 Pipe connections

The pipes connecting the units vibrate as a result of the transfer of vibrations from the heat pump, but also the heat pump's fluid pulsations can cause vibrations. If the pipes are rigidly mounted to buildings - including in decks or walls - vibrations can be emitted as noise from the building surfaces.

Pipe connections must therefore have a flexible element between the heat pump and the inlet to the house. For thin pipelines, the flexible element can be made alone by a 90 ° sharp bend. For thicker tubes is the tube formed to a large "U" bend. Flex hoses, which are rubber hoses with a woven steel sock, can also be used. A flex hose must be bent at least 60 ° to obtain flexibility

Pipe supports should be of the vibration-insulating type (for example, steel hanger with rubber mimic coating, see Figures 2-11 left and 2-11 right, which are examples of good supports). Pipe penetrations in walls should be performed so that the pipe does not touch the wall hole. The pipe is jointed with elastic sealant.

You should avoid pipe carriers on light walls. If this is not possible, then you must put the support on the stiffest part of the wall or ceiling, which means where there pillar or beam inside the wall.


Figure 2-11:(left) Insulated pipe carrier, (right) Insulator for ceiling suspension

2.8.2 Thumb rules regarding vibration isolation

In order for the vibration insulators to deliver the insulation percentage indicated in the catalogs, the surface at the ground must be heavy, rigid and homogeneous. It can for example. be a concrete tile or concrete floor / deck. If the surface is lightweight and gives up a little, the vibration insulation can completely disappear. The substrate under the heat pump should at least weigh the same as the heat pump.

The vibration isolators must also be properly adjusted to the weight of the heat pump. If the vibration isolator is designed to carry much more than the weight of the heat pump, the vibration isolation is greatly reduced. If the heat pump weighs more than the indicated capacity of the vibration insulators, the insulation capacity will disappear completely.

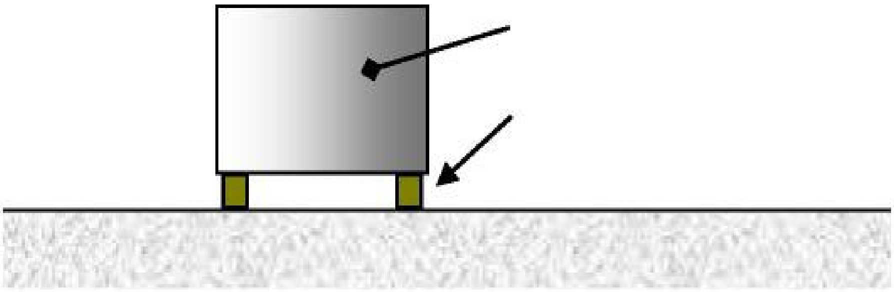


Figure 2-12: Vibration isolators (machine shoes) under heat pump

Figure 2-13: Examples of vibration isolators

2.8.2.1 Outdoor unit

You must ensure the following:

- The weight of the substrate (tiles, concrete, etc.) covered by the heat pump must at least be the weight of the heat pump

- If you exceptionally use suspension brackets to support the heat pump, you can advantageously put e.g. a thick concrete tile under the pump's vibration insulators (see Figure 2-12)

- Instead of mounting the heat pump on a lightweight wall, it often makes less noise if you mount it on posts anchored to the terrain.

- Choose 4 vibration dampers whose maximum carrying capacity is each approx. 30% higher than one quarter of the heat pump weight; see Figure 2-13.

- Place the vibration dampers in each corner.

2.8.2.2 Indoor unit

The following must be ensured:

- the weight of the substrate (tiles, concrete, etc.) covered by the heat pump must at least correspond to the weight of the heat pump

- If you use exceptionally hanging brackets or a light floor to support the heat pump, you can advantageously put e.g. a thick concrete tile under the heat pump's vibration insulators (see Figures 2-14 and 2-15)

- Instead of mounting the unit on a lightweight wall or light floor, it often makes less noise if you mount it on posts cast into the terrain structure. Vibration insulators are mounted between the heat pump and the columns

- Select eg. 4 pieces. vibration insulators whose maximum carrying capacity is approx. 30% higher than one quarter of the unit weight; see Figures 2-12 and 2-13. It is important that bolts and the like. do not short-circuit the insulators

- Place the vibration insulators in each corner

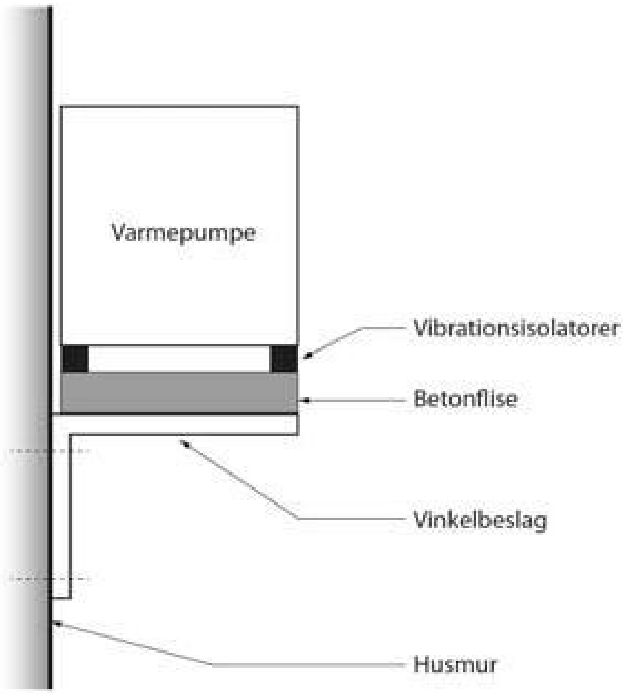


Figure 2-14:Example of heat pump suspension

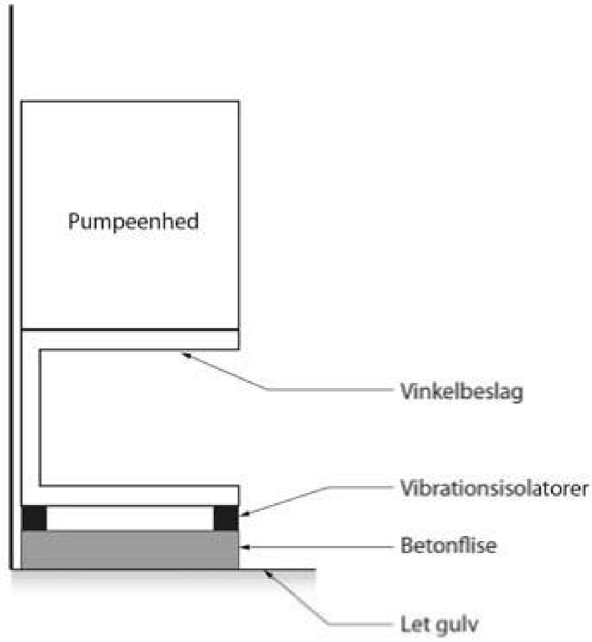


Figure 2-15:Set up on a light floor

2.9 Control Measurement

If you want to ensure that your heat pump meets the supplier's noise declaration when installed, you can use the measurement method below. An inexpensive noise meter that can measure dB (A) is sufficient. Many mobile phones have a noise meter built in, and there are also apps for smartphones. Mobile phones are not accurate noise meters, but they can give you a reasonable clue (if properly calibrated).

It is the noise of the neighbor that is crucial. However, there is often a lot of other noise mixed with the noise from the heat pump. There are no noise meters that can separate one kind of noise from the other. Therefore, the noise from the heat pump should be measured close to the pump instead. Here the noise is usually so dominant that other noise is of no significance. The supplier is only responsible for ensuring that the noise emitted by the heat pump does not exceed what is promised in the sales material. How the noise is spread to the neighbor is your own responsibility.

The transmitted noise is checked 1 meter in front of the heat pump when it is in maximum operation. However, check that the operating condition is correct (pressure, temperatures, etc. are within the operating range allowed by the supplier). The measurement should be carried out as far as possible before setting up any noise screens. Keep the noise meter 1.2-1.5 meters above the ground. Avoid standing directly in front of or behind the sound meter in relation to the heat pump. Read the average noise level. In the calculation program, a control value is shown which is based on the supplier's declaration (found under 'Additional info' which can be obtained by pressing "Next" after the location of the heat pump. If the measured value you have found is more than 5 dB[2] higher than the value shown in the calculation program, there is a certain

[2] There will naturally be differences in noise from one heat pump to another. For completely similar heat pumps, variations of ± 2-3 dB from one unit to another must be expected. The

probability that the heat pump does not live up to what it promises in the sales material, so contact the supplier for clarification.

2.10 Noise Reduction

You can mitigate the noise from the heat pump in various ways. Below are examples of some of the methods you can use to reduce noise

2.10.1 Noise Shield

A noise shield can reduce the noise at the neighbor by 5-10 dB, which is a significant reduction. However, there are some requirements that the screen must meet in order to achieve this effect:

- The screen must be "airtight" and made of a material weighing at least 12 kg / m^2, e.g. metal, wood or glass. If there are tiles under the screen, the screen should go all the way down to the tiles. If there is grass, soil or gravel under the screen, a small crack of up to 5 cm height along the ground may be allowed.

- The screen must cover all the way around the heat pump in the direction towards the neighboring dwelling (see Figures 2-16 and 2-17). If the terrain rises towards the neighbor, the screen must be higher than that shown in Figure 2-16.

The screen must have a sound-absorbing surface towards the heat pump and may e.g. builds up as shown in Figure 2-18. There are a number of standard products on the market that meet this requirement

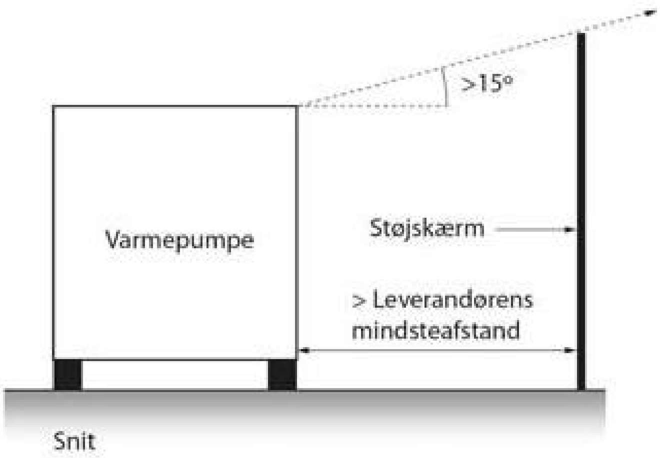


Figure 2-16:Noise barrier height requirements

measurement result must therefore differ significantly from the declaration value before there is a significant probability of errors.

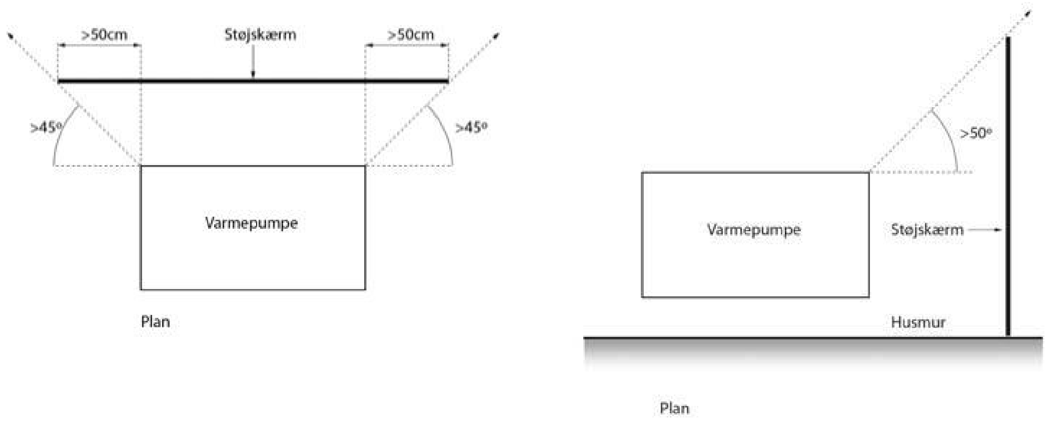


Figure 2-17:Requirements for the extent of the noise barrier (left): Screen front, (right) Side screen

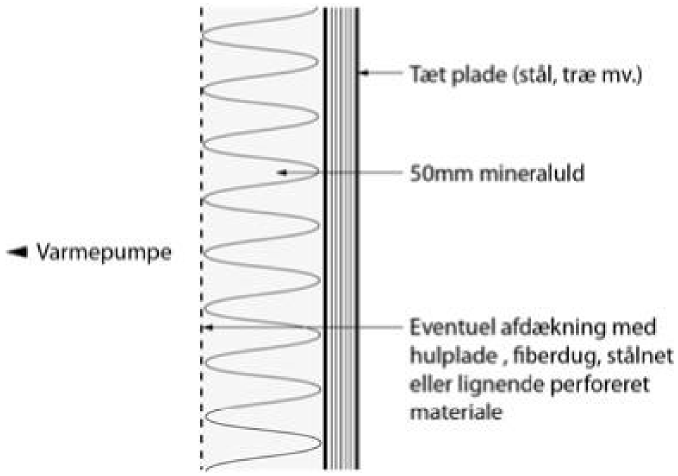


Figure 2-18: Structure of the screen

The calculation program uses screens that exactly meet the requirements in Figures 6-16, 6-17 and 6-18. If the noise shield is performed to a greater extent, a greater reduction of the neighboring noise can be achieved, but typically only a few extra dB.

2.10.2 Noise Gate

Since the fan noise is often dominant, it may be a good idea to mount a so-called sound lock to dampen the noise. In a sound lock, the sound is forced through narrow passages where it can hit a sound absorbing material many times. See Figure 6-19 for examples of designing a sound lock.

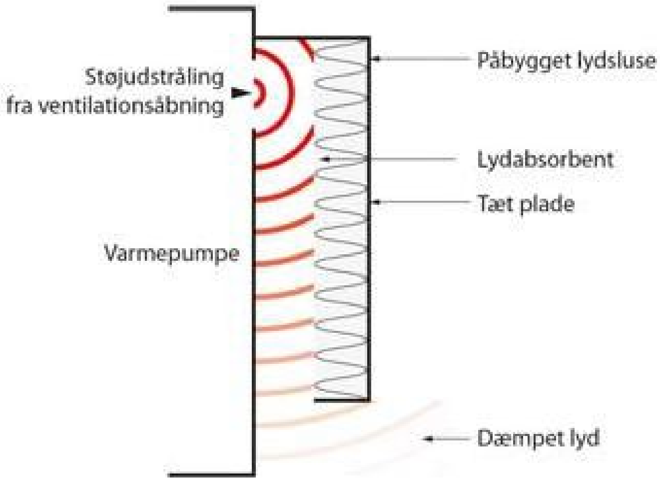


Figure 2-19: Principle structures of sound locks

The narrower and the longer the air gap, the more noise is reduced. However, the thickness of the sound absorber is also important. A thick sound absorber is usually better than a thin one.

Figure 2-20: Example of mounted silencer

It is not only through the fan exhaust that the ventilation noise comes out of the heat pump. The air is also sucked into the heat pump - either at the bottom or at the back. It may also be necessary to provide these openings with a sound lock, as just as much noise may come out this way.

When using sound locks, it is important to ensure that the heat pump can still get the necessary operating air. Do not install sound locks without acceptance from the supplier / installer, otherwise the warranty may lapse. Some vendors have standard solutions that you can purchase without losing your warranty.

2.10.3 Cabinet vibrations

The enclosure enclosing the heat pump is typically made of a thin plate. If vibrations from the compressor or fan are transmitted to the cabinet, the cabinet plates may act as an unintended speaker.

The best solution is to disconnect the housing from the load-bearing parts of the heat pump - this usually also from the fan and compressor - but this often requires major intervention in theheat pump design, which only the supplier can do.

The risk of the cabinet acting as a loudspeaker can be reduced by mounting the vibration damping foil on the inside (see Figure 10.3.1). For thin sheets, this is often an effective solution. The foil is mounted on as large areas as possible, but is not avoided where there are stiffening ribs etc. The foil must be mounted with a good adhesion to the cabinet over the entire area of the foil.

Figure 2-21: Example of antivibration film

2.10.4 Cabinet noise

Inside the cabinet, the fan and compressor cause some noise, which is radiated partly through ventilation openings and partly directly through the cabinet plates. A sound absorber mounted inside the cabinet can reduce this noise.

The sound absorber is typically a 2-3 cm thick foam board (see Figure 6-22). The plate may optionally be provided with a thin plastic or metal foil which can prevent dirt over time, which can be an advantage. The sound absorber is mounted on as many internal surfaces as possible, but so that the heat pump can get the necessary operating air.

The individual absorbents do not need to be coherent to work well, but a large part of the cabinet surfaces should be covered. However, the areas most close to the fan and compressor are the most efficient. The sound absorbers may also be included as sound locks for the ventilation air.

Since mounting sound absorbers is a major step in the heat pump, you should get the supplier's / installer's acceptance, as otherwise the warranty may lapse. Some suppliers have standard solutions so you can buy without losing the warranty.

Figure 2-22: Example of foam absorbent (Source: B6-Akustik)

2.11 Examples

2.11.1 Unappropriate placement

A sports club in a smaller village installed a heat pump at the clubhouse. The club house was located between two neighboring houses in one strip along the main street through the village. The location was conditional on a simple installation and so that the heat pump was hidden slightly out of the way (see Figure 6-23).

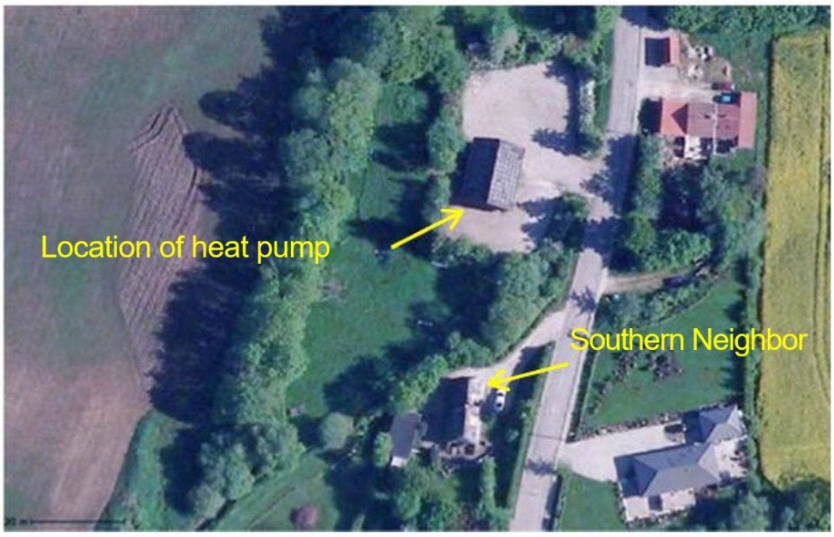


Figure 2-23: – Heat pump at clubhouse (Copyright © Kort & Matrikelstyrelsen)

No thought was made about the noise consequences. Immediately after the heat pump was installed, complaints about the noise came from the neighbor south of the clubhouse. North of the clubhouse, the noise from the heat pump was well shielded, so here the heat pump did not bother. The municipality made noise measurements at the southern neighbor, which showed noise levels of 44 dB. However, the background noise was at the same level, so the correct noise load could not be determined. The municipality then sought help to partly determine the noise load and partly to get suggestions for noise reduction.

The noise calculation showed that the noise load at the neighbor was not higher than 36 dB, which largely met the noise requirement. However, it was decided to make a noise reduction. The heat pump was moved around the corner and provided with noise screens on the sides (see Figure 2-24).

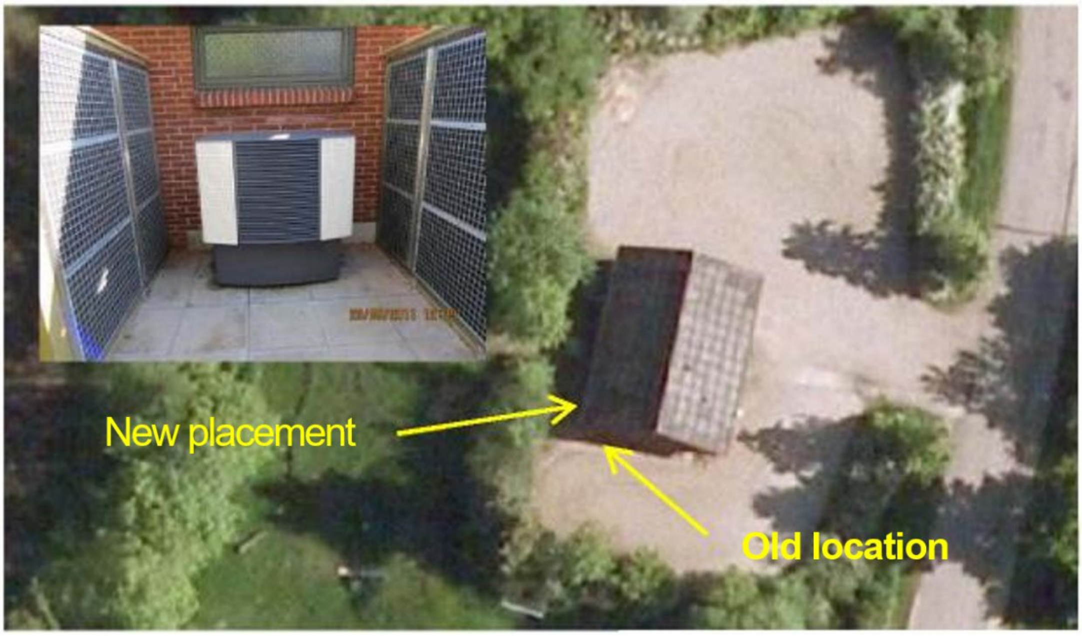


Figure 2-24: Moved and noise shielded heat pump

The result was a noise load of 30 dB by the neighbors both north and south of the clubhouse - and two satisfied neighbors.

2.11.2 Good and bad placements

The good location of the heat pump depends on the local conditions, especially where the neighbors are located (direction and distance). Of course, how much noise the noise pump has is of significance, but there is typically much better economy in finding a noisy optimal location. Below are some examples of good and bad locations.

2.11.2.1 <u>One stip of houses</u>

In the remote areas where there is only one strip of houses on each side of the road - and open terrain outside the back yards - there are good opportunities for a good location.

Figure 2-25:Opportunities for a good location

Location A is the poor choice. The heat pump is hidden well out of the way of the owner and the pipe connections are short, but the heat pump is located just towards the neighbor's main terrace. A dissatisfied neighbor is almost inevitable.

Location B is a better choice. Utility room noise shields the neighbor's terrace. Supplemented by a noise shield against the neighbor, the noise load of the neighbor can be kept low. The pipe connections are only marginally longer than location A. The disadvantages, however, are the noise on the owner's secondary living area. However, a noise shield on both sides of the heat pump can reduce the noise along the housing end.

Location C is the best purely noisy. Hidden behind the garden sheds, the heat pump only loads the non-noise-sensitive neighboring area. The heat pump can be set up with completely free air movements, providing the best operating economy. The disadvantage is relatively long pipe connections.

2.11.2.2 Close construction

When the houses are close to each other, the location of the heat pump requires great care. It is almost impossible to find a direction in which the heat pump can noise freely. As a starting point, a particularly quiet heat pump must be selected.

Figure 2-26:Location in dense construction (Copyright © Kort & Matrikelstyrelsen)

Location A is bad. The heat pump is well tucked away by the owner, but the pump will at least load two neighbors with a lot of noise. A noise shield can only reduce the noise of one neighbor, otherwise the heat pump may not get enough air.

Location B is good. There is a great distance to the neighbor to both east and west (the noise at the road does not matter). The noise to the north can be reduced by placing a noise shield in front of the heat pump. Another option is to turn the heat pump so that it is parallel to the building's facade. The noise from the side of the heat pump is significantly lower than the front and rear heat pump. The noise to the north is thus limited simply by reversing the heat pump.

Location C is also good. The owner's own home screens the neighbors in all directions, except to the east. The intermediate road can ensure sufficient distance to the neighbor in this direction. A screen may be installed in front of the heat pump. It will partly limit the noise to the east and partly hide the heat pump so that it is not visible from the road.

2.11.2.3 Townhouses

In terraced buildings the distance to the neighbor is very small. A particularly quiet heat pump must be selected. There are not many usable locations.

Figure 2-27:Townhouse development (Copyright © Kort & Matrikelstyrelsen)

Location A is the natural location, just outside the brewery. A screen on both sides of the heat pump can protect both the neighbor's and the owner's façade and living areas. Towards the neighbor the screen should be extra high and extra long to ensure good noise protection. Part of both the owner's and neighbor's distant garden area will be noise-burdened.

Location B can be established by setting up a noise screen on the north side (corresponds to the normal "up house" location) and the east side. The heat pump will make a noise across the road, but it is only at the reboot that the noise can become critical. It is the distance to the dwelling and the sound effect of the heat pump that determines whether the noise becomes critical. Location B provides a low noise level in the gardens around the heat pump pen. On the other hand, the pipe connections become long.

2.11.2.4 Apartment buildings

It can also be difficult to find a good location for its heat pump at an apartment block. This guide is limited to smaller heat pumps. Heat pumps of limited size can only cover the heat consumption for a small number of apartments. More pumps per building can thus come to talk.

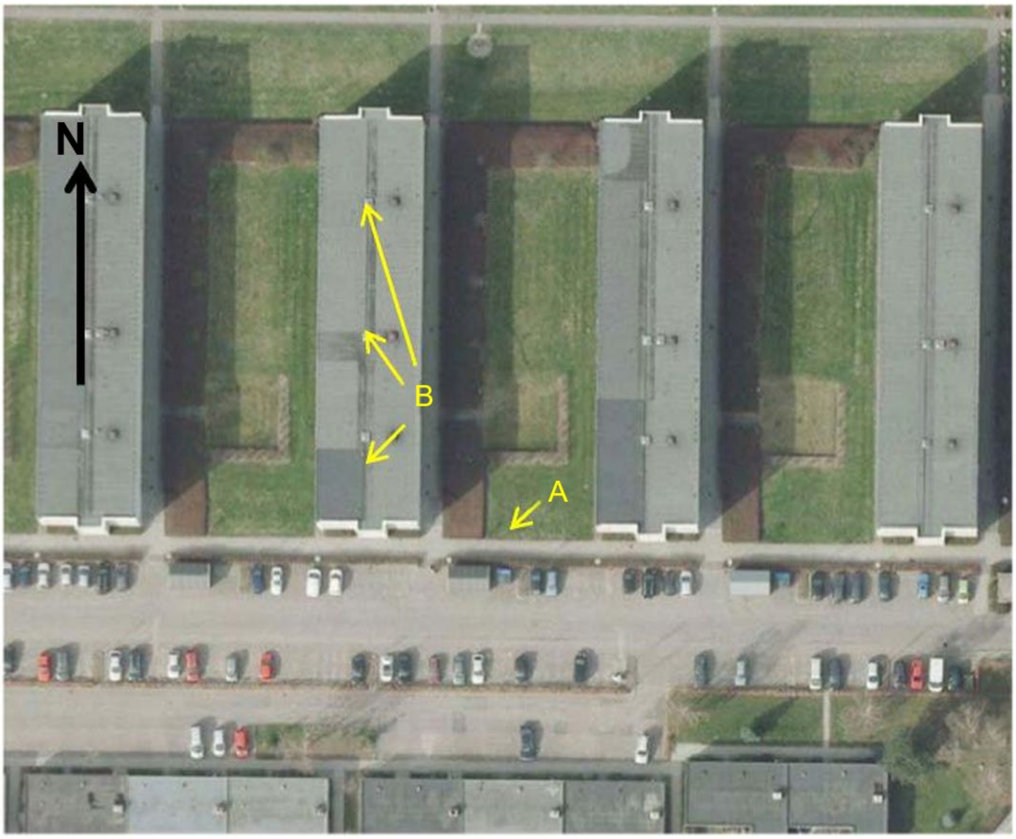


Figure 2-28:Apartement buildings (Copyright © Kort & Matrikelstyrelsen)

Position A can be made in a U-shaped shield, which is open to the parking space. It can shield the noise load of living areas and apartments at terrain level, but it is difficult to shield the noise from the higher situated apartments. The applicability of the solution depends a lot on the local conditions (distances, building heights, etc.). In this case, an actual noise calculation according to the guidelines of the Environmental Protection Agency should be carried out. The solution can also cause very long pipe connections.

Location B, where the heat pumps are distributed over a flat roof surface, can be a good solution. Pipe connections can be kept relatively short. By putting noise screens on the east and west sides, noise is reduced against neighboring buildings. The heat pumps should be positioned as far inside the roof surface as possible, as the roof edges function as a noise shield as best as possible.

2.11.3 Control measurement of noise

Once you have installed your heat pump, it is a good idea to ensure that the installation and heat pump comply with the noise data shown in the supplier's sales material. You can advantageously use the method described in section 2.9. The advantage of measuring so close to the heat pump is that all other noise has little influence on the measurement result. You should not perform the measurement if you can clearly hear noise other than that coming from the heat pump, e.g. noise from passing cars. In this case, choose another time to measure the noise where there is more calm.
By using the calculation program on the Danish Energy Agency's website you can calculate a limit on the noise that heat pumps should emit. This is a noise level measured 1 meter in front of the heat pump. An ordinary sound meter is used. Figure 2-29 shows the performance of a

control measurement. There will always be deviations from catalog data, so only when the measured value exceeds the limit by more than 5 dB is there a significant likelihood that the heat pump, its operating condition or its assembly is likely to be faulty.

Figure 2-29: Control measurement of installation

In connection with the noise measurement, control measurements were also carried out in the surroundings. The results are shown in Figure 2-30 as point values which are compared with the noise program's noise curves.

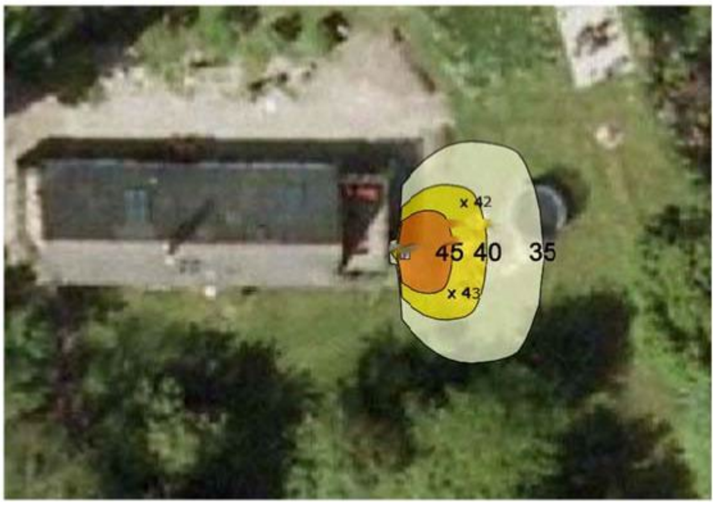


Figure 2-30: Control measurement in rounds

2.12 Literature

[1] Miljøstyrelsens vejledning nr. 5/1984 "Ekstern støj fra virksomheder"

[2] Miljøstyrelsens vejledning nr. 6/1984 "Måling ekstern støj fra virksomheder"

[3] Miljøstyrelsens vejledning nr. 5/1993 "Beregning af ekstern støj fra virksomhe-der"

[4] Orientering fra Miljøstyrelsen nr. 9, 1997 "Lavfrekvent støj, infralyd og vibratio-ner i eksternt miljø"

[5] Erhvervs- og Byggestyrelsen, Bygningsreglement 2010 (BR 10)

3 Heat pumps & environment acoustics

This is a translation from fiche technique N°1 of AFPAC – Association Francaise pour les Pompes A Chaleur (French Association for Heat Pump) - AFPAC c/o Certex, 31 rue du Rocher - 75008 PARIS, Tél. : 01 42 93 52 25 - Fax : 01 45 22 33 55. www.afpac.org – the French Original is available on the Annex 51 Website https://heatpumpingtechnologies.org/annex51/

3.1 Sound power and sound pressure - Definitions

Sound power level Lw, in dB(A): It characterises the sound emission capacity of the source independently of its environment. This sound power (Lw) is measured in the laboratory. It is the value that allows direct comparison
between devices.

Sound pressure Lp, in dB(A): It is the acoustical quantity **perceived by the human ear** and measured by the sound level meter. For a given source, the acoustic pressure (Lp) depends on the installation environment and the distance at which the the measurement is made.

Reduction of pressure level with distance: The sound pressure level is reduced by 6 dB(A) by doubling the distance. Thus, a sound pressure level Lp[3] of 54 dB(A) at 2 metres from the machine becomes 48 dB(A) at 4 metres, etc.

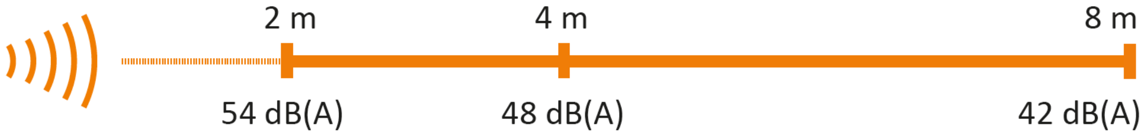


Figure 3-1: Reduction of pressure level with distance

[3] In the open field

Determination of a probable residual noise level +/- 5 dB(A)			
Type of area	day	intermediate	night
Hospital area, rest area, areas for the protection of natural areas	45 dB	40 dB	32 dB
Residential, rural or suburban, with low land, water or air land, water or air traffic	50 dB	45 dB	37 dB
Urban residence	55 dB	50 dB	42 dB
Urban or suburban residence, with some workshops or business centres, or land traffic routes, or air traffic routes	60 dB	55 dB	50 dB
Area with predominantly commercial, industrial industrial activities	65 dB	60 dB	55 dB
Predominantly industrial area (heavy industry)	70 dB	65 dB	60 dB

Table 3-1 – EPA recommended noise limitations

3.2 Adding two sound sources – Calculation method

First case: the two sound sources are of the same level.
Example: two heat pumps with a sound pressure[4] Lp of 60 dB(A)

Lp_1 = 60 dB(A) and Lp_2 = 60 dB(A)
Lp - Difference = 0 dB(A)
$Lp_1 + Lp_2 = 60 + 3 = 63$ dB(A)

Second case: the two sources are not of the same sound level.
Example: two PACs with a sound pressure Lp of 60 dB(A) and 66 dB(A).
The difference between these 2 noise levels must be made and the table below must be consulted. The left-hand column shows the difference between the two noise levels. The right-hand column gives the value to be added to the higher of the two the higher of the two levels.

[4] In relation to a given distance

$Lp_1 = 60$ dB(A) and $Lp_2 = 66$ dB(A)
Lp - Difference = 6 dB(A)
$Lp_1 + Lp_2 = 66 + 1 = 67$ dB(A)

Calculation method for adding 2 sound sources	
Difference in dB(A) between the 2 sources	Number of dB(A) to be added to the highest sound level most important
0 or 1	3
2 or 3	2
Between 4 and 6	1
Above 6	0

Table 3-2 – Calculation method for adding 2 sound sources

3.3 Recommendations for the implementation - Basic rules

3.3.1 Location

Anything that is discret is better for the environment. It is recommended that to provide for the integration of the AAC (hedges, hedges, canisses...).

3.3.2 Reflection of emitted noise

Avoid corners and inner courtyards. The smaller the yard, the greater the reflection.
In an inner courtyard, the level is increased by at least 9 dB(A) compared to the free field.

Figure 3-2: (left) Heat pump placed on the ground or on a terrace (free field), (right) Heat pump placed against a wall : + 3 dB(A)

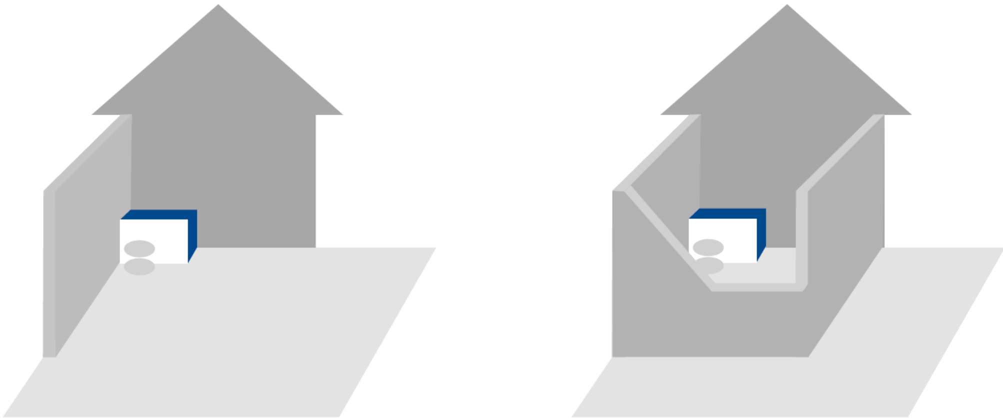


Figure 3-3: (left) Heat pump placed in a corner: + 6 dB(A), (right) Heat pump placed in a yard: indoor: + 9 dB(A)

3.3.3 Reflection of received noise

The same rules as above apply. At the same distance from the heat pump, the level received at the front is 3 dB higher than that received in a free field and 3 dB lower than in a corner.

3.3.4 Directivity of ventilations

Do not direct ventilation towards neighbours

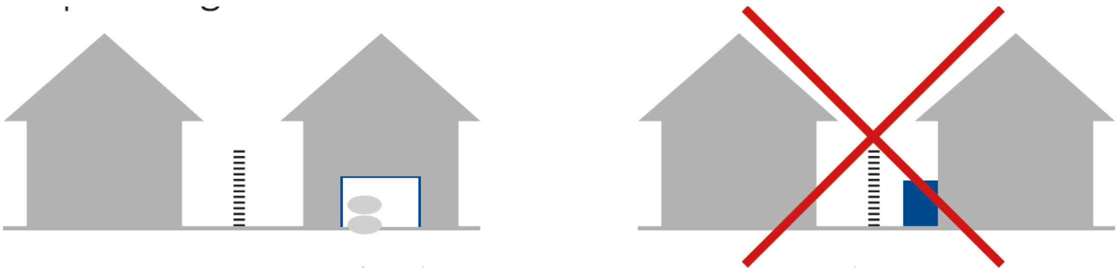


Figure 3-4: (left) Correctly placed heat pump, (right) placement to be avoided

3.3.5 Distance to property lines

Install the heat pump away from property lines.

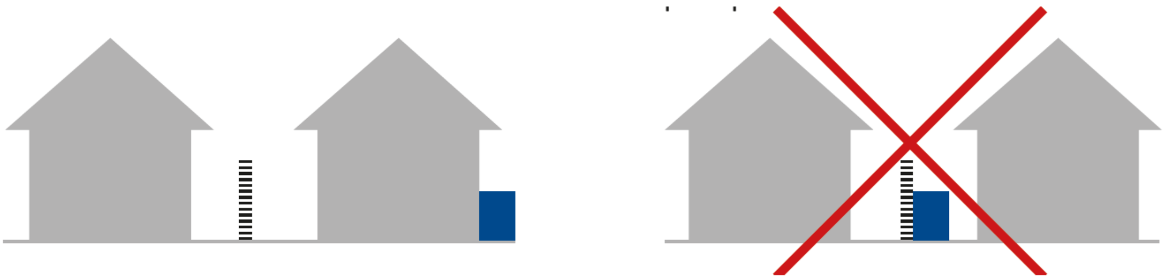


Figure 3-5: (left) Correctly placed heat pump, (right) placement to be avoided

3.3.6 Installation under windows

Windows are less soundproof than walls, and more importantly, they can be opened. can be opened. The heat pump should therefore be kept away from windows (both your own and those of your neighbours).

Figure 3-6: (left) Correctly placed heat pump, (right) placement to be avoided

Solutions to reduce noise pollution: noise barriers

The screen should be placed as close as possible to the sound source while allowing free airflow. The shielding reduces the emergence of noise from the equipment in relation to a given environment.

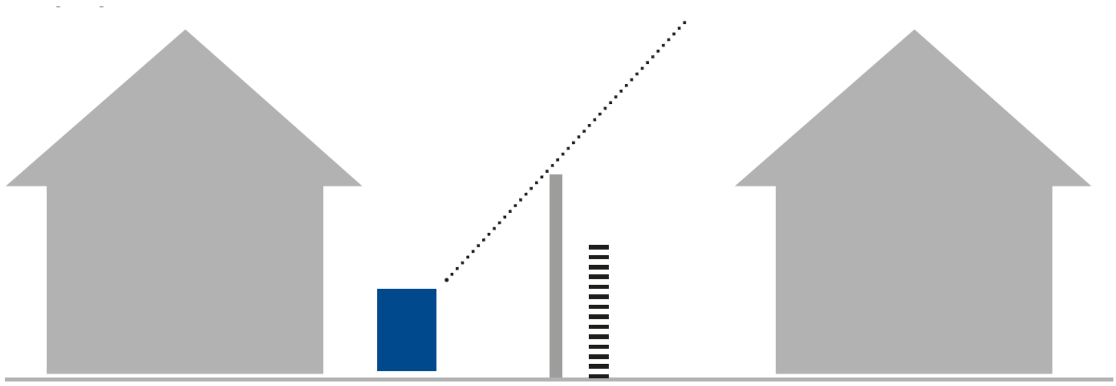


Figure 3-7: The noise barrier must be made of insulating materials.

3.4 Reminder on the regulation of neighbourhood noise

(For more information: decree of 31 August 2006 and standard NF S 31-010)

The nuisance is defined by the **emergence number**, i.e. the difference between the sound pressure level measured when the equipment is stationary compared to the level measured when the equipment is in operation at the same location.

Measurements of emergence should be taken at the property line. In the case of buildings, these measurements must be made in living rooms with windows open and with windows closed. The regulations differentiate between day and night emergence.

- **Daytime (7am - 10pm), maximum permissible deviation: 5 dB(A)**
- **At night (22:00 - 7:00), maximum permitted deviation: 3 dB(A)**

3.5 Application examples and emergence calculation

There are corrective terms for non-permanent noise: consult directly the decree n°2006-10-99 of 31/08/2006 relating to the fight against neighbourhood noise and modifying the Public Health Code.

3.5.1 Case of an outdoor measurement

- Step 1: Measure the residual noise at the property line with the heat pump at standstill.
- Step 2: Measure the noise with the heat pump in operation.

3.5.2 Case of an measurement inside buildings

- Step 1: Measure the residual noise with the windows closed and then windows open, with the heat pump switched off.
- Step 2: Measure the noise with the heat pump in operation.

To **calculate the emergence**, make the difference between the two measurements in steps 1 and 2. This difference should be less than 3 dB(A) at night (22:00 - 7:00) and 5 dB(A) during the day (7:00 - 22:00).

4 Heat pumps & recommendations for installation

This is a translation from fiche technique N°2 of AFPAC – Association Francaise pour les Pompes A Chaleur (French Association for Heat Pump) - AFPAC c/o Certex, 31 rue du Rocher - 75008 PARIS, Tél. : 01 42 93 52 25 - Fax : 01 45 22 33 55. www.afpac.org – the French Original is available on the Annex 51 Website https://heatpumpingtechnologies.org/annex51/

4.1 The Support

Objective: to reduce the transmission of the vibrations of the heat pump by the support.

4.1.1 Concrete base

Favour the installation of the heat pump on an inertia base. The two essential principles to respect:

A. The inertia of the base

- Its mass must be at least 2 times the mass of the heat pump.
- The base must be independent of the building (1).

B. Anti-vibration devices

- Anti-vibration mounts must be installed under the inertia base (1), (2), (3).
- All load pick-ups on the building must have anti-vibration devices (2), (3).

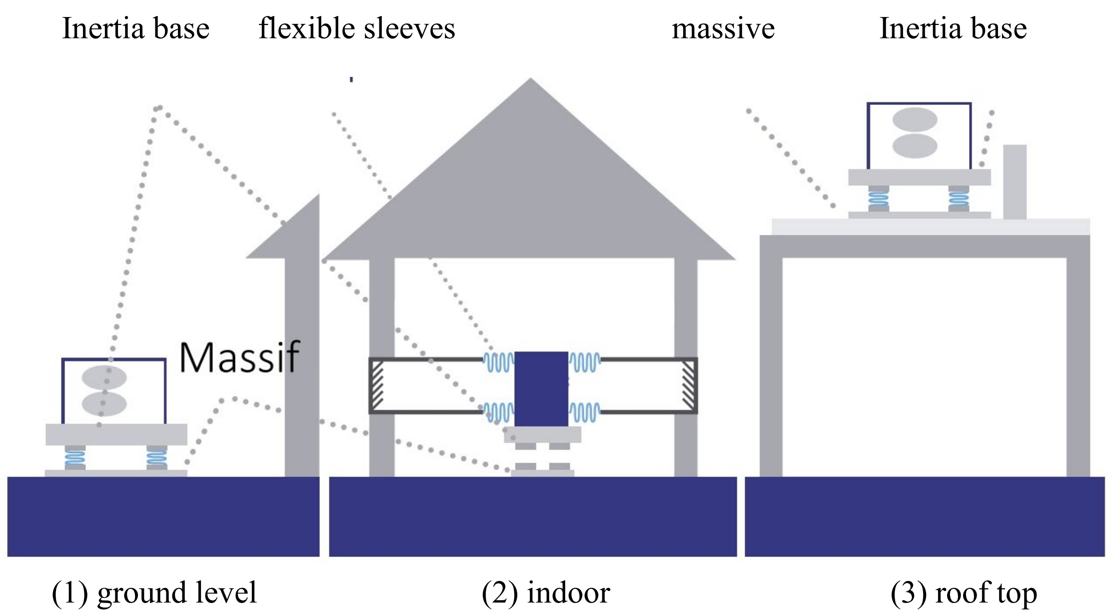


Figure 4-1: Concrete Base

Very important! Select the anti-vibration mounts according to:

Load distribution: in the case of uneven load distribution, the selection may result in studs of the same nature but which can support different loads, due to

- the frequency of the vibrations of the heat pump

- the efficiency required (filtering rate).

Observe the manufacturer's installation requirements!

4.1.2 Metal frame

If it is impossible to install the heat pump on a concrete base, a metal support can be used with the following precautions:

A. The support chair must be very rigid and installed on a supporting wall.

B. Anti-vibration devices

- Provide anti-vibration pads selected according to the load distribution, the frequency of the vibrations of the heat pump and the desired efficiency (filtering rate).

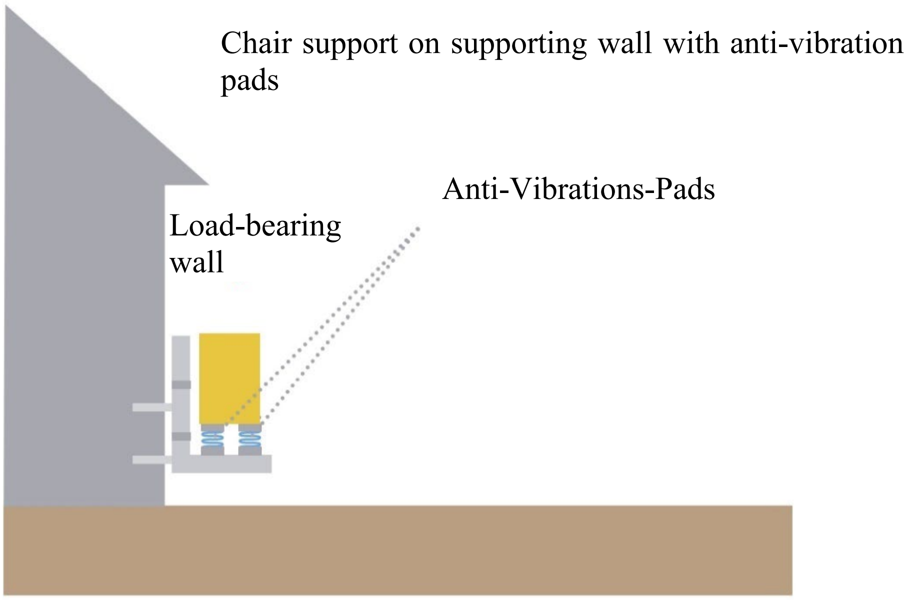


Figure 4-2: Metal frame

In any case, design a heavy, robust and rigid chassis, which will have the minimum of deflection.

4.2 Network design rules

Particular attention will be paid to the air networks, but the hydraulic networks should not be neglected.

4.2.1 Design principles to be respected

- **Diameter**: The greater the flow rate, the larger the diameter should be. Use a selection chart.
- **Elbow**: The radius of curvature must be at least three times
- than the diameter.
- **Straight lines**: To be used after each turbulent passage.

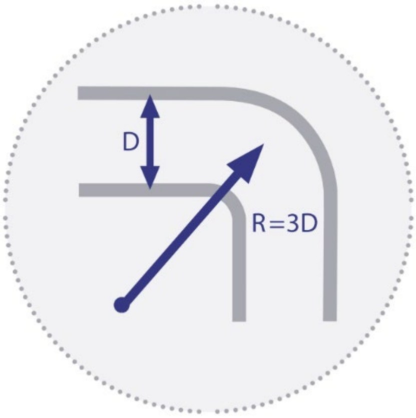


Figure 4-3: Design princliples

Some examples to avoid:

- the T-junction

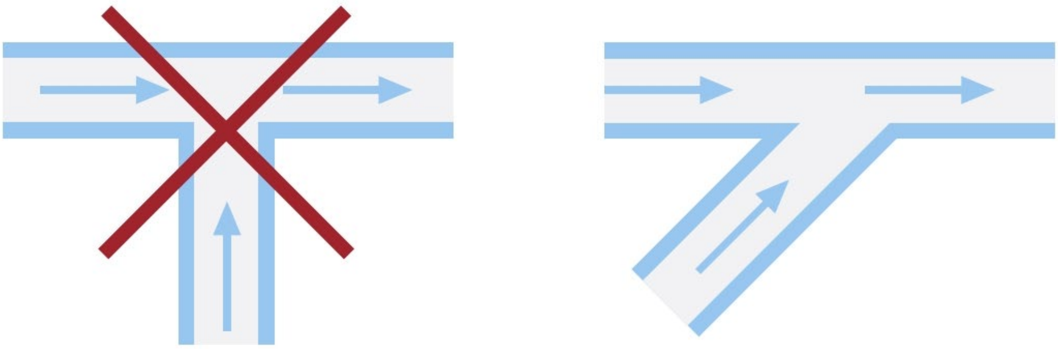


Figure 4-4: avoid the T-junction

- too large a diameter change: more than 2 DN in one go

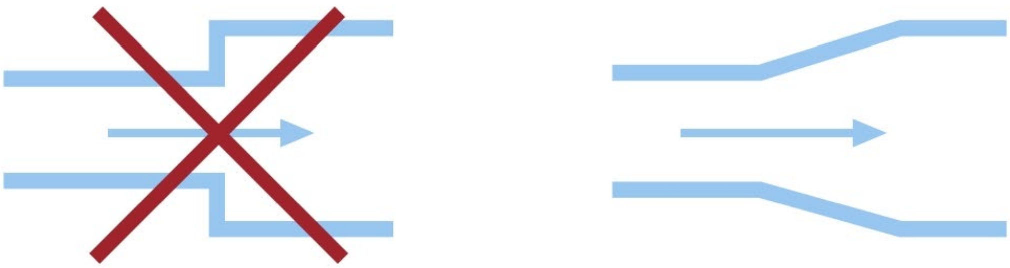


Figure 4-5: avoid too large a diameter change

Disposition to be avoided:

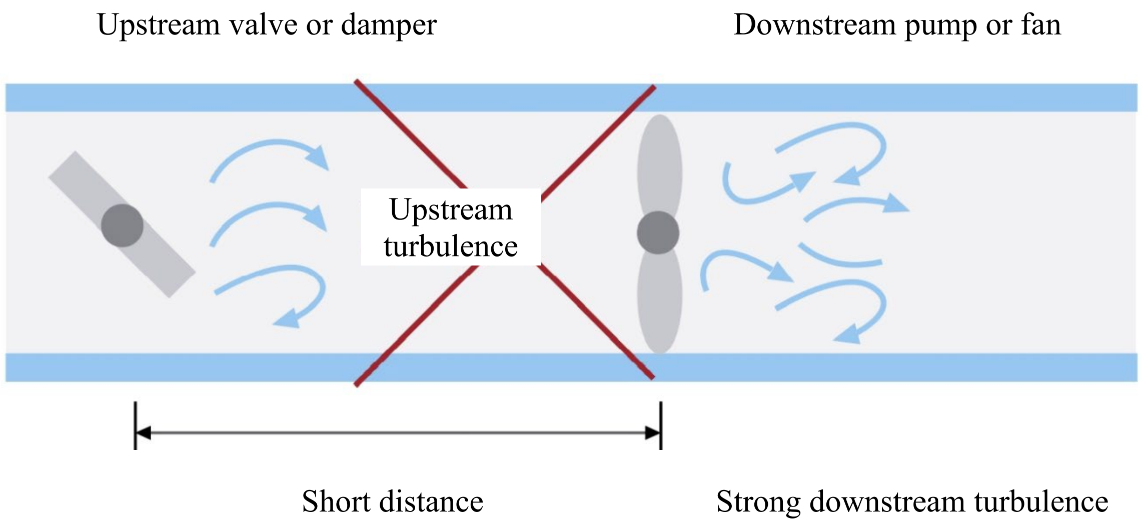


Figure 4-6: fan dispositions to be avoided

Correct layout:

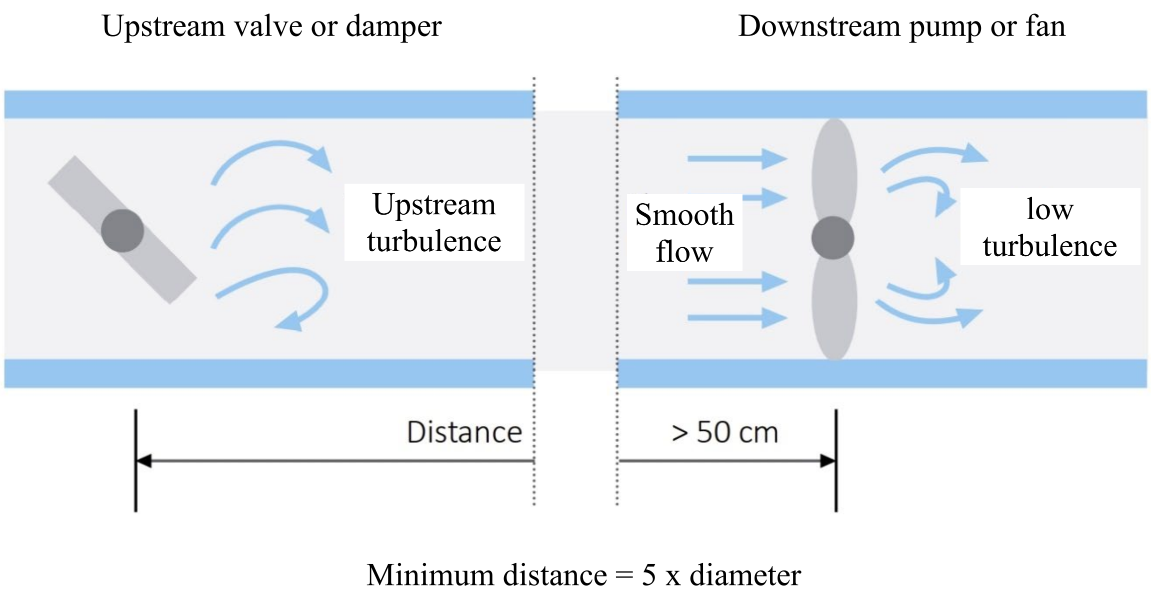


Figure 4-7: correct layout with fans

4.2.2 Crossing the walls

Reducing parasitic transmission

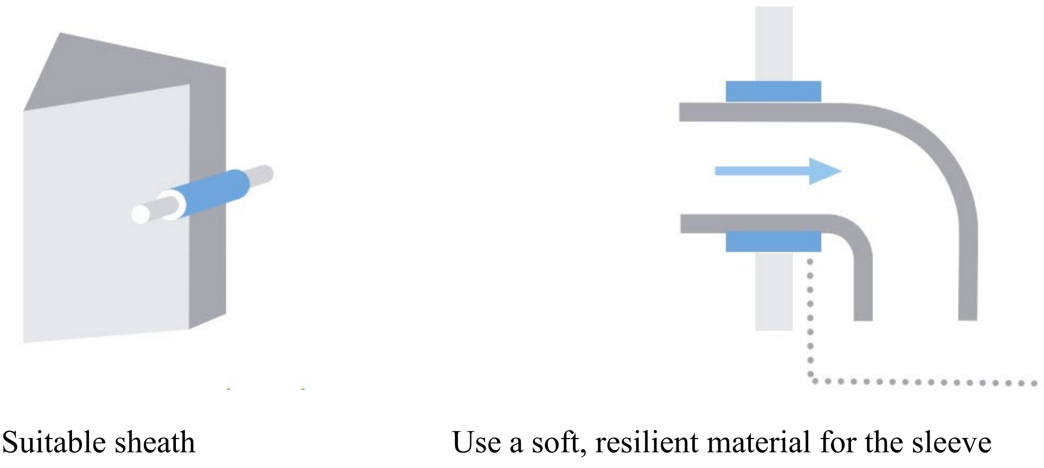


Figure 4-8: Usage of sleeve material

Use a sleeve when passing through walls.

4.2.3 Mounting

Provide supports with a soft, anti-vibration material (e.g. rubber or neoprene).

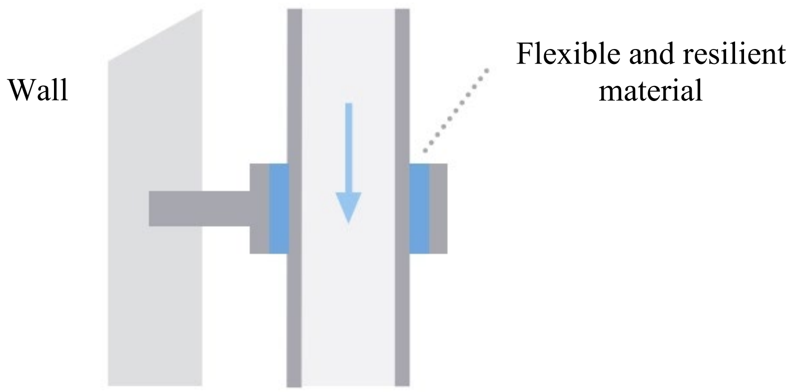


Figure 4-9: Flexible and resilient material for mounting

4.3 The pipes

The aim is to reduce the transmission of vibrations from the heat pump through the refrigeration connections and water pipes.

Any transmission of vibrations is likely to generate noise.

4.3.1 Case of refrigeration links: direct expansion

Provide vibration damping devices:

- loop (1),

- lyre (2),

- three bends in three directions (3).

Provide a fixing point (with resilient) immediately after the anti-vibration device.

- Mufflers and hoses (recommended by specialists).

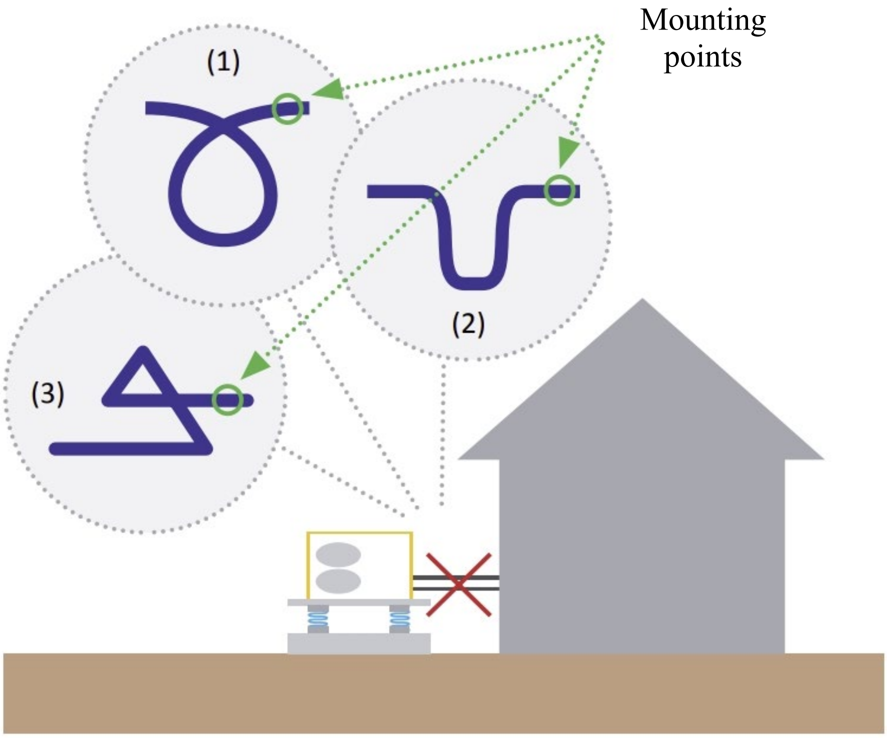


Figure 4-10: Case of refrigeration links: direct expansion

Note: Provide one or more devices depending on the efficiency required.

4.3.2 Case of water pipes

Provide an attenuation device on the water flow and return:

- flexible hose (minimum length 40 times the internal diameter of the DN<25 pipe).

Form a loop or a complete loop with the hose.

Provide a fixing point (with resilient) immediately afterwards.

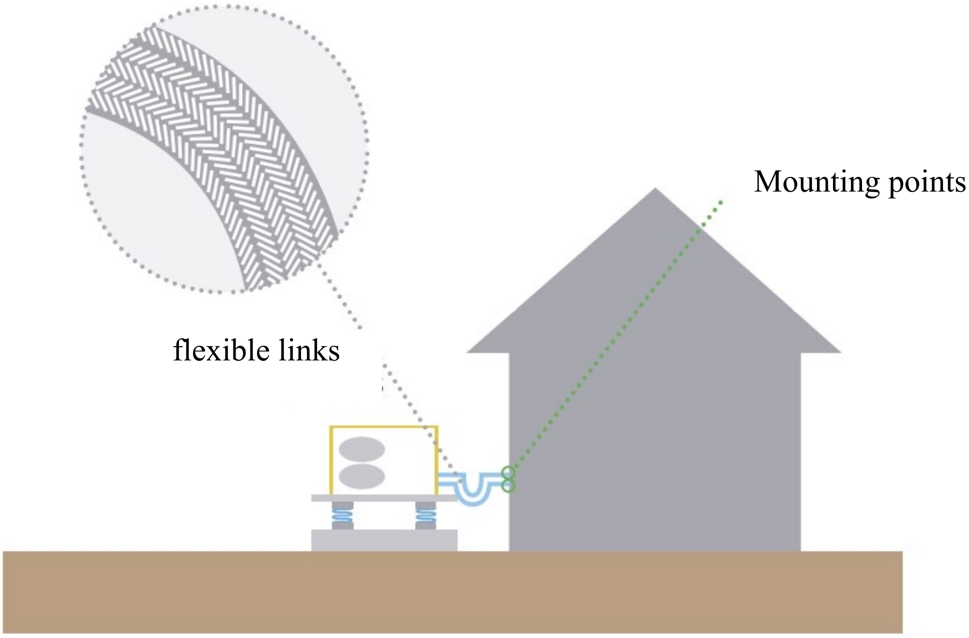


Figure 4-11: Case of water pipes

4.4 Air networks

Objective: to reduce the transmission of noise and vibrations from the heat pump through the air ducts.

4.4.1 Reduce vibration transmission through ducts

Any transmission of vibrations is likely to generate noise. Use flexible sleeves at the junctions with the heat pump.

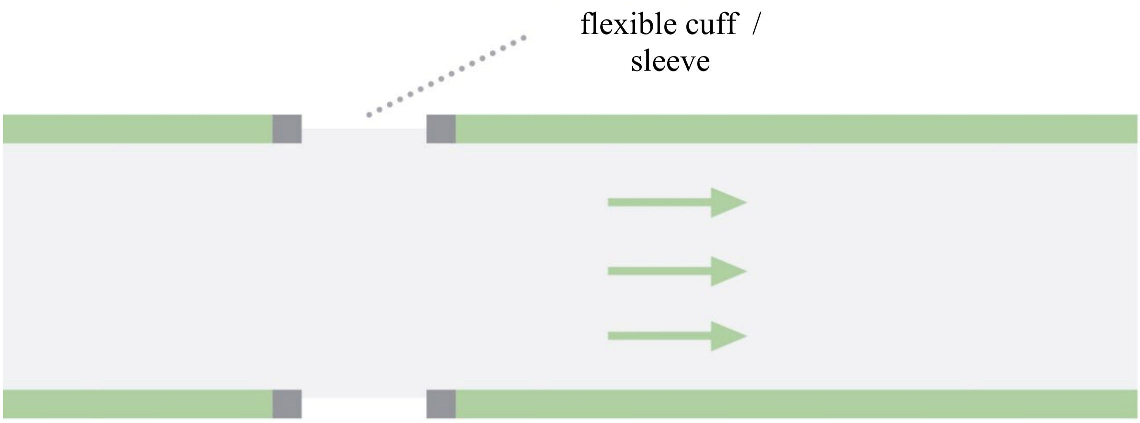


Figure 4-12: Reduction of vibration transmission in ducts

4.4.2 Reduction of noise transmission through ducts

Noise increases with air speed and pressure drop. Install a sound trap on the air supply and if necessary on the air intake.

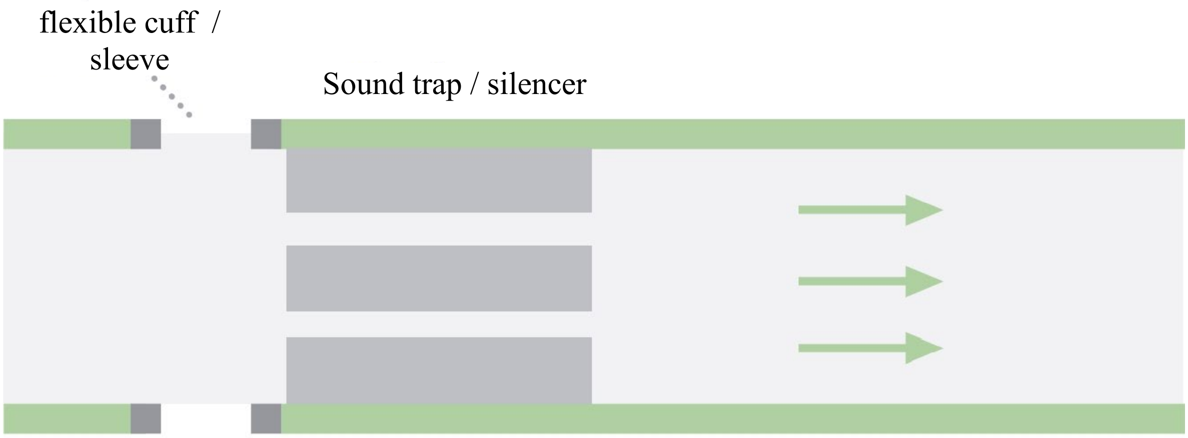


Figure 4-13: Reduction of noise transmission through ducts

Check the compatibility - pressure drop - of the sound traps with the available static pressure of the fan.

4.4.3 Reduction of the radiation of noise through the walls of the duct

Noise increases with air speed and pressure drop. Install a sound trap on the air supply and if

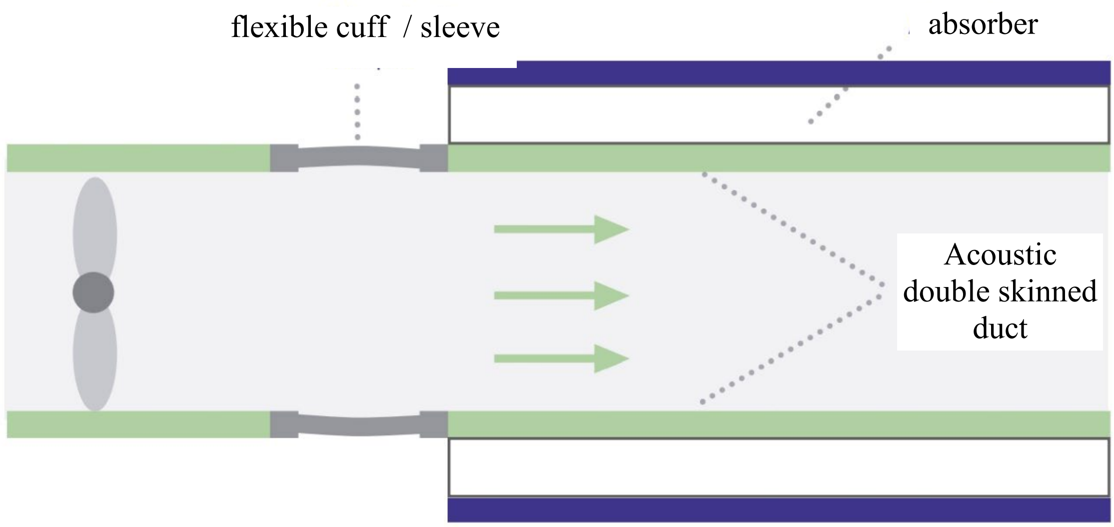


Figure 4-14: Reduction of noise transmission through ducts in vicinity of fans

4.4.4 Design principles to be respected

External air intake grilles should have a maximum velocity of 2.5 m/s to avoid water entrainment.

Provide an expansion plenum between the ductwork and the grille.

4.5 Acoustic attenuation devices

It is advisable to call in an acoustician to implement mitigation solutions.

4.5.1 Absorbent on the wall

Principle: A heat pump installed against a wall generates 3 dB(A) more for the neighbourhood than if it were installed in a free field (6 dB(A) if the heat pump is in a corner).

Solution: Placement of an acoustic absorbing material on the wall(s) behind the heat pump to reduce the reflection of noise on the façade. The surface area of the absorber sheet should be larger than the dimensions of the heat pump.

If the heat pump is installed in a corner, it is advisable to treat both walls.

Possible mitigation:

- Maximum 2 dB(A) if the heat pump is against a wall
- Maximum 4 dB(A) if the heat pump is in a corner

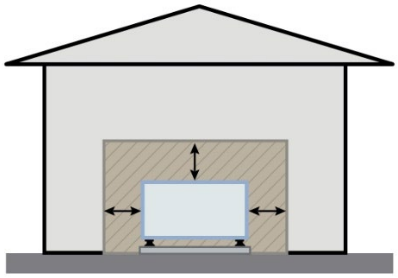


Figure 4-15: Absorbent on the wall

4.5.2 The sound barrier

Principle: Reduce sound transmission and absorb noise in one direction. Use natural barriers wherever possible (earth banks, etc.). A hedge of trees cannot be used as a sound barrier. The effectiveness of a barrier depends on its location, size and materials.

Location: The screen must be positioned as close as possible to the heat pump while allowing free air circulation.

Dimensions: The surface of the screen must be larger than the the dimensions of the heat pump.

Figure 4-16: Sound barrier

To increase the effectiveness of the screen, flaps (caps and returns) may be necessary.

Materials: Choose solid materials, acoustic bricks, concrete blocks possibly covered with absorbent materials (mineral wool panels), etc. Pay attention to weathering, especially rain and wind

Possible mitigation: maximum 6 dB(A)

+ 1 dB(A) if the wall behind the heat pump is treated.

4.5.3 Enclosure

Principle: Enclosure to reduce noise transmission and absorb noise around the heat pump in all directions.

- Provide acoustic treatment for access and pipework and power supply.
- Avoid contact with any vibrating part (frame, piping, etc.)
- Provide internal ducting to avoid air recycling.
- If necessary, install an additional fan (with sound trap on air inlets and outlets) to remove heat and combat additional pressure drop due to enclosure.

Possible mitigation: maximum 25 dB(A)

4.6 Maintenance

Regularly check absorbent materials, seals, anti-vibration devices, etc. replace as necessary.

5 Heat pumps - study of the risk of noise pollution in the vicinity

This is a translation from fiche technique N°3 of AFPAC – Association Francaise pour les Pompes A Chaleur (French Association for Heat Pump) - AFPAC c/o Certex, 31 rue du Rocher - 75008 PARIS, Tél. : 01 42 93 52 25 - Fax : 01 45 22 33 55. www.afpac.org – the French Original is available on the Annex 51 Website https://heatpumpingtechnologies.org/annex51/

5.1 Study of the risk of noise pollution in the vicinity

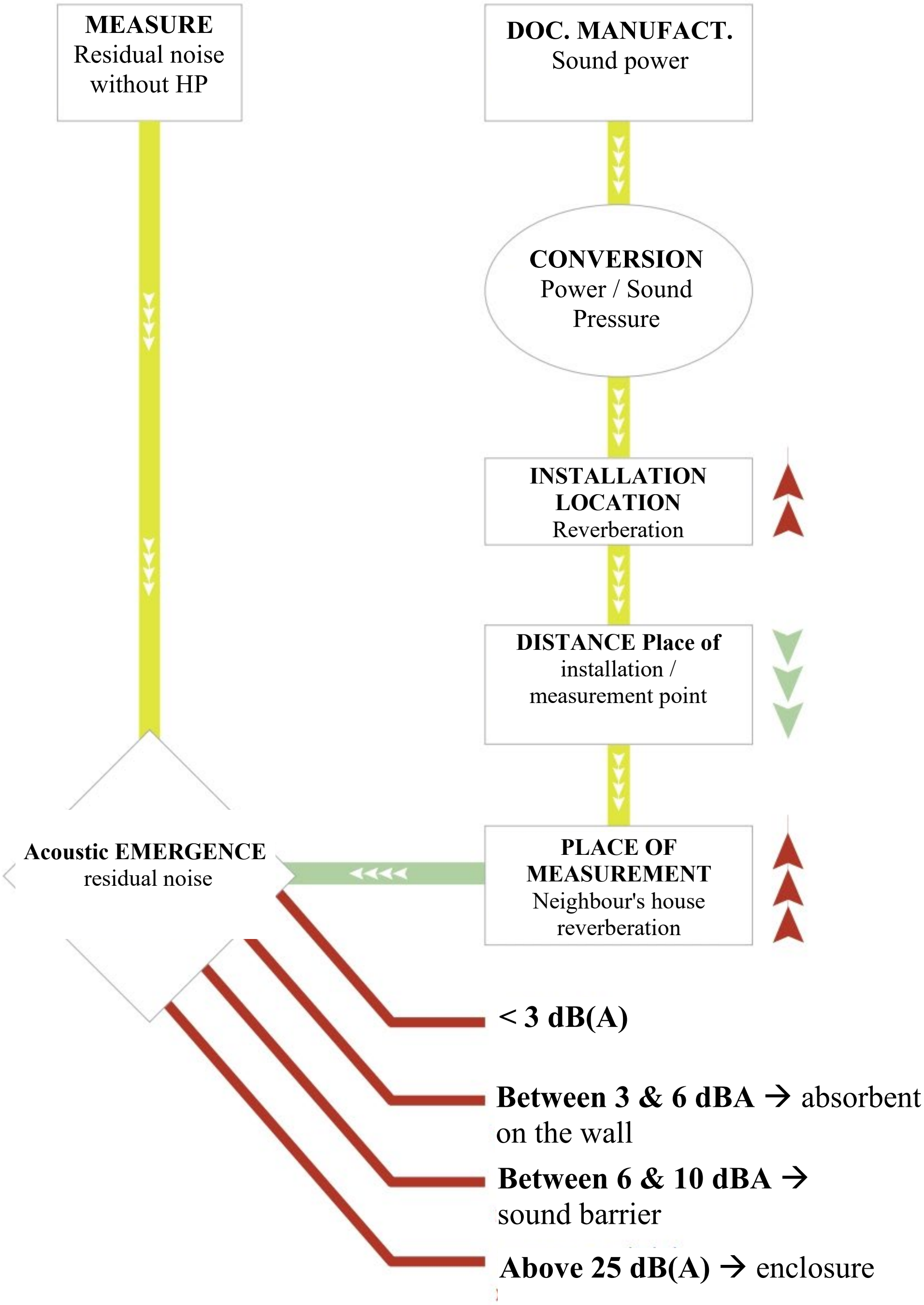


Figure 5-1: Study of the risk of noise pollution in the vicinity

5.2 Measurement of residual noise (without heat pump)

Determination of a probable residual noise level +/- 5 dB(A)			
Type of area	day	intermediate	night
Hospital area, rest area, areas for the protection of natural areas	45 dB	40 dB	32 dB
Residential, rural or suburban, with low land, water or air land, water or air traffic	50 dB	45 dB	37 dB
Urban residence	55 dB	50 dB	42 dB
Urban or suburban residence, with some workshops or business centres, or land traffic routes, or air traffic routes	60 dB	55 dB	50 dB
Area with predominantly commercial, industrial industrial activities	65 dB	60 dB	55 dB
Predominantly industrial area (heavy industry)	70 dB	65 dB	60 dB

Table 5-1 – Measurement of residual noise without heat pump

5.3 Acoustic emergence – residual noise

Measurements of emergence should be taken at the property line. In the case of buildings, these measurements must be made in living rooms with windows open and with windows closed. The regulations differentiate between day and night emergence.

- **Daytime (7am - 10pm), maximum permissible deviation: 5 dB(A)**
- **At night (22:00 - 7:00), maximum permitted deviation: 3 dB(A)**

5.4 *Manufacturer Documentation – Acoustic power*

Sound power level Lw, in dB(A)

It characterises the sound emission capacity of the source independently of its environment. This sound power (Lw) is measured in the laboratory. It is the value that allows direct comparison between devices.

Sound pressure Lp, in dB(A)

This is the acoustic value **perceived by the human ear** and measured by a sound level meter. by the sound level meter. For a given source, the sound pressure (Lp) depends on the installation environment and the distance at which the measurement is made. measurement

5.5 *Conversion Acoustic Power / Pressure*

Sound Power (dB)	1m	2m	3m
45	37	31	27
50	42	36	32
55	47	41	37
60	52	46	42
65	57	51	47
70	68	56	52

Table 5-2 – Free field power/pressure conversion table for a distance (dB value)

5.6 *Place of installation - reverberation*

5.6.1 Location

Anything that is discret is better for the environment. It is recommended that to provide for the integration of the AAC (hedges, hedges, canisses...).

5.6.2 Reflection of emitted noise

Avoid corners and inner courtyards. The smaller the yard, the greater the reflection.
In an inner courtyard, the level is increased by at least 9 dB(A) compared to the free field.

Figure 5-2: (left) Heat pump placed on the ground or on a terrace (free field), (right) Heat pump placed against a wall : + 3 dB(A)

5.7 Location of measuremnent – at the neighbour's

Reflection of received noise - The same rules as above apply. At the same distance from the heat pump, the level received at the front is 3 dB higher than that received in a free field and 3 dB lower than in a corner.

5.8 Measurement of acoustic emergence

5.8.1 Absorbent on the wall, if acoustic emergence < 3 dB(A)

Principle: A heat pump installed against a wall generates 3 dB(A) more for the neighbourhood than if it were installed in a free field (6 dB(A) if the heat pump is in a corner).

Solution: Placement of an acoustic absorbing material on the wall(s) behind the heat pump to reduce the reflection of noise on the façade. The surface area of the absorber sheet should be larger than the dimensions of the heat pump.

If the heat pump is installed in a corner, it is advisable to treat both walls.

Possible mitigation:

- Maximum 2 dB(A) if the heat pump is against a wall
- Maximum 4 dB(A) if the heat pump is in a corner

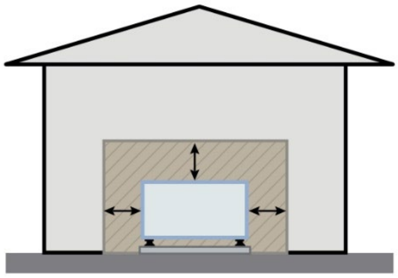


Figure 5-3: Absorbent on the wall

5.8.2 The sound barrier, if acoustic emergence between 3 and 6 db(A)

Principle: Reduce sound transmission and absorb noise in one direction. Use natural barriers wherever possible (earth banks, etc.). A hedge of trees cannot be used as a sound barrier. The effectiveness of a barrier depends on its location, size and materials.

Location: The screen must be positioned as close as possible to the heat pump while allowing free air circulation.

Dimensions: The surface of the screen must be larger than the the dimensions of the heat pump.

Figure 5-4: Sound barrier

To increase the effectiveness of the screen, flaps (caps and returns) may be necessary.

Materials: Choose solid materials, acoustic bricks, concrete blocks possibly covered with absorbent materials (mineral wool panels), etc. Pay attention to weathering, especially rain and wind

Possible mitigation: maximum 6 dB(A)

+ 1 dB(A) if the wall behind the heat pump is treated.

5.8.3 Enclosure, if acoustic emergence between 10 and 25 db(A)

Principle: Enclosure to reduce noise transmission and absorb noise around the heat pump in all directions.

- Provide acoustic treatment for access and pipework and power supply.
- Avoid contact with any vibrating part (frame, piping, etc.)
- Provide internal ducting to avoid air recycling.
- If necessary, install an additional fan (with sound trap on air inlets and outlets) to remove heat and combat additional pressure drop due to enclosure.

Possible mitigation: maximum 25 dB(A)

6 FIGURES INDEX

7 TABLES INDEX

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