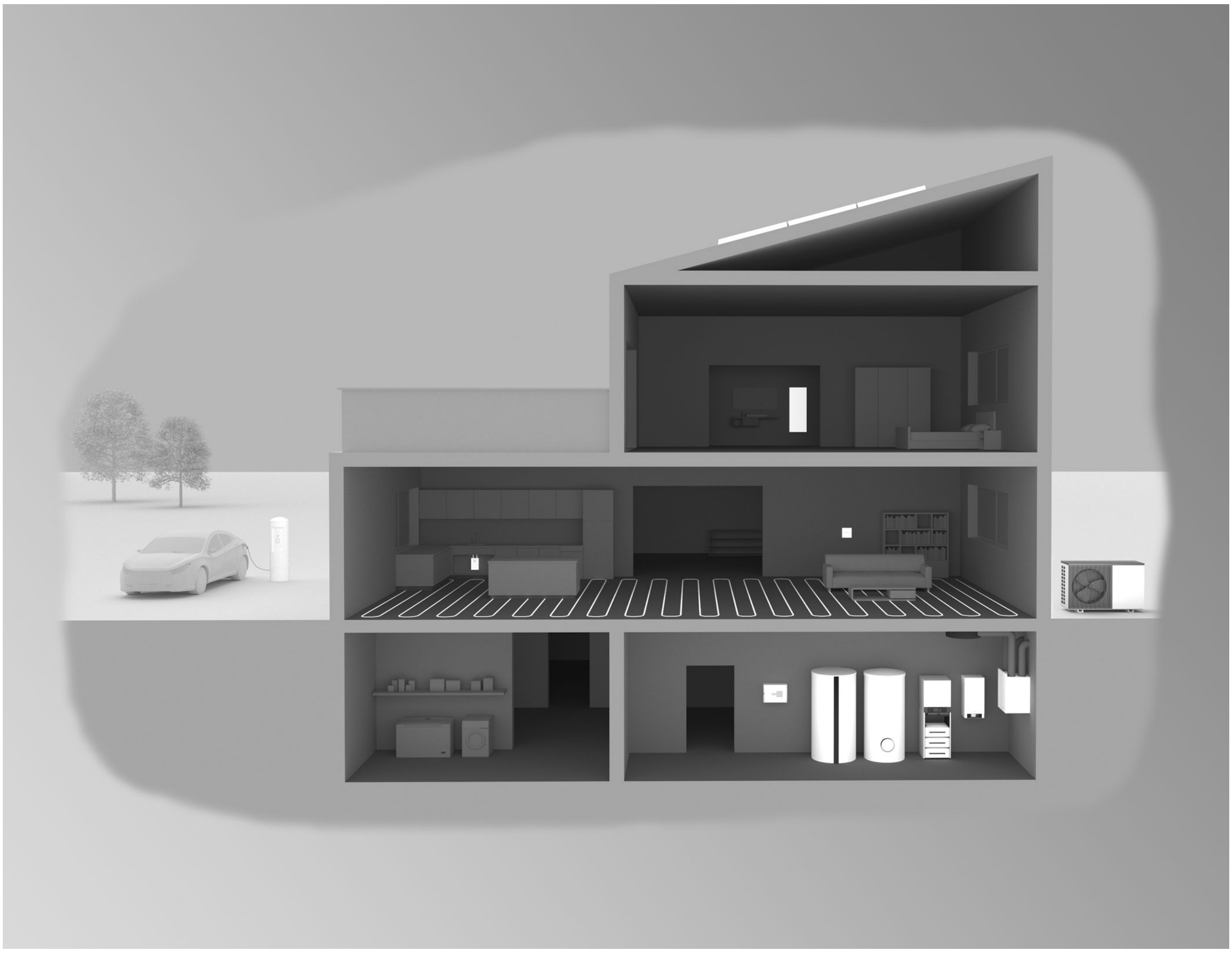
Heat pump principles

Technical guide



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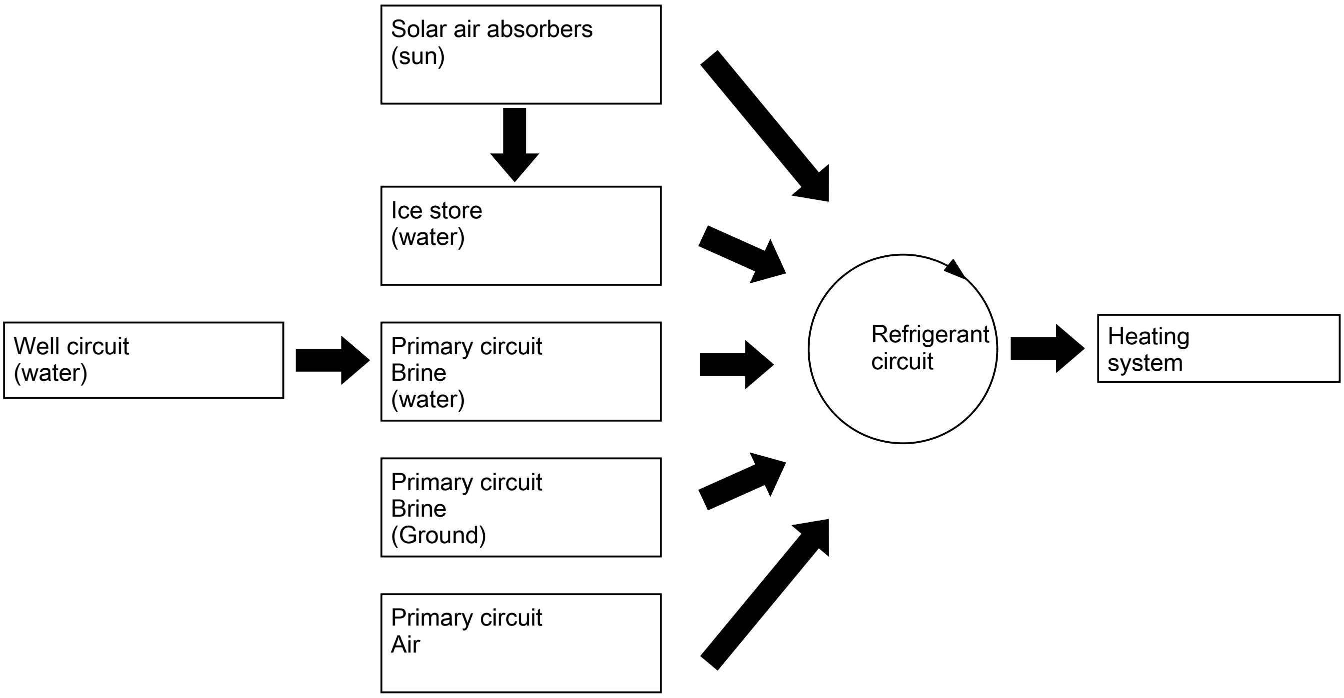
1. Principles

1.1 Heat yield

Heat flux



Ground as heat source
Geothermal collectors or geothermal probes extract heat from the ground. The primary circuit (brine) transfers this heat to the refrigerant circuit of the heat pump. The higher temperature level required for the heating system is generated there.

Water as heat source (well circuit)
The water circulating in the well circuit transfers the heat to the primary circuit (brine). From here, heat is transferred in the same way as heat extracted from the ground. For this reason, many brine/water heat pumps can be converted to water/water heat pumps with a conversion kit.

Ice store/solar air absorber as heat source
The heat store medium (water) in the ice store is heated by the surrounding ground and by the solar air absorber. The heat pump draws this primary energy from the ice store and transfers it to the heating system via the refrigerant circuit. If, at this point, the temperature of the medium in the ice store drops below freezing point, the heat released by the crystallisation process is additionally utilised.

The solar air absorber can also serve directly as a primary source.

Air as heat source
To transfer energy to the heat pump, a fan draws the ambient air over the evaporator of the heat pump.
The high temperatures required to heat the heating water/DHW are achieved through the heat pump process (refrigerant circuit). The condenser transfers the heating energy to the heating water/DHW.

Heat yield with geothermal collectors/geothermal probes

Heat yield with geothermal collectors
Geothermal collectors for brine/water heat pumps are shallow geothermal energy systems installed close to the surface, which extract thermal energy from the ground at a depth of approx. 1 to 2 m. They are suitable for areas where deep drilling is not possible for legal reasons.
A brine medium circulates in all geothermal collectors, absorbing the thermal energy from the ground and transporting it to the brine/water heat pump.
The most common types of collectors include surface collectors, trench collectors, spiral collectors and geothermal basket collectors.

For heat recovery, geothermal collectors are installed horizontally, close to the surface and below the frost line, similar to an underfloor heating system. The frost line varies according to region. In practice, most geothermal collectors are located 1.0 to 1.5 m below the surface of the ground.
Depending on the type of collector and the installation, excavation or drilling to a depth of 5 m is sufficient. When laying the pipes, it is important to ensure that they have a defined, even distance between them. If the distance between the pipes is too small, the collectors will extract too much heat from the ground in some places, which may cause the area around them to freeze.

Geothermal collectors usually consist of plastic pipes with a diameter of 2 to 4 cm. The pipe diameter depends on the soil conditions and the installation depth. Since the correct sizing of the geothermal collectors has a direct positive effect on the productivity of the system, the pipe diameter must be matched as precisely as possible to the heat demand.

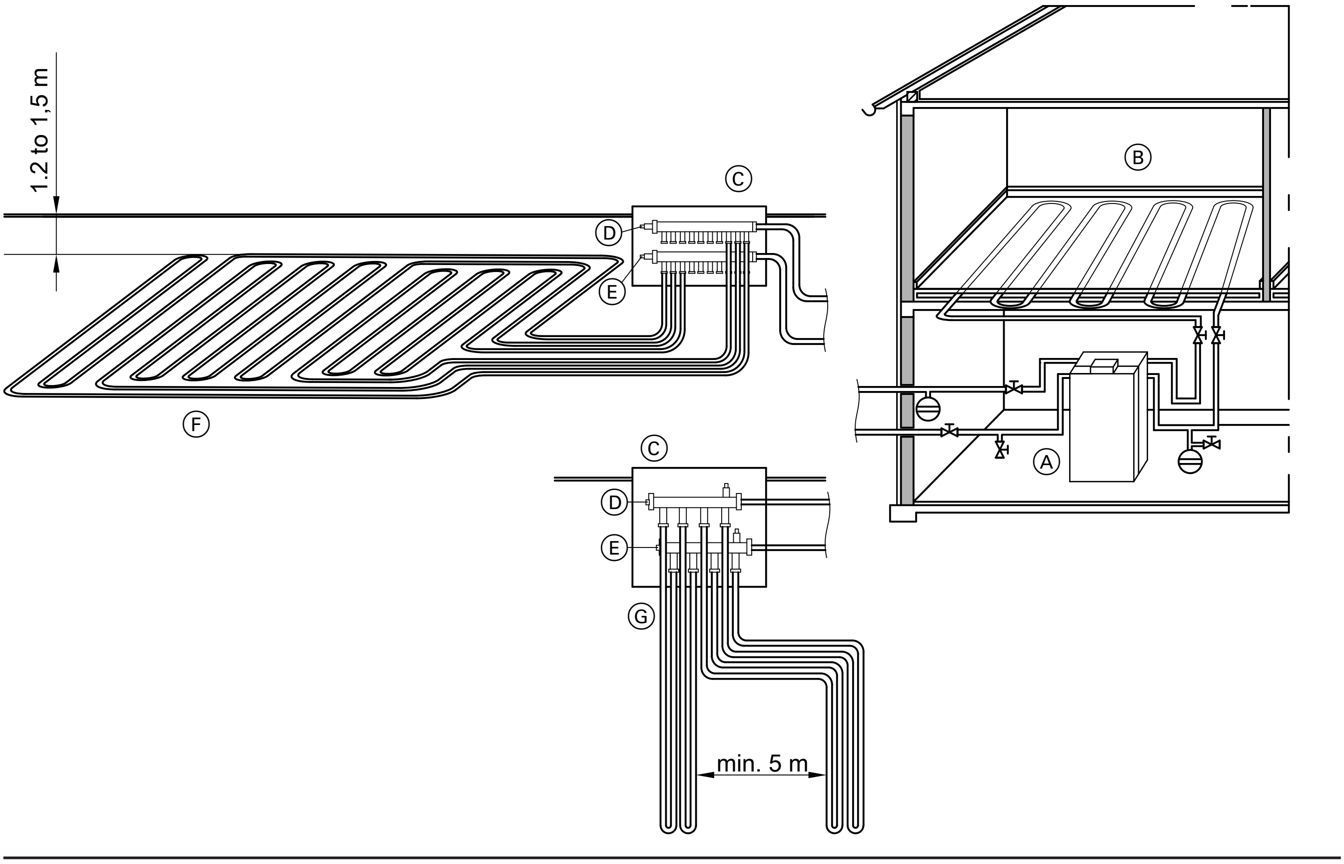
The amount of heat that can be extracted from the ground depends on various factors:

- Experience has shown that a loam soil with a high water content is particularly suitable as a heat source.
  Here, a specific heat extraction capacity (cooling capacity) of q_E = 10 to 35 W/m^2 ground area can be assumed as an annual average for (mono mode) operation all year round: See also "Design information" in the technical guides to brine/water heat pumps.
- The heat extraction capacity for very sandy soil is lower. In this case, a geological surveyor may have to be consulted for inspection.

Due to increasing solar radiation and precipitation, the cooled soil begins to regenerate from the second half of the heating season. This makes the ground as a "thermal store" available for heating purposes again in the next heating season.

Generally, observe the following:

- Deep-rooted plants should not be located in the vicinity of the collector pipes.
- Do not seal the surfaces above the geothermal collector. Sealing the surfaces prevents ground regeneration.



Ⓐ Heat pump
Ⓑ Underfloor heating system
Ⓒ Common duct with brine distributor
Ⓓ Brine distributor for geothermal collectors or probes (flow)
Ⓔ Brine distributor (return)
Ⓕ Geothermal collector:
Total length of one line: ≤ 100 m
Ⓖ Geothermal probe (Duplex probe)

Heat yield with geothermal probes

Geothermal probes can be used to extract the heat stored in deeper layers of the ground for brine/water heat pumps.
Brine circulates in the geothermal probes, absorbing the thermal energy from the ground and transporting it to the brine/water heat pump.
One of the main reasons for using geothermal probes is the very small space requirement. A single probe has a small diameter of approx. 15 cm. Sufficient space is only required for the drilling vehicle.

A further advantage of geothermal probes is the high efficiency all year round, which is achieved by the consistently warm temperature deeper in the ground.
1 or more boreholes are required for the installation of a geothermal probe. Double U-pipes are inserted into the boreholes and sealed with a concrete mixture.
Under standard hydrogeological conditions, an average extraction rate of 50 W/m probe length can be assumed for a geothermal probe system (according to VDI 4640).

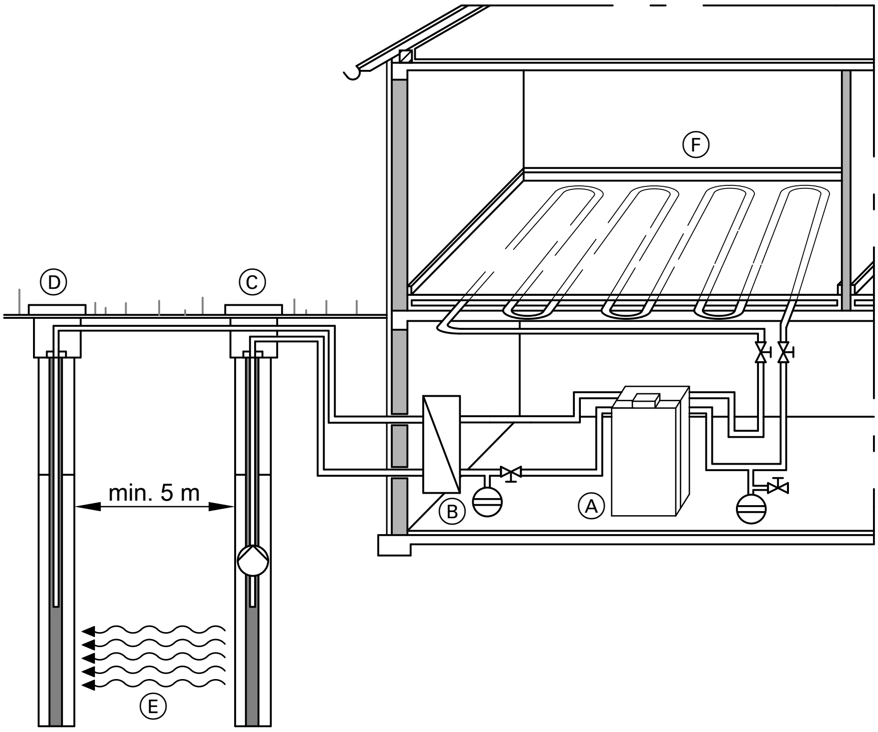
Boreholes:
- Boreholes to a depth < 100 m are subject to approval from your local water board.
- Boreholes to a depth > 100 m must be approved by your local mining board.

Drilling contractors certified to DVGW Code of Practice W 120 should be engaged to carry out the drilling work. We recommend processing via Viessmann.

Heat yield from groundwater

The utilisation of groundwater must be authorised by the appropriate body (e.g. local water board).

To enable the energy to be utilised, a delivery well and a return well or dry well must be constructed.



Ⓐ Heat pump
Ⓑ Separating heat exchanger
Ⓒ Delivery well with well pump
Ⓓ Return well
Ⓔ Groundwater flow direction
Ⓕ Underfloor heating system

The water quality must meet the limits listed in the following table for stainless steel (1.4401) and copper. If these limits are observed, trouble-free well operation can be expected. Due to fluctuating water quality, we recommend using a separating heat exchanger made from stainless steel: See also chapter "Design information" in the technical guides for the relevant heat pumps.

In the following cases, a threaded stainless steel heat exchanger is always required as separating heat exchanger:
- Where the limits for copper cannot be maintained.
- When using water from lakes and ponds

Note
Fill the primary circuit (intermediate circuit) with antifreeze mixture, e.g. Tyfocor.

Resistance of copper or stainless steel plate heat exchangers to waterborne substances

Note
The following table does not cover all eventualities.
This table is for guidance only.

\+ Good resistance under standard conditions
0 At risk from corrosion: Especially if several substances have a 0 rating.
– Unsuitable

Electrical conductivity	Plate heat exchanger	
	Copper	Stainless steel
< 10 μS/cm	0	0
10 to 500 μS/cm	+	+
> 500 μS/cm	–	0

pH value	Plate heat exchanger	
	Copper	Stainless steel
< 7.5	**0**	**0**
7.5 to 9.0	+	+
> 9.0	0	+

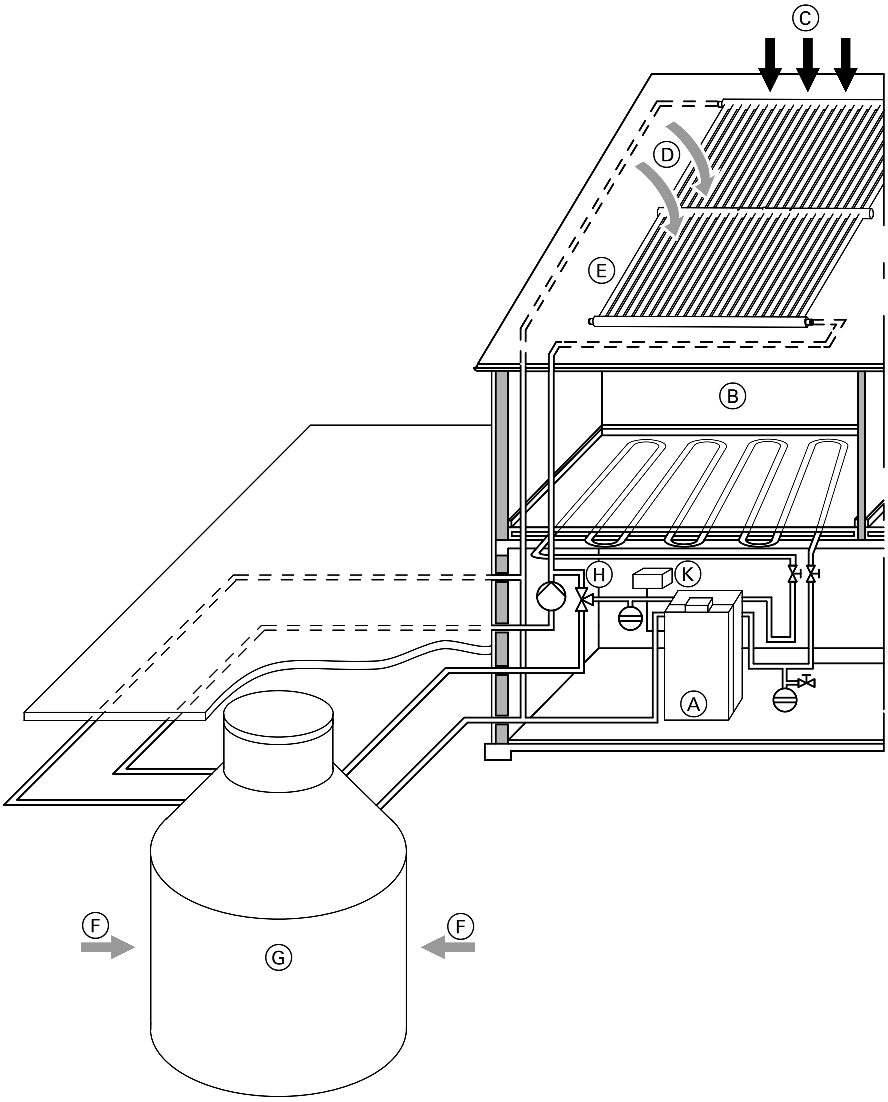
Constituent materials	Concentration in mg/l	Plate heat exchanger	
		Copper	Stainless steel
Organic materials	If verifiable	0	0
Ammonia (NH_3)	< 2 2 to 20 > 20	+ 0 –	+ + 0
Chloride (Cl^-)	< 300 > 300	+ 0	+ 0
Iron (Fe), dissolved	< 0.2 > 0.2	+ 0	+ 0
Free (aggressive) carbonic acid (CO_2)	< 5 5 to 20 > 20	+ 0 –	+ + 0
Manganese (Mn), dissolved	< 0.1 > 0.1	+ 0	+ 0
Nitrates (NO_3), dissolved	< 100 > 100	+ 0	+ +
Oxygen	< 0.2 > 0.2	+ 0	+ +
Hydrogen sulphide (H_2S)	< 0.05 > 0.05	+ –	+ 0
Hydrogen carbonate (HCO_3^-)/sulphates (SO_4^{2-})	< 1.0 > 1.0	0 +	0 +
Hydrogen carbonate (HCO_3^-)	< 70 70 to 300 > 300	0 + 0	+ + 0
Aluminium (Al), dissolved	< 0.2 > 0.2	+ 0	+ +
Sulphates (SO_4^{2-})	< 70 70 to 300 > 300	+ 0 –	+ + 0
Sulphite (SO_3)	< 1	+	+
Free chlorine gas (Cl_2)	< 1 1 to 5 > 5	+ 0 –	+ + 0

Heat recovery with ice store/solar air absorber

In the case of brine/water heat pumps, an ice store combined with a solar air absorber can be used as an alternative primary source. The changeover is carried out via a 3-way diverter valve.

The following operating states are possible, depending on the temperatures in the ice store and the solar air absorber:

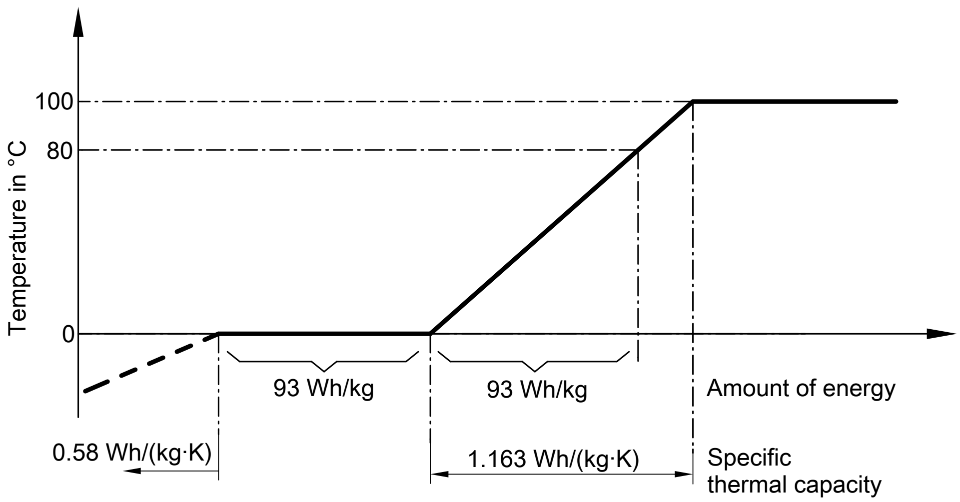
- The ice store is used as the sole primary source.
- The solar air absorber is used as the sole primary source.
- The ice store is regenerated via the solar air absorber and the ground.



Ⓐ Heat pump
Ⓑ Underfloor heating system
Ⓒ Heat from insolation
Ⓓ Heat from ambient air
Ⓔ Solar air absorber
Ⓕ Heat from the ground
Ⓖ Ice store with extraction and regeneration heat exchangers
Ⓗ 3-way diverter valve for changing the primary source
Ⓚ Solar control unit

The ice store is completely embedded in the ground and filled with water. The required water volume is calculated based on the heating and cooling capacity. A heating output of 10 kW, for example, requires a water volume of approx. 10 m^3.
If the ice store is used as the primary source, the water in the ice store cools down. The amount of energy made available by this cooling process is 1.163 Wh/(kg · K). If the water freezes, the heat pump can also utilise the heat released by the crystallisation process. The amount of energy available in this case is 93 Wh/kg, the same as the amount available when water is cooled from 80 to 0 °C.

The following diagram shows the amounts of energy available as a result of temperature changes and phase changes (when water changes from a liquid into a solid state).



In order to guarantee year-round heat pump operation, the ice store is continually regenerated by the solar air absorber and by heat from the ground. The solar air absorber can also be used as the sole energy source.
The efficiency of a correctly sized ice store system is comparable with that of geothermal probe systems.

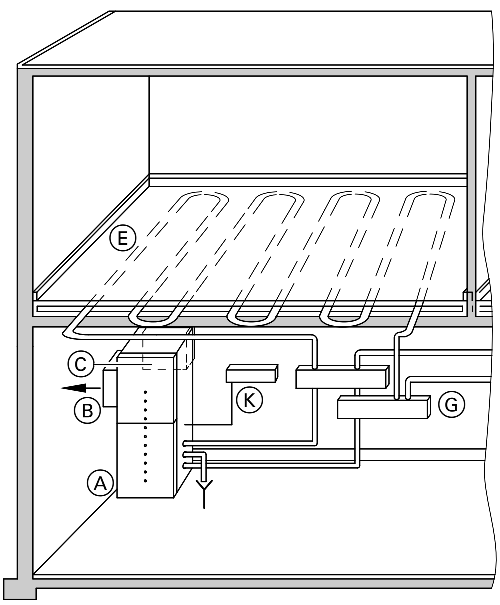
In the summer months, the ice store can also be used for central cooling purposes (natural cooling function). To perform this function efficiently, the ice store must be completely frozen at the end of the heating season.

Heat yield from the ambient air

Like geothermal and groundwater heat pumps, air/water heat pumps can be operated all year round, subject to application limits (min. air intake temperature) being observed.
In buildings constructed according to the low energy house standard, mono energetic operation is possible, i.e. operation in conjunction with an electric booster heater, for example an instantaneous heating water heater.

In air source heat pumps, the heat extraction rate from the ambient air is defined by the design and size of the appliance. An integral fan inside the appliance routes the required air volume to the evaporator. The evaporator transfers the heating energy from the air to the heat pump circuit.

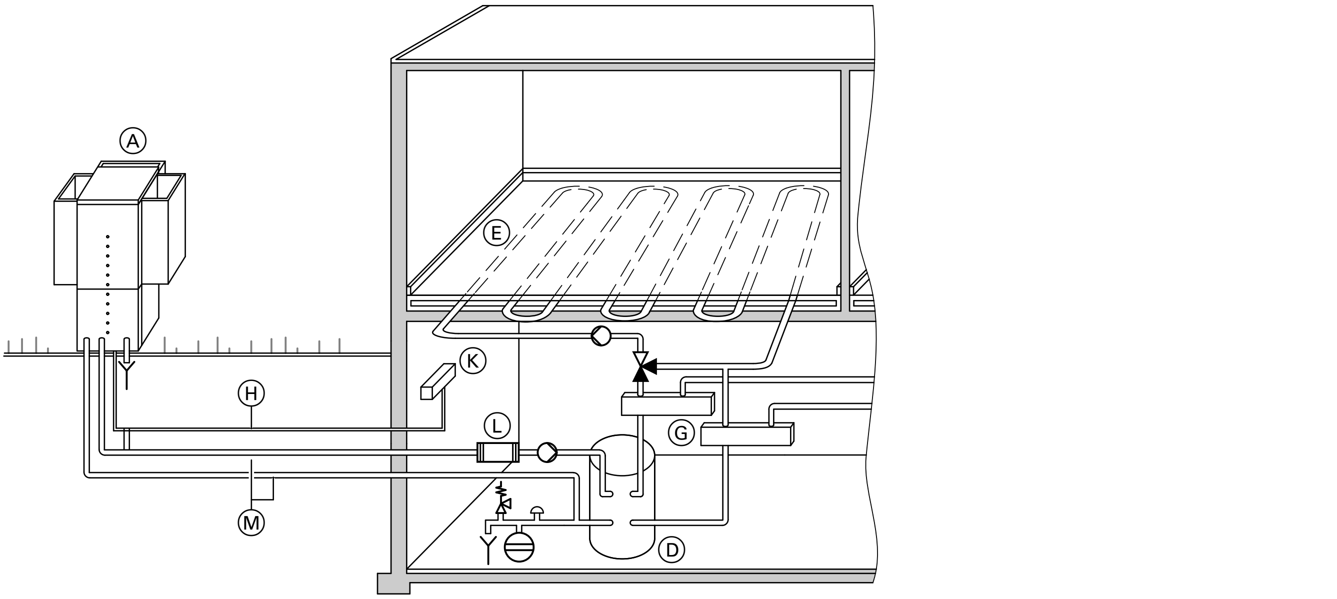
Indoor installation



Ⓐ Heat pump installed indoors
Ⓑ Extract air duct
Ⓒ Ventilation air duct
Ⓔ Underfloor heating
Ⓖ Heating circuit distributor
Ⓚ Heat pump control unit

Where heat pumps are installed internally, the ventilation and extract air apertures in the building must be arranged in such a way that no "air short circuit" can be generated. We therefore recommend installation in a corner.

Outdoor installation



- Ⓐ Heat pump installed outdoors
- Ⓓ Heating water buffer cylinder
- Ⓔ Underfloor heating
- Ⓖ Heating circuit distributor
- Ⓗ Connecting cables
- Ⓚ Heat pump control unit
- Ⓛ Instantaneous heating water heater
- Ⓜ Hydraulic connection set

A hydraulic connection set (accessory), which is available in different lengths, is required for connecting heat pumps installed externally to the heating system.
Connecting cables (accessories) are required for the communication between the heat pump and the control unit installed inside the building.

Any instantaneous heating water heater (accessory) used must be installed inside the building.

Operating modes

The operating mode of heat pumps depends largely on the selected or existing heat distribution system.
Depending on the model, Viessmann heat pumps reach flow temperatures of up to 70 °C. For higher flow temperatures or extremely low outside temperatures, an additional heat generator is required to cover the heat load (mono energetic or dual mode operation).
Generally in new build, any heat distribution system can be selected. However, heat pumps can only achieve high seasonal performance factors in conjunction with heat distribution systems that have low flow temperatures, e.g. 35 °C.

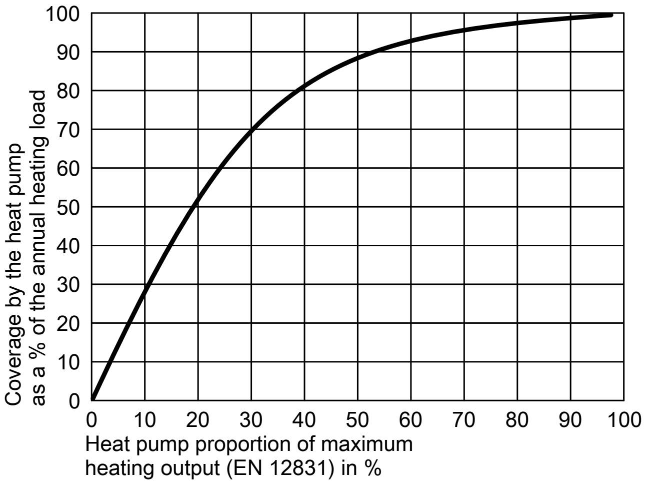
Mono mode operation
In mono mode operation, the heat pump acts as the sole heat generator to cover the entire heat load of the building to EN 12831. A prerequisite for this operating mode is that the heat distribution system is designed for a flow temperature below the maximum flow temperature of the heat pump.
When sizing the heat pump, allowances must be made to cover power-OFF times and special tariff regulations by the power supply utility.

Note
In the case of air/water heat pumps, the lower application limits must be observed: See the technical guide for the relevant heat pump. When outside temperatures drop below the application limit, the heat pump switches off. It does not then deliver any heat.

Dual mode operation
In dual mode operation, the heat pump system is supplemented during heating operation by an additional heat generator, e.g. an oil/gas boiler. This additional heat generator is controlled by the heat pump control unit.

Mono energetic operation
Operating mode in which the additional heat generator is operated electrically, the same as the heat pump compressor. An additional heat generator could be an instantaneous heating water heater in the secondary circuit, for example.

Coverage in mono energetic operation

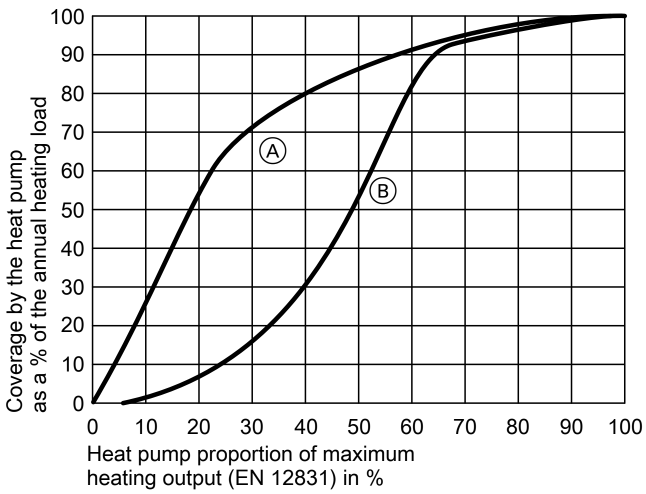


Coverage of the heat pump in % of the annual heat load (heating mode only) of a standardised domestic building, subject to the heat pump heating output in mono energetic mode

Due to the low investment costs for the heat pump, compared to mono mode operation, operating a heat pump in mono energetic mode offers economic advantages, particularly in new build.
In typical system configurations, the heating output of the heat pump is designed for approx. 70 to 85 % of the maximum required heat load of the building (in accordance with EN 12831). The heat pump covers approx. 92 to 98 % of the annual heat load.

Dual mode parallel operation

Coverage of dual mode operation



Coverage of the heat pump in % of the annual heat load (heating mode only) of a standardised domestic building, subject to the heat pump heating output and the selected operating mode

Ⓐ Dual mode parallel operation
Ⓑ Dual mode alternative operation

Due to the lower investment costs for the entire heat pump system, dual mode operation is particularly suitable for existing boiler systems in renovated buildings.

Note
With mono energetic and dual mode parallel operation, the heat source (ground) must be sized to be able to cover the ***total heat demand*** *of the building, due to the longer running times (compared to dual mode alternative operation).*

Subject to outside temperature and heat load, the heat pump control unit starts the second heat generator in addition to the heat pump.
In typical system configurations, the heating output of the heat pump is sized for approx. 50 to 70 % of the maximum required heat load of the building to EN 12831. The heat pump covers approx. 85 to 92 % of the annual heat load.

Dual mode alternative operation
Up to a certain outside temperature (dual mode temperature), the heat pump covers the entire heat demand of the building. Below the dual mode temperature, the heat pump switches off. The additional heat generator (oil/gas boiler) heats the building on its own. The changeover between the heat pump and additional heat generator is controlled by the heat pump control unit.
The dual mode alternative operating mode is particularly suitable for existing buildings with conventional heat distribution and transfer systems (radiators).

Power supply tariffs
Most power supply utilities offer special tariffs to enable cost effective operation of heat pumps. These special tariffs enable power supply utilities to temporarily interrupt the power supply to heat pumps during peak times.
For heat pumps, maximum power-OFF periods of 3 x 2 hours within 24 hours are usually possible.For underfloor heating systems, these power-OFF times have no noticeable effect on the room temperature due to the system inertia. With other systems, power-OFF times can be bridged by using heating water buffer cylinders.
As an alternative, for dual mode heat pump systems the additional heat generator can cover the total heat demand of the building during power-OFF times.

Note
The ON periods between 2 power-OFF times must not be shorter than the previous power-OFF time.

There are no special tariffs available in conjunction with an uninterrupted power supply. In this case, the heat pump power consumption is billed together with the domestic or commercial electricity.

Drying buildings/drying screed (higher heat demand)

Subject to construction (e.g. monolithic), new buildings contain large amounts of water held in tile or cement screeds, plaster finish, etc. Top covers (such as tiles, parquet flooring, etc.) permit only minor residual moisture in the screed prior to their application.
The bound moisture must be evaporated through heating to prevent damage to the building. For this purpose, a higher heat demand is determined than that required for general central heating.

Correctly sized heat pumps are often **not** able to cover this higher heat demand. In such cases, therefore, the demand must be covered by drying equipment provided on site or by an instantaneous heating water heater.

Coefficient of performance and seasonal performance factor

To assess the efficiency of electrically operated compressor heat pumps, the EN 14511 standard specifies the coefficient of performance and performance factor parameters.

Coefficient of performance
The coefficient of performance ε is the ratio of the current heating output to the effective power consumption of the appliance.

$$\varepsilon = \frac{P_H}{P_E}$$

P_H Heat in W transferred by the heat pump to the heating water per unit of time
P_E Average power consumption of the heat pump within a specific period, including control unit, compressor, conveyor devices and defrosting in W

Advanced heat pumps have a coefficient of performance of between 3.5 and 5.5, i.e. a COP of 4 means that 4 times more heating energy is available than the electrical energy consumed. The vast majority of the heating energy originates from the heat source (air, ground, groundwater).

Operating point
The coefficient of performance is measured at fixed operating points. The operating point is specified by the inlet temperature of the heat source medium (air A, brine B, water W) in the heat pump and the heating water outlet temperature (secondary circuit flow temperature).

Example:
- Air/water heat pumps
  A2/W35: Air intake temperature 2 °C, heating water outlet temperature 35 °C
- Brine/water heat pumps
  B0/W35: Brine inlet temperature 0 °C, heating water outlet temperature 35 °C
- Water/water heat pumps
  W10/W35: Water inlet temperature 10 °C, heating water outlet temperature 35 °C

The lower the temperature differential between the inlet and the outlet temperature, the higher the coefficient of performance. To increase the COP, it is best to opt for the lowest possible flow temperatures, for example 35 °C in conjunction with an underfloor heating system, since the inlet temperature of the heat source is subject to the ambient conditions.

Seasonal performance factor
The seasonal performance factor β is the ratio of the annual amount of heat provided by the heat pump system to the overall power drawn by the heat pump system over the same period. This includes the power drawn by pumps, control units, etc.

$$\beta = \frac{Q_{WP}}{W_{EL}}$$

Q_{WP} The amount of heat in kWh delivered by the heat pump over the course of a year
W_{EL} The electrical power in kWh supplied to the heat pump system over the course of a year

Calculating the seasonal performance factor

See online forms at **www.viessmann.de** or **www.waerme-pumpe.de**.

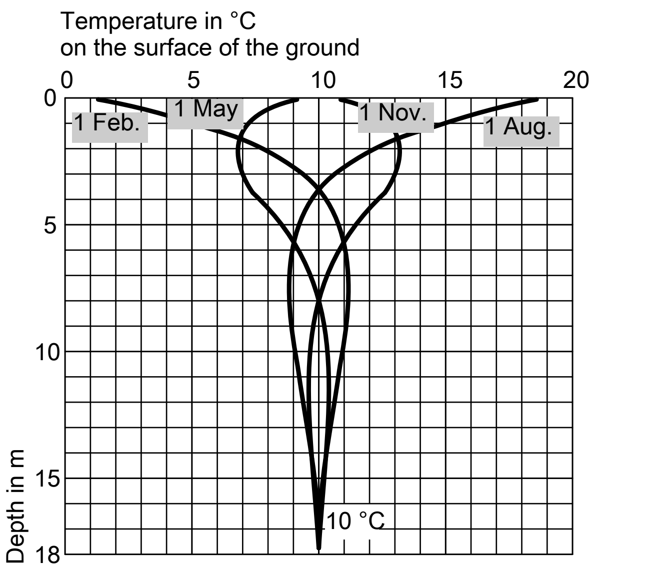
To open the online form, go to **www.viessmann.de** and click on the following links in sequence:
- "Trade partner login"
- "Trade partner information"
- "Software service"
- "Online tools"
- "HP seasonal performance factor"
- "Calculating the seasonal performance factor SPF of the heat pump"

1.2 Cooling

Utilisation of the primary source

With reversible air/water heat pumps or in conjunction with the AC-Box (accessory) for brine/water and water/water heat pumps, the simultaneous operation of the compressor enables active cooling which utilises the cooling capacity of the compressor.
The heat generated is dissipated via the primary source (or a consumer).
During spring, summer or autumn, brine/water and water/water heat pumps can utilise the temperature level of the heat source (primary source) to cool the building with natural cooling.

Underground, temperatures are relatively constant all the year round. In undisturbed ground, it is assumed that from a depth of 5 m, there are only minor temperature fluctuations of ±1.5 K around an average temperature of 10 °C.



Temperature curve in undisturbed ground subject to depth and time of year

On hot summer days, buildings heat up as a result of high outside temperatures and insolation. With appropriate accessories, brine/water and water/water heat pumps can utilise the low temperatures of the ground to dissipate heat from the building to the ground via the primary circuit.

Regeneration of the ground
In heating mode, the heat pump extracts heating energy permanently from the ground. At the end of the heating season, the temperature near the geothermal probe/collector is around freezing. By the start of the next heating season, the ground will be sufficiently regenerated. Natural cooling accelerates this process by extracting heat from the building and transferring it to the ground. The average brine temperature may increase subject to the heat ingress into the geothermal probe during summer. This has positive effects on the seasonal performance factor of the heat pump.

"Natural cooling"/"Active cooling"

Natural cooling is a very efficient cooling function, as it requires the operation of only two circulation pumps. For this function, the heat pump compressor stays off. During natural cooling, the heat pump will only be started to generate DHW. Utilising the heat removed from the interior increases the efficiency of the heat pump when heating DHW.

Natural cooling is possible with the following systems:
- Underfloor heating systems
- Fan convectors
- Chilled ceilings
- Concrete core tempering

The indoor air can only be dehumidified in conjunction with natural cooling if fan convectors are connected (requires a condensate drain).

Cooling capacity
The capability of the natural cooling function cannot generally be compared with that of air conditioning systems or chillers. The cooling capacity depends on the heat source temperature, which itself is subject to seasonal fluctuations. Experience has shown that the cooling capacity is higher at the beginning of summer than at the end.

In active cooling mode, the heat pump operates like a chiller and cools the building with the available cooling capacity. The constant cooling capacity available is subject to the heat pump output.
With active cooling, the cooling capacity is significantly higher than with natural cooling.

1.3 Noise development

Sound

Human beings are capable of hearing sounds in the pressure range from $20 \cdot 10^{-6}$ Pa (hearing threshold) to 20 Pa (1 to 1 million). The pain threshold is at around 60 Pa.

Changes in air pressure are perceived provided they take place at a rate of between 20 and 20,000 times per second (20 Hz to 20,000 Hz).

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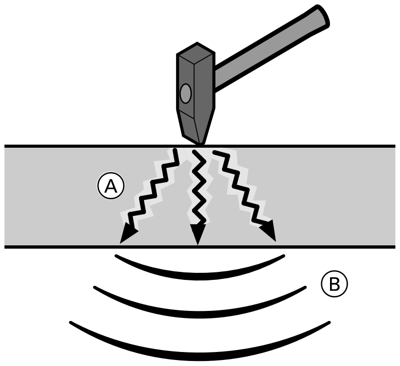
Sound source	Sound level in dB(A)	Sound pressure in μPa	Perception
Silence	0 to 10	20 to 63	Inaudible
Ticking of a watch, quiet bedroom	20	200	Very quiet
Very quiet garden, quiet air conditioning	30	630	Very quiet
House or flat in a quiet neighbourhood	40	$2 \cdot 10^3$	Quiet
Gentle stream	50	$6.3 \cdot 10^3$	Quiet
Normal speaking volume	60	$2 \cdot 10^4$	Loud
Loud speaking volume, office noise	70	$6.3 \cdot 10^4$	Loud
Intensive traffic noise	80	$2 \cdot 10^5$	Very loud
Heavy-duty truck	90	$6.3 \cdot 10^5$	Very loud
Car horn at a distance of 5 m	100	$2 \cdot 10^6$	Very loud

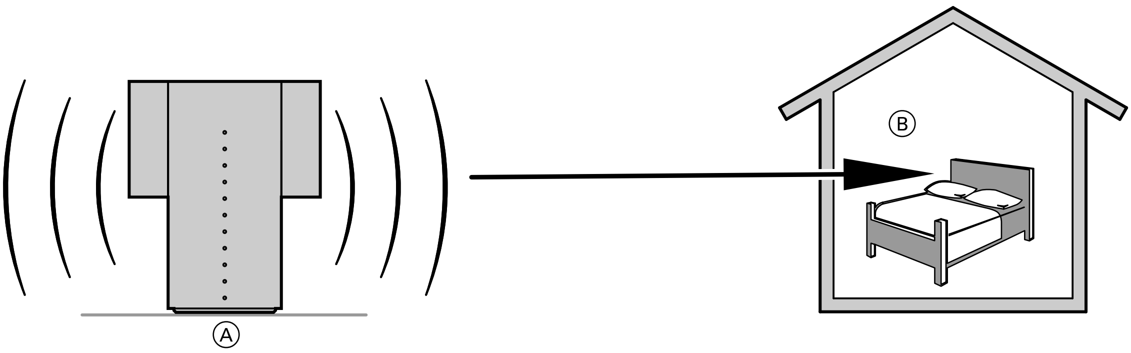


Ⓐ Structure-borne noise
Ⓑ Airborne noise

Structure-borne noise, liquid-borne noise
Mechanical vibrations present in equipment, such as machine and building components as well as in liquids, are transmitted through them and radiated out by them at different points as airborne noise.

Airborne noise
Sound sources (equipment in which vibrations are present) create mechanical vibrations in the air that propagate in wave form and are audible to the human ear at different levels.

Sound power level and sound pressure level



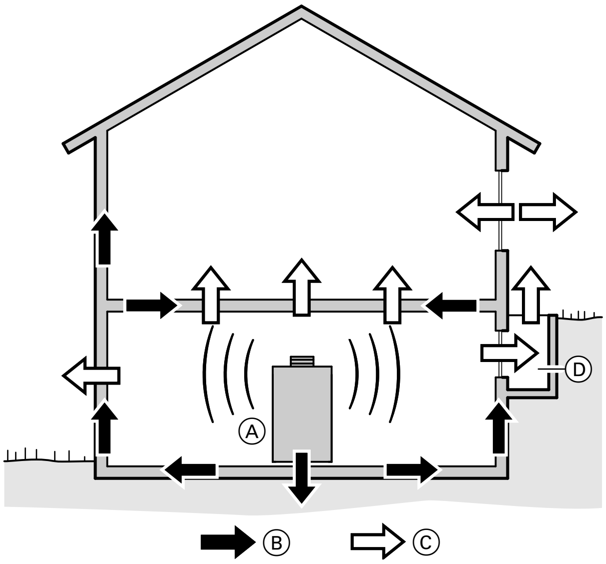
Ⓐ Source of sound (heat pump)
Emission site
Measured variable: Sound power level L_W
Ⓑ Location of incoming sound emission
Immission site
Measured variable: Sound pressure level L_P

Sound power level L_W
This describes the entire sound emissions in all directions emanating from the heat pump. It does **not** depend on the surrounding conditions (reflections) and is a value that can be used for direct comparisons of sound sources (heat pumps).

Sound pressure level L_P
The sound pressure level is a measure to assist orientation regarding the volume of noise perceived by the ear at a specific location. The sound pressure level is largely defined by the distance and the characteristics of the surroundings and is thus dependent upon the measuring location (often at a distance of 1 m). Standard measuring microphones measure the sound pressure directly.
The sound pressure level is the variable that is used to assess imissions from individual systems.

Principles (cont.)

Propagation of sound in buildings



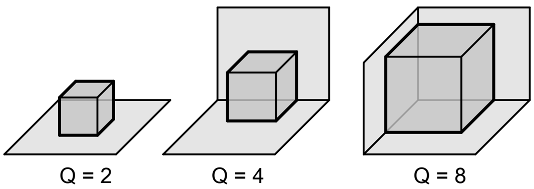
Sound transmission paths

- Ⓐ Heat pump
- Ⓑ Structure-borne noise
- Ⓒ Airborne noise
- Ⓓ Light well

Sound is propagated in buildings both directly by airborne noise Ⓒ radiating from the heat pump and from the transmission of structure-borne noise Ⓑ to the building structure (floor, walls, ceiling). Structure-borne noise is transmitted not only through the feet of the heat pump, but also through all mechanical connections between the vibrating heat pump and the building, such as pipes, air ducts and cables. In addition, vibrations can be transmitted as liquid-borne noise via the heating water and heat transfer medium in the primary circuit.
Sound transmission does not necessarily reach specific locations, e.g. bedrooms, directly. For example, it is possible for sound transferred to the outside via the light well to return into the room.
Reduce sound propagation to rooms requiring sound protection (living rooms and bedrooms in the dwelling, neighbourhood) through careful planning and selection of the installation location, in order to comply with local requirements and regulations. In Germany, observe the DIN 4109 ("Noise attenuation in building structures"), the TA Lärm and any other local regulations or obligations set out in individual contracts (sales discussion/sales contract). In other countries, follow the regional laws and legal regulations.
If in doubt, please consult an acoustic engineer.

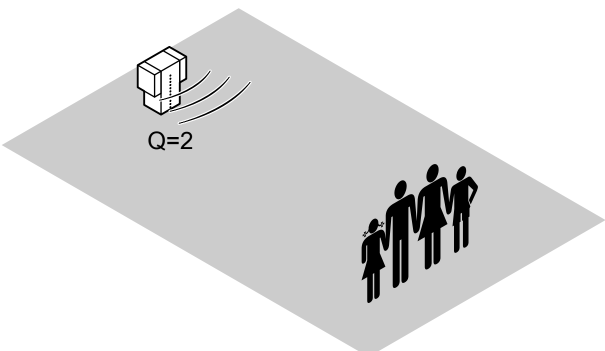
Sound reflection and sound pressure level (directivity Q)

The sound pressure level increases exponentially with the number of adjacent, vertical, fully reflective surfaces (e.g. walls) compared to installation in a free field (Q = directivity), as sound projection is restricted compared to installation in a free field.

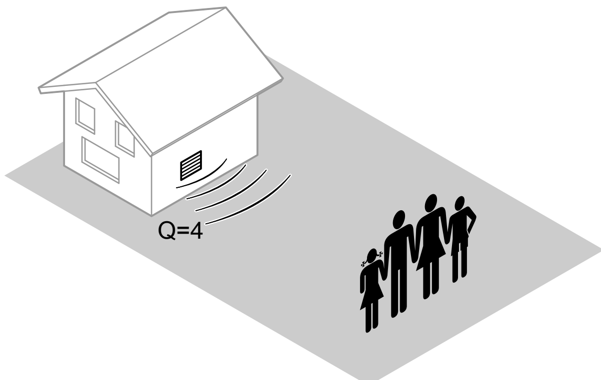


Q Directivity

Q=2: Freestanding outdoor installation of the heat pump



Q=4: Heat pump or air intake/discharge (for indoor installation) on one wall of the building



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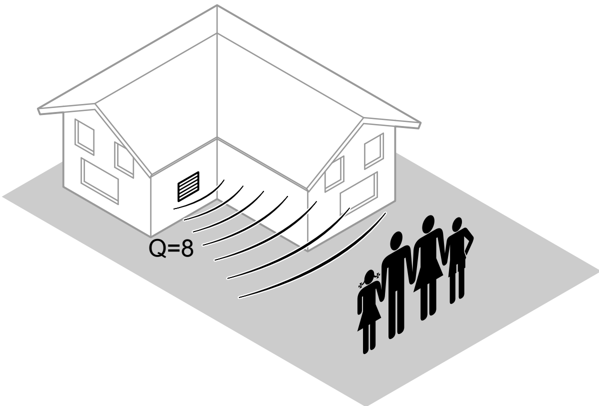
Q=8: Heat pump or air intake/discharge (for indoor installation) on one external wall of the building, next to a projecting wall corner



The following table shows the extent to which the sound pressure level L_P changes according to directivity Q and the distance from the appliance (in relation to the sound power level L_W measured directly at the appliance or at the air discharge).

The values listed in the table were calculated according to the following formula:

$$L = L_W + 10 \cdot \log \left(\frac{Q}{4 \cdot \pi \cdot r^2} \right)$$

L	=	Sound level at the receiver
L_W	=	Sound power level at the sound source
Q	=	Directivity
r	=	Distance between receiver and sound source

The legal requirements concerning sound propagation apply under the following idealised conditions:
- The sound source is a point source of sound.
- The heat pump installation and operating conditions correspond to the conditions for determining the sound power level.
- At Q=2, sound is emitted in a free field (no surrounding reflective objects/buildings).
- At Q=4 and Q=8, full reflection on adjacent surfaces is assumed.
- Unrelated noise from other surrounding sources is not taken into account.

Directivity Q, calculated on site	Distance from the sound source in m								
	1	2	4	5	6	8	10	12	15
	Energy-equivalent duration of sound pressure level L_P of the heat pump in relation to the sound power level L_W measured at the appliance/air duct in dB(A)								
2	-8.0	-14.0	-20.0	-22.0	-23.5	-26.0	-28.0	-29.5	-31.5
4	-5.0	-11.0	-17.0	-19.0	-20.5	-23.0	-25.0	-26.5	-28.5
8	-2.0	-8.0	-14.0	-16.0	-17.5	-20.0	-22.0	-23.5	-25.5

Note
- *In practice, actual values may differ from those shown here due to sound reflection or sound absorption as a result of local conditions. For example, the situations described by Q=4 and Q=8 often only give an inaccurate picture of the actual conditions at the emission site.*
- *If the heat pump sound pressure level as calculated approximately from the table is less than 3 dB(A) different from the permissible standard value given by the TA Lärm, a precise sound immissions prognosis must be produced (consult an acoustic engineer).*

Standard values for assessing the sound pressure level to TA Lärm (measured outside the building)

Area/object*1	Standard immissions value (sound pressure level) in dB(A)*2	
	During the day	At night
Area with a mix of commercial installations and residential units where neither commercial installations nor residential units dominate	60	45
Areas with predominantly residential units	55	40
Areas with only residential units	50	35
Residential units that are structurally connected to the heat pump system	40	30

1.4 Overview - engineering steps for a heat pump system

The "Heat pump checklist for sizing/quotation purposes" can be downloaded from **www.viessmann.de**.

*1 *Determined according to outline planning restrictions; check with local authorities.*
*2 *Valid for the sum of all sounds that have an influence.*

To access it, click on the following links in sequence:
- "Trade partner login"
- "Trade partner information"
- "Documentation"
- "Checklists"
- "Heat pumps"

Recommended method:
1. **Determining the building details**
   - Calculate the precise building heat load to DIN 4701/EN 12831.
   - Determine the hot water demand.
   - Define the mode of heat delivery (radiators or underfloor heating).
   - Determine the system temperatures of the heating system (aim – low temperatures).
2. **Sizing the heat pump** (see sizing)
   - Define operating mode of the heat pump (mono mode, mono energetic, dual mode).
   - Consider possible power-OFF times imposed by the power supply utility.
   - Determine and size the heat source.
   - Size the DHW cylinder.
3. **Determining the legal and financial framework conditions**
   - Approval procedure for the heat source (only for geothermal probes or wells)
   - Options for subsidies from central or regional authorities Förderdatenbank at www.viessmann.de includes up-to-date details of almost all subsidy programmes available in the Federal Republic of Germany.
   - Power tariffs and subsidies from the local power supply utility
   - Possible noise disturbance to neighbours (particularly in the case of air/water heat pumps)
4. **Determining responsibilities and interfaces**
   - Heat source for heat pump (for brine/water or water/water heat pumps)
   - Heat source(s) for the heating system
   - Electrical installation (heat source)
   - Structural conditions (see point 5)
5. **Engaging a drilling contractor (only brine/water and water/water heat pumps)**
   - Size the geothermal probe (drilling contractor).
   - Enter into a service contract.
   - Implement the drilling work.
6. **Structural conditions (only air source heat pumps)**
   - For indoor installation: Check the structural calculations for the wall outlet. Create the wall outlet.
   - For outdoor installation: Design and construct the foundations in accordance with local conditions and the standard rules of building engineering.
7. **Electrical work**
   - Apply for a meter.
   - Install the power and control cables.
   - Create meter locations.

1.5 Fill and top-up water

The quality of the fill and top-up water is one of the key factors for preventing damage caused by deposits or corrosion in the heating system.
In order to prevent system damage, the European standards and national guidelines for fill and top-up water must be observed right from the design stage, e.g. VDI 2035.
- Regular checks of the appearance, water hardness, conductivity and pH value of the heating water during operation lead to higher operational reliability and system efficiency. These properties must also be observed for the top-up water. According to VDI 2035, the quantity and properties of the top-up water must always be documented in the system log or maintenance reports.
- The basis for filling the heating system is tap water of potable water quality. For use as heating water, it is normally sufficient to soften the tap water. VDI 2035 specifies the maximum recommended concentrations of alkaline earths (hardeners), depending on the heating output and the specific system volume (ratio of the heating output of the heat generators to the heating water volume of the system): See the table below.
- We recommend always softening the fill and top-up water, as the water hardness can vary due to the mixture of different sources of supply, and the information provided by water supply utilities only gives average values. The information provided by water supply utilities is not sufficient for designing the system. In addition, it must be taken into account that the quantity of top-up water that will be added to the system during its service life cannot be predicted precisely at the design stage (especially in the case of existing heating circuits).
- If no aluminium or aluminium alloy components are installed, the heating water in systems with Viessmann heat generators does not need to be fully desalinated.
- The use of glycol as antifreeze without adequate inhibition and buffering is not permitted. The suitability of an antifreeze or other chemical additive should be certified by the manufacturer. Chemical additives in the heating water require more extensive monitoring and maintenance. Observe the manufacturer's instructions. Viessmann accepts no liability for damage or operational failure arising due to the use of unsuitable additives, incorrect dosing or poor maintenance.
- Chemical water treatments may only be planned and carried out by appropriately qualified specialist companies.

Total permissible hardness of the fill and top-up water according to VDI 2035

Total heating output of heat generator	Specific water capacity of heat generator*3	Specific system volume*4		
		≤ 20 l/kW	> 20 to ≤ 40 l/kW	> 40 l/kW
≤ 50 kW	≥ 0.3 l/kW	None	≤ 3.0 mol/m^3 (16.8 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)
	< 0.3 l/kW	≤ 3.0 mol/m^3 (16.8 °dH)	≤ 1.5 mol/m^3 (8.4 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)
> 50 to **≤ 200 kW**	—	≤ 2.0 mol/m^3 (11.2 °dH)	≤ 1.0 mol/m^3 (5.6 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)
> 200 to **≤ 600 kW**	—	≤ 1.5 mol/m^3 (8.4 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)
> 600 kW	—	≤ 0.05 mol/m^3 (0.3 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)	≤ 0.05 mol/m^3 (0.3 °dH)

Further requirements for the fill and top-up water independent of the heating output according to VDI 2035

Appearance
Clear, free of sedimented substances

Electrical conductivity
If the conductivity of the heating water is above **1500 µS/cm** due to a high salt content (e.g. in supply areas near the coast), desalination is necessary.

pH value

Materials in the system	pH value
Without aluminium alloys	8.2 to 10.0
With aluminium alloys	8.2 to 9.0

Information about system design

- For softening the heating water, use softening systems with water flow meters: See Vitoset pricelist.
- During installation, ensure that individual pipework sections can be drained separately. This avoids the need to drain all the heating water in the case of maintenance and repair work.
- As the formation of sludge and magnetite in the heating water cannot generally be completely prevented during operation, we recommend the installation of suitable magnetic dirt separators: See Vitoset pricelist.

Notes on commissioning and operating the system

- In order to prevent corrosion by remaining flushing water, fill the system completely immediately after flushing.
- Even treated fill water contains oxygen and small amounts of foreign matter. In order to prevent local concentrations of corrosion products and other deposits on the heating surfaces of the heat generator, commission the system in stages with a high heating water flow rate. Start with the heat generator at its lowest output. For the same reason, in the case of multi boiler systems and cascades, commission all heat generators at the same time.
- If extending the system or conducting maintenance or repair work, only drain the pipework sections where absolutely necessary.
- Check and clean filters, dirt traps and other blow-down or separating facilities in the heating water circuit after filling and commissioning.
- Special regional regulations regarding fill and top-up water must be observed. When disposing of heating water containing additives, check whether additional treatment may be required before it is discharged into the public waste water system.
  CH: Observe SWKI guideline BT 102-01.

1.6 Regulation on fluorinated greenhouse gases

The Regulation (EU) No. 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 (F-gas Regulation) is a legal instrument of the European Union regarding the handling of fluorinated greenhouse gases (F-gases).
This regulation applies since January 2015 in all EU member states*5. It replaces the previously valid Regulation (EC) No. 842/2006.
F-gases are present in the refrigerants in heat pumps.

The F-gas Regulation regulates the reduction and the use of F-gases with the aim of reducing the emissions and the harmful effects of these gases. This is achieved by means of the following measures:
- Step-by-step reduction of available quantities of F-gases in the EU (phase-down)
- Step-by-step bans on the use and marketing of certain F-gases
- Extension of the regulations to include tightness tests for refrigerant circuits etc.

*3 *In the case of systems with several heat generators that have several different specific water capacities, the smallest specific water capacity is definitive.*
*4 *To calculate the specific system volume, the smallest individual heating output should be used for systems with several heat generators.*
*5 *As a deviation from the European regulation, country-specific standards that can go beyond the requirements of the F-gas Regulation must be taken into consideration.*

The regulation must be observed by the following groups:
- Manufacturers and importers of F-gases into the EU
- Individuals who market products containing F-gases, e.g. heat pumps
- Individuals who install systems that use F-gases, shut down such systems and perform maintenance work and servicing on such systems
- Individuals who operate systems that use F-gases

Tightness tests for heat pumps

There are new standards for the tightness test for refrigerant circuits of heat pumps. The following criteria are taken into consideration when determining the maintenance intervals:
- GWP value of the refrigerant (global warming potential)
- Refrigerant charge in the refrigerant circuit
- CO_2 equivalent of the refrigerant (CO_2e)

On the basis of the GWP value and the respective application (e.g. in heat pumps), it is established from which point in time refrigerant may no longer be marketed in the EU.

GWP value
The GWP values of the individual components are added proportionately in the case of refrigerant mixtures.

Example:
R410A comprises 50 % R32 and 50 % R125.

Calculation of GWP, based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)

GWP_{R32} = 675
GWP_{R125} = 3500

GWP_{R410A} = (0.5 · 675) + (0.5 · 3500) = **2088**

Calculation of GWP, based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

GWP_{R32} = 677
GWP_{R125} = 3170

GWP_{R410A} = (0.5 · 677) + (0.5 · 3170) = **1924**

GWP values of the refrigerants used in Viessmann heat pumps

Refrigerant	GWP
R32	675[*6]/677[*7]
R449A	1397
R407C	1774
R410A	2088[*6]/1924[*7]

CO_2 equivalent
The CO_2 equivalent CO_2e is calculated from the GWP value and the refrigerant charge as follows:

$$CO_2e_{refrigerant} = m_{refrigerant} \cdot GWP_{refrigerant}$$

$CO_2e_{refrigerant}$ — CO_2 equivalent of the refrigerant in the refrigerant circuit
$m_{refrigerant}$ — Mass of the refrigerant in the refrigerant circuit in kg
$GWP_{refrigerant}$ — GWP value of the refrigerant

Example:
- Vitocal 300-G, type BWC 301.C06
- Refrigerant R410A
- Refrigerant charge 2.0 kg

$$CO_2e_{R410A} = 2.0\ \text{kg} \cdot 1924^{*7} = 3848\ \text{kg} \approx 3.9\ \text{t}$$

Intervals for tightness test

According to Regulation (EU) No. 517/2014, the intervals between tightness tests depend on the CO_2 equivalent of the refrigerant as follows:

Hermetically sealed systems	Non-hermetically sealed systems	Max. intervals between tightness tests	
		Without a device for leakage detection	With a device for leakage detection
$CO_2e_{refrigerant}$ < 10 t	$CO_2e_{refrigerant}$ < 5 t	Tightness test not necessary	
10 t ≤ $CO_2e_{refrigerant}$ < 50 t	5 t ≤ $CO_2e_{refrigerant}$ < 50 t	12 months	24 months
50 t ≤ $CO_2e_{refrigerant}$ < 500 t	50 t ≤ $CO_2e_{refrigerant}$ < 500 t	6 months	12 months
500 t ≤ $CO_2e_{refrigerant}$	500 t ≤ $CO_2e_{refrigerant}$	3 months	6 months

Example:

Test interval for a refrigerant circuit subject to the refrigerant charge m_{R410A} (GWP_{R410A} = 2088[*6])

Hermetically sealed systems	Non-hermetically sealed systems	Max. intervals between tightness tests	
		Without a device for leakage detection	With a device for leakage detection
m_{R410A} < 4.79 kg	m_{R410A} < 2.39 kg	Tightness test not necessary	
4.79 kg ≤ m_{R410A} < 23.9 kg	2.39 kg ≤ m_{R410A} < 23.9 kg	12 months	24 months
23.9 kg ≤ m_{R410A} < 239 kg	23.9 kg ≤ m_{R410A} < 239 kg	6 months	12 months
239 kg ≤ m_{R410A}	239 kg ≤ m_{R410A}	3 months	6 months

*6 *Based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*
*7 *Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*

1.7 Safety groups for refrigerants

Refrigerants are divided into the following safety groups according to ANSI/ASHRAE Standard 34 with regard to toxicity and flammability:

Flammability	A: Low toxicity	B: Toxic
Non-flammable	A1	B1
Low flammability	A2L	B2L
Flammable	A2	B2
Highly flammable	A3	B3

Safety group of the refrigerants used in Viessmann heat pumps

Refrigerant	Safety group
R32	A2L
R449A	A1
R407C	A1
R410A	A1

1.8 Regulations and directives

When engineering, installing and operating the system, observe the following standards and guidelines in particular:

General current regulations and directives

BImSchG	Heat pumps are "systems" according to the German Immissions Act. The BImSchG draws a distinction between systems that require approval and those that do not (Paragraphs 44, 22). The systems that are subject to approval are listed in the 4th German Immissions Ordinance (4th BImSchV). Heat pumps of any kind are not subject to this ordinance. This therefore means that heat pumps are subject to Paragraphs 22 to 25 BImSchG, i.e. they must be set up and operated in such a way that avoidable disturbances are restricted to a minimum.
TA-Lärm	With regard to noise emissions from heat pump systems, observe the technical instructions on noise protection – the TA-Lärm –.
DIN 4108	Thermal protection in buildings
DIN 4109	Sound insulation in buildings
VDI 2067	Economic efficiency of building installations - Fundamentals and economic calculation
VDI 2081	Noise reduction in air-conditioning systems
VDI 2715	Noise reduction at domestic hot water central heating systems
VDI 4640	Thermal use of the underground – Ground source heat pump systems Part 1 and Part 2 (for brine/water and water/water heat pumps)
VDI 4650	Heat pump calculations – abridged procedure for calculating the seasonal performance factor of heat pump systems – electric heat pumps for central and DHW heating
EN 12831	Heating systems in buildings – Method for calculation of the design heat load
EN 15450	Heating systems in buildings – Design of heat pump heating systems

Regulations concerning the water side

DIN 1988	Specification for installations inside buildings conveying water for human consumption
DIN 4807	Expansion vessels part 5: Closed expansion vessels with membrane for drinking water installations
DVGW Code of Practice W101	Guidelines for protected drinking water areas Part 1: Areas where groundwater is protected (for water/water heat pumps)
DVGW Code of Practice W551	DHW heating and pipework systems; Technical measures for the reduction of the development of legionella bacteria
EN 806	Specification for installations inside buildings conveying water for human consumption
EN 12828	Heating systems in buildings; Design for water-based heating systems

Regulations concerning the electrical side
Make the electrical connection and installation compliant with VDE regulations (DIN VDE 0100) [or local regulations] and the technical connection requirements laid down by your local power supply utility.

VDE 0100	Erection of power installations with rated voltages below 1000 V
VDE 0105	Operation of power installations
EN 60335-1 and EN 60335-2-40 (VDE 0700-1 and -40)	Household and similar electrical appliances - Safety
DIN VDE 0730 Part 1/3.72	Regulations for devices with electromotive drive for domestic use

Regulations concerning the refrigerant side

ANSI/ASHRAE Standard 34	Designation and Safety Classification of Refrigerants
DIN 8901	Refrigerating systems and heat pumps; protection of soil, ground and surface water – Technical safety and environmental requirements and tests
DIN 8960	Refrigerant, requirements

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EN 378	Refrigerating systems and heat pumps – safety and environmental requirements
Regulation (EU) No. 517/2014	Regulation (EU) No. 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing the Regulation (EC) No. 842/2006

Additional standards and regulations for dual mode heat pump systems

VDI 2050	Requirements for mechanical equipment rooms. Technical bases for planning and execution
EN 15450	Design of heat pump heating systems

Additional standards and regulations for extract air ventilation systems

DIN 1946-6	Ventilation for residential buildings
VDI 6022	Ventilation and indoor air quality

1.9 Glossary

Defrosting
Removing hoarfrost and ice from an evaporator of air/water heat pump by supplying heat. For Viessmann heat pumps, defrosting takes place according to demand by the refrigerant circuit.

Alternative operation
If the outside temperature is above the set dual mode temperature, the heat demand is covered solely by the heat pump. The alternative heat generator is not activated.
If the temperature is below the dual mode temperature, the heat demand is only covered by the alternative heat generator. The heat pump does not operate.

Process medium
Special term for refrigerants in heat pump systems.

Performance factor
Quotient of heating energy and compressor drive load over a fixed period, e.g. 1 year.
Symbol: β

Dual mode heating system
Heating system that covers the central heating demand of a building by means of 2 different energy sources, e.g. heat pump and additional combustion heat generator.

CO_2 equivalent (CO_2e)
This value indicates the extent to which a fixed mass of gas contributes to global warming in relation to CO_2.

Ice store
Large container filled with water, used by the heat pump as the primary source. If the extraction of heat causes the water to freeze, large amounts of heat from the crystallisation process can also be utilised as heating energy.
The ice store is regenerated by a solar air absorber and the ground.

Expansion device (expansion valve)
Heat pump component between the condenser and the evaporator for reducing the condenser pressure to the evaporation pressure corresponding to the evaporation temperature.
In addition, the expansion device regulates the injection volume of the refrigerant depending on the evaporator load.

Global warming potential (GWP)
This value indicates the extent to which a gas in comparison to CO_2 contributes to global warming.

Heating output
The heating output is the available heat delivered by the heat pump.

Refrigerating capacity
Heat flux extracted from a heat source by the evaporator.

Refrigerant
Material with a low boiling point that is evaporated by heat absorption and re-liquefied through heat transfer in a circular process.

Circular process
Constantly recurring changes in the state of a heat transfer medium by adding and extracting energy in a sealed system.

Cooling capacity
The cooling capacity is the available heat extracted by the heat pump from the cooling circuit.

Coefficient of performance (COP)
Ratio of heating output and compressor drive output.
The coefficient of performance can only be given as a temporary value under specific operating conditions.
Symbol: ε

Energy efficiency ratio (EER)
Ratio of cooling capacity and compressor drive output.
The energy efficiency ratio can only be given as a temporary value at specific operating conditions.
Symbol: ε

Mono energetic
Dual mode heat pump system, where the 2nd heat generator is operated with the same type of energy (electric power).

Mono mode
The heat pump is the sole heat generator. This operating mode is suitable for all low temperature heating systems up to a max. 55 °C flow temperature.

Natural cooling
Energy saving cooling method utilising the ground as a heat sink.

Rated power consumption
The maximum power consumption of the heat pump in constant operation under defined conditions. This value is only relevant for the connection to the power supply and is stated by the manufacturer on the type plate.

Efficiency
Factor derived from the utilised and related expended work (heat).

Parallel mode
Operating mode of a dual mode heating system with heat pumps. On all heating days of the year, the bulk of the heat demand is covered by the heat pump. It is only necessary to switch on the additional heat generator to cover the peak demand "in parallel" to the heat pump on a few heating days of the year.

Reversible operation
In reversible operation, the sequence of the process steps in the refrigerant circuit is reversed. The evaporator operates as a condenser and vice versa. The heat pump extracts the heating energy from the heating circuit, e.g. for central cooling. The refrigerant circuit is reversed to defrost the evaporator.

Solar air absorber
Collector that can absorb energy from the sun and from heated ambient air. The solar air absorber can be used to regenerate an ice store or can be utilised directly as the heat pump's primary source.

Evaporator
Heat exchanger of a heat pump, where heat is extracted from a heat source by evaporating a refrigerant.

Compressor
Machine for the mechanical transportation and compression of vapours and gases. Different types are available.

Condenser
Heat exchanger of a heat pump, where heat supplied to a heat transfer medium by liquefying a refrigerant.

Heat pump
Technical equipment that absorbs a heat flux at a low temperature (primary side) and transfers it by means of additional energy at a higher temperature (secondary side).
Refrigerators use the primary side. Heat pumps use the secondary side.

Heat pump system
Overall system comprising the heat source system and the heat pump.

Heat source
Medium (ground, air, water, ice store, solar air absorber) from where the heat pump extracts energy.

Heat source system (HSS)
Equipment for the extraction of energy from a heat source and the transportation of the heat transfer medium between the heat source and the "cold side" of the heat pump, incl. all auxiliary equipment.

Heat transfer medium
Liquid or gaseous medium (e.g. water or air), with which heat is transported.

Keyword index

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Keyword index

Subject to technical modifications.

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