GROUND-SOURCE & AIR-SOURCE HEAT PUMPS

Using nature's energy to heat and cool homes

HEAT PUMPS FOR HOUSES

Principles
Selection guide
Useful technical information

Abridged version for international distribution - October 2008

CS/JC

CIAT HABITAT

FOREWORD

The aim of this document is to remind the reader and provide him/her with practical advice about the basic industry rules that must be followed when designing and installing heat pump systems to heat and cool homes.

It addresses requirements related to:

- design,
- use,
- installation,
- maintenance.

It is based on the work of the French heat pump association (AFPAC), which is made up of specialists in thermodynamic heating techniques. More specifically, it addresses heating and heating/cooling systems in houses equipped with heat pumps that use air, water or a mix of glycol and water as a heat-transfer medium.

This guide should be used as a supplement to applicable standards and regulations. The recommendations given in it should be kept in mind through every step in the design, building, operation and maintenance a heat pump system.

1 OUR PLANET IS A SOURCE OF ENERGY

Nature is a source of renewable energy. Our planet constantly absorbs the sun's energy and stores it as heat in the air, in rock, in the ground and in water. Heat pumps can be used to tap into this source of free heat.

1.1 BENEFITS OF USING RENEWABLE ENERGIES

- Replace fossil fuels (expensive, polluting and dwindling) as sources of heat.
- Do not produce polluting combustion gases; reduce CO_2 emissions.
- Help to protect the environment.
- Lower heating and domestic hot water bills.
- Ensure comfortable conditions in both summer and winter for the entire family.

	Fuel oil	Natural gas	Electrical	Heat pump
CO_2 emissions per kWh produced	350 g	220 g	180 g	60 g

Comparison based on the average for systems built in 2006.

1.2 TYPES OF RECOVERABLE ENERGY

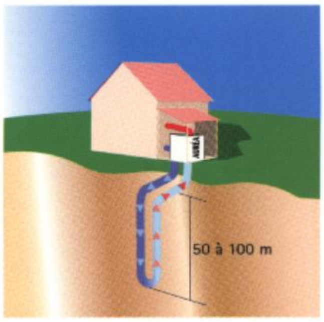
The type of energy that can be recovered depends on the available natural resources.

1.2.1 ENERGY CONTAINED IN THE GROUND - GEOTHERMAL ENERGY

The ground contains a vast amount of heat provided by sources such as the sun and rain. Stored in the upper layers of the earth and in groundwater, this energy can be harnessed using two types of heat pump:

- **water-to-water heat pumps** (groundwater, aquifers, wells). This type of pump is also known as a **water-source geothermal heat pump.** The advantage of such a system is that the temperature of water deep under the ground remains virtually stable (10/12°C) year round, ensuring a high level of efficiency.

- **heat pumps that use a mix of glycol and water** to absorb heat stored in the ground or rock. However, the actual amount of heat transferred can be affected by the type of soil (e.g. sandy, clay).



A vertical or geothermal loop system

A horizontal underground loop system.

1.2.2 ENERGY CONTAINED IN THE AIR – AIR-SOURCE ENERGY.

Our Earth's atmosphere is heated directly by the sun and human activity. The huge thermal mass of this air makes it a major source of potential energy that can be harnessed using **air-to-water heat pumps.**

The latest technologies allow today's heat pumps to operate at outdoor temperatures as low as -20°C..
One advantage of this type of heat pump is that it requires no excavation work or drilling.

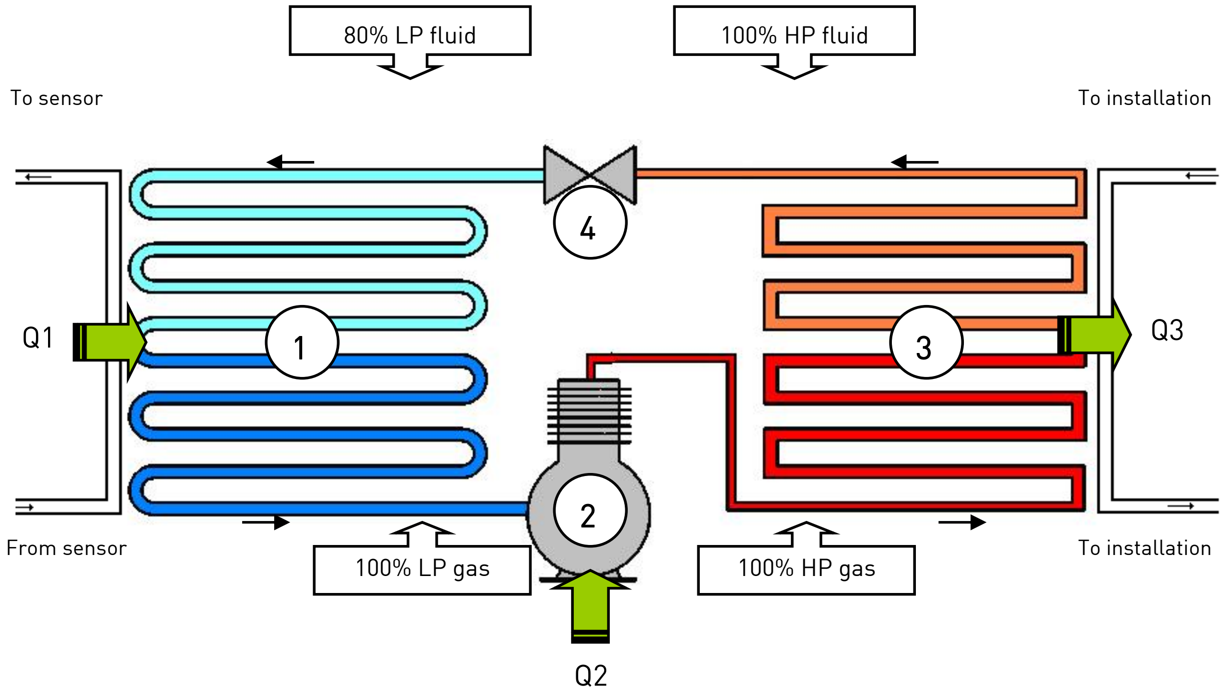
2 HOW A HEAT PUMP WORKS

A heat pump is a device that takes heat from a medium-temperature source (the environment) and converts it into higher-temperature heat to be used for purposes such as indoor heating.

2.1 BASIC PRINCIPLE

Heat is absorbed from outdoors by refrigerant. This refrigerant passes through an **evaporator**, ① where it evaporates into low-temperature, low-pressure gas. This gas is then compressed by a **compressor** ② driven by an electric motor. It is then circulated at high pressure and high temperature towards the **condenser** ③. Here, the gas cools, releasing its heat to the heating system and reverting to a liquid state. The high pressure and low pressure sections of the system are separated by a **pressure-reducing device** ④ which lowers the pressure and, as a result, the temperature of the refrigerant coming from the condenser.

Heating cycle of a water-to-water heat pump



Free energy Q1 + Electrical Energy Q2 = Heating Energy Q3

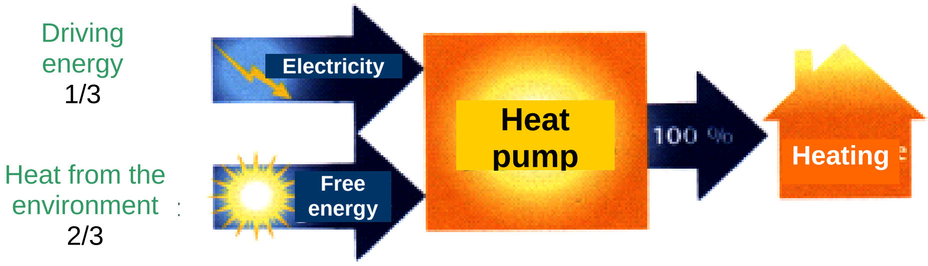
2.2 COEFFICIENT OF PERFORMANCE

The efficiency of a heat pump is measured by its coefficient of performance (COP).

In the diagram on the previous page, the output recovered in the condenser (Q3) – i.e. heat – is equal to the "free" output absorbed in the evaporator (Q1) plus the compression output (Q2).

The energy efficiency of the heat pump in heating mode is characterised by the COP, which is calculated as follows:

$$COP = \frac{\text{Heat output}}{\text{Energy input}} = \frac{Q3}{Q2}$$



IMPORTANT

Heat pumps are highly efficient solutions for two reasons: they can reduce the amount of electricity needed for heating by at least two-thirds, and they help to reduce pollution and CO_2 emissions.

2.3 HEAT PUMP TYPES

There are two types of heat pump:

2.3.1 AIR-SOURCE HEAT PUMPS

Designed for installation outside a structure to be heated, these heat pumps extract heat from the outdoor air.

AQUALIS 2

High temperature AQUALIS CALEO

High capacities AQUACIAT 2

2.3.2 GROUND-SOURCE (GEOTHERMAL) HEAT PUMPS

Designed for installation inside a structure to be heated, these heat pumps absorb heat from the ground or groundwater.

AGEO

High temperature
AUREA CALEO

High capacities
DYNACIAT

2.4 STANDARDS, REGULATIONS AND CERTIFICATION

Heat pumps must be designed according to standards on performance, ease of use and electrical safety.

These standards entail the following requirements:

- each unit must be tested,
- tests must be performed on a regular basis and their results documented,
- guarantees on quality must be verified by periodic tests.

EUROVENT is the name of a certification body set up by European manufacturers to guarantee performance specifications stated in catalogues and allow easier comparison between brands.

AQUALIS 2
AGEO 2
AQUACIAT 2
DYNACIAT2

AQUALIS 2
AGEO

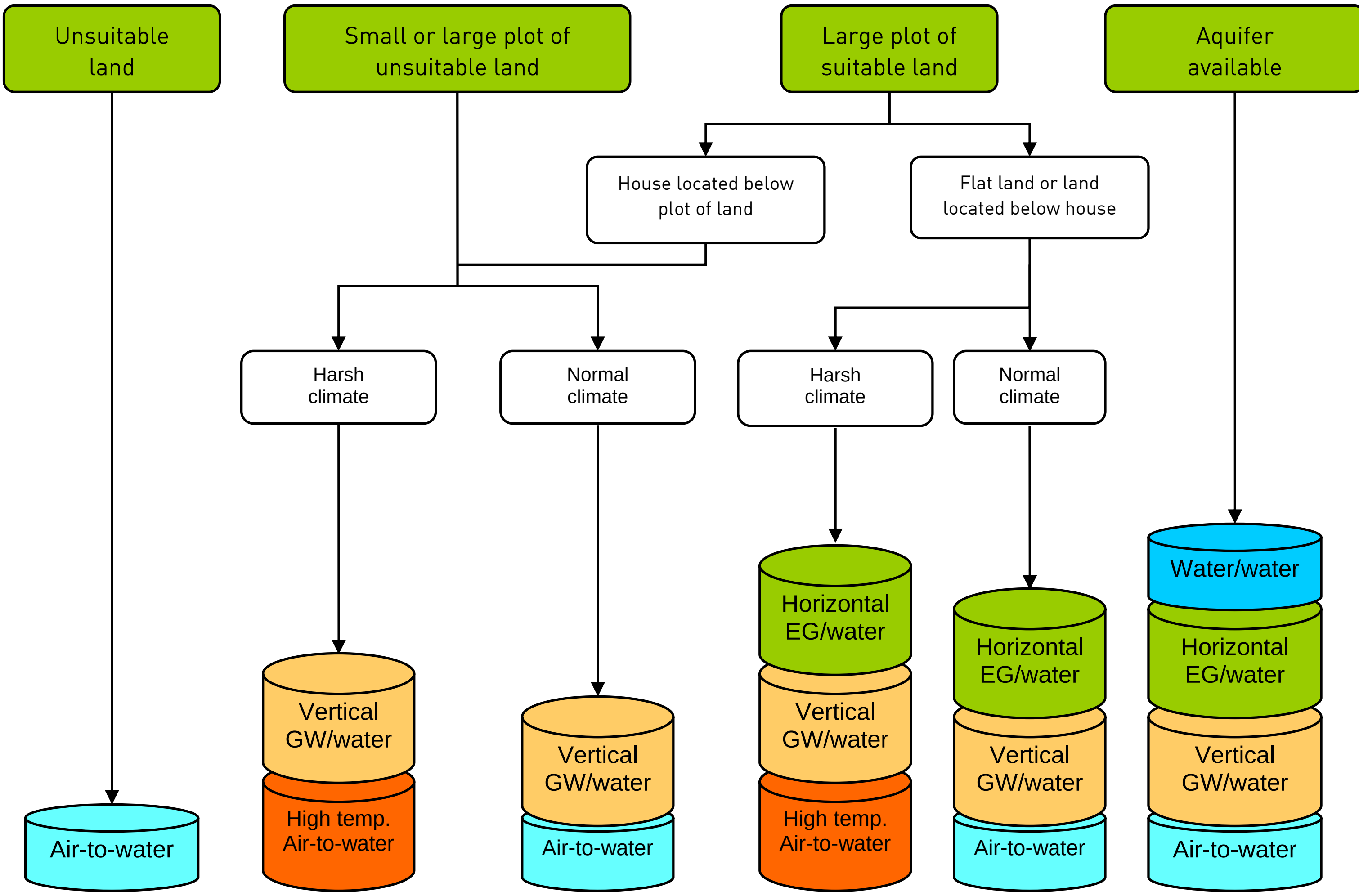
In the process of certification
AQUALIS CALEO
AGEO CALEO

3 CHOOSING THE RIGHT TYPE OF HEAT PUMP

Selecting a heat pump requires having a thorough understanding of many criteria before commencing the design phase:

The type of coupling system will depend on the land:

- What is the lie of the land (area, altitude)?
- Is there adequate space?
- Is ground water present?
- etc.



GW = Glycol/water mix

Once the type of coupling system has been determined, a number of project-specific criteria must be considered:

- Is the home new or being renovated?
- Will the existing boiler be kept or replaced?
- Will the system be reversible?
- Will high, medium or low temperature terminal units be used?

All these criteria will aid in selecting the best heat pump for any project. Once that is done, the next step is to determine the heat pump's required capacity.

3.1 SELECTING THE RIGHT CAPACITY FOR A HEAT PUMP

The capacity (or size) of a heat pump is directly related to three factors:

- heat losses of the structure to be heated,
- the type of heat pump (air-to-water, water-to-water, ground-to-water),
- cost calculations that can be performed beforehand (see CIAT tools).

- The first thing to do is to have the heat losses calculated by a specialised engineering office. This study (mandatory in some countries) is essential in order to correctly size the heat pump and terminal units. The minimum capacity to be provided will depend on a home's heat losses.

- The next step consists of finding the solution that offers the best compromise between the investment cost and the annual running cost. Depending on the type of heat pump selected (water-to-water, ground-to-water or air-to-water) an auxiliary heating device (boiler or electric heating element) may be added to keep the investment cost down without putting a strain on the operating budget.

The Geoconfort software is helpful in drawing up an estimate of these costs. It makes it possible to select the right equipment, calculate the return on investment (ROI), and print out an estimate complete with the necessary accessories.

IMPORTANT:

- Oversizing presents a number of disadvantages: it will needlessly increase an installation's electrical cost without providing any significant drop in heating consumption, potentially generate more noise, and require a greater flow of water through the condenser (not always practicable). In addition, the risk of compressor short-cycling, and therefore premature compressor wear, is high.

- Never undersize a water-to-water heat pump without an auxiliary heating device or an air-to-water heat pump with an auxiliary heating device. Although such a system is less expensive to install, the resulting longer operating cycles will drive up the energy costs. Undersizing is therefore not recommended.

3.2 HEAT PUMP SIZING

A heat pump is sized differently depending on the source of heat.

- The capacity of a ground-source heat pump must be at least equal to the heat losses in a home. These losses are calculated using the design temperature (heat output +20% maximum as a safety measure).

- The capacity of an air-source heat pump must be sized to 80% of a home's heat losses (calculated using the design temperature) to avoid short-cycles during the mild seasons (0–5°C).

3.2.1 AUXILIARY HEATING DEVICE

Not all heat pumps are sized to meet a home's entire heating needs.

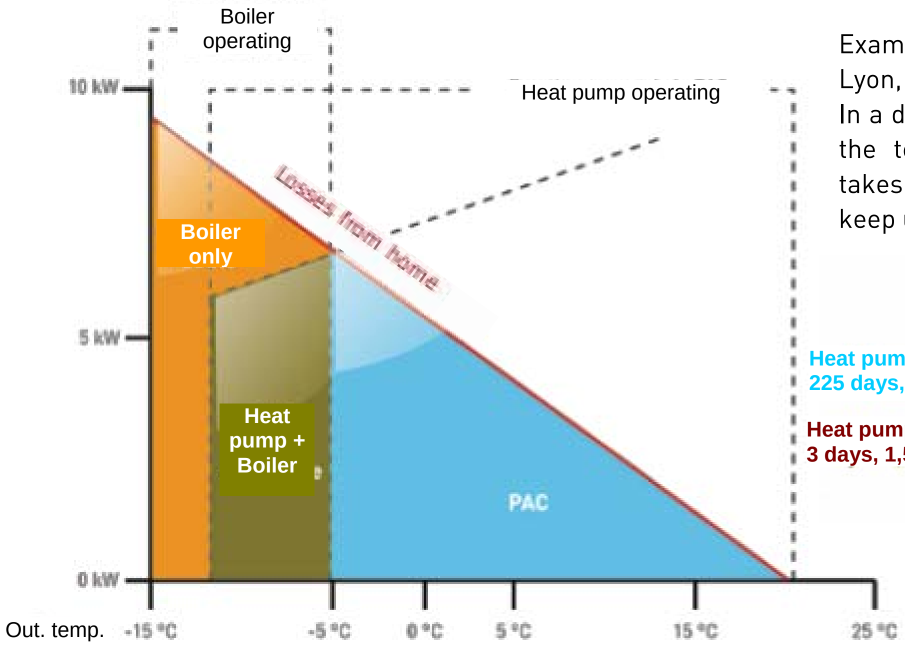
BECAUSE THE GROUND COOLS MORE SLOWLY THAN AIR, a geothermal heat pump provides more consistent heat than an air-source heat pump. As a result, an auxiliary heating device is not always necessary. An auxiliary heating device is necessary in areas where temperatures frequently drop below freezing or if the installation is intentionally designed with an auxiliary source. Aquifers remain at a constant temperature of 8°C to 12°C, obviating the need for auxiliary heating devices.

BECAUSE AIR-SOURCE heat pumps are sized to 80% of the heating needs, an auxiliary is often necessary or even mandatory.

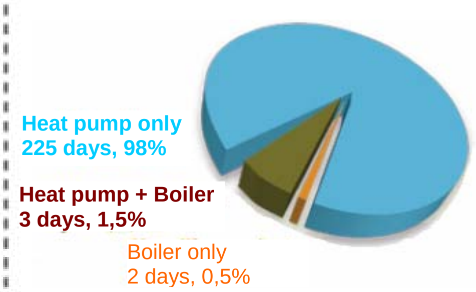
3.2.1.1 VARIOUS AUXILIARY SOURCES

- Auxiliary electric heating device (heating element on hot water circuit)
- Existing boiler – for controlled auxiliary backup
- Wood stove, fireplace, etc. for uncontrolled auxiliary heating
- etc.

CUSTOMERS RENOVATING THEIR HOMES often keep their existing fireplace, wood stove, boiler or other source of heat. Each are potential auxiliary sources. It is important to ensure that these auxiliary sources provide sufficient heating capacity and, if they are used often, to not oversize the heat pump.
If they are used only very rarely, the heat pump should be normally sized and an additional auxiliary heat source (e.g. electrical) provided.



Example of a controlled system in Lyon, France.
In a dual system, the boiler fires when the temperature drops to -5°C and takes over when the heat pump cannot keep up with the demand.



IN NEW HOMES, installing an auxiliary heater is recommended if an air-source heat pump will be the only source of heat. The auxiliary will help the heat pump during periods of high demand and it will act provide a minimum level of comfort in the event the heat pump breaks down.

3.3 HEAT PUMP SPECIFICATIONS

Once the type of heat pump and its capacity have been determined, the system designer should have access to the following information:

- the heating and cooling capacity at each operation point,
- the input power in the heating mode and the cooling mode (if reversible),
- the A-weighted sound power level,
- the pressure drops in the exchangers in the cooling or heating modes,
- the real operating temperature limits

(i.e. the air inlet/outlet and the water inlet/outlet temperature limits between which the heat pump is able to operate),

- the minimum and maximum air and water flow rates,
- the thermal, electrical and refrigerant protections,
- the refrigerant charge,
- the type of defrosting system (for air-to-water heat pumps),
- cold start protections,
- the weight and necessary lifting equipment,
- the footprint,
- the diameters of hydraulic and electrical connections.

All the technical specifications on CIAT heat pumps – essential for thoroughly designing a system – are provided in our sales and technical brochures.

4 GROUND-SOURCE HEATING

4.1 WATER-SOURCE COUPLING SYSTEM

4.1.1 PRINCIPLE

Because subsurface water generally remains at a temperature of 8 to 12°C all year round, it constitutes a significant, stable and ideal source of energy for heating a detached house with a water-to-water heat pump.

There are two ways of collecting subsurface water:

- via a single extraction well: after being circulated through the heat pump, the water is discharged to surface water (e.g. a river, pond or lake),
- via an extraction well and a reinjection well: water is pumped from the first and reinjected back into the aquifer via the latter (located at least 15 m downstream from the source well).

Surface water (rivers, lakes, springs) may be used as a heat source provided the following three factors are met:

- The temperature of the water

never drops below 8°C in the winter.

- The minimum flow rate all year round

is sufficient to meet the requirements of the heat pump (between 1.5 and 3 m^3/h on average for a 100 to 200 m^2 home).

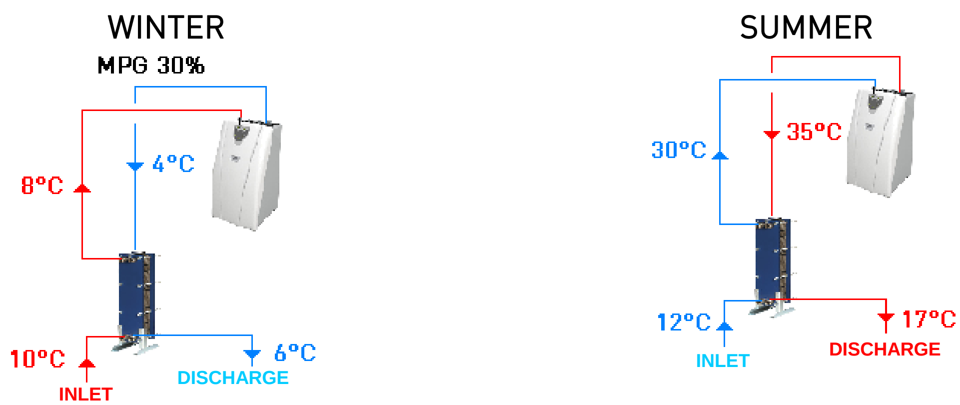
- The water is

neutral or slightly aggressive, free of pollution and contains few alluvial deposits.

IMPORTANT

In the event of any doubts as to whether surface water may be used as a cold source, it is highly recommended to consider an alternative solution, such as horizontal or vertical underground loops or an air-to-water heat pump.

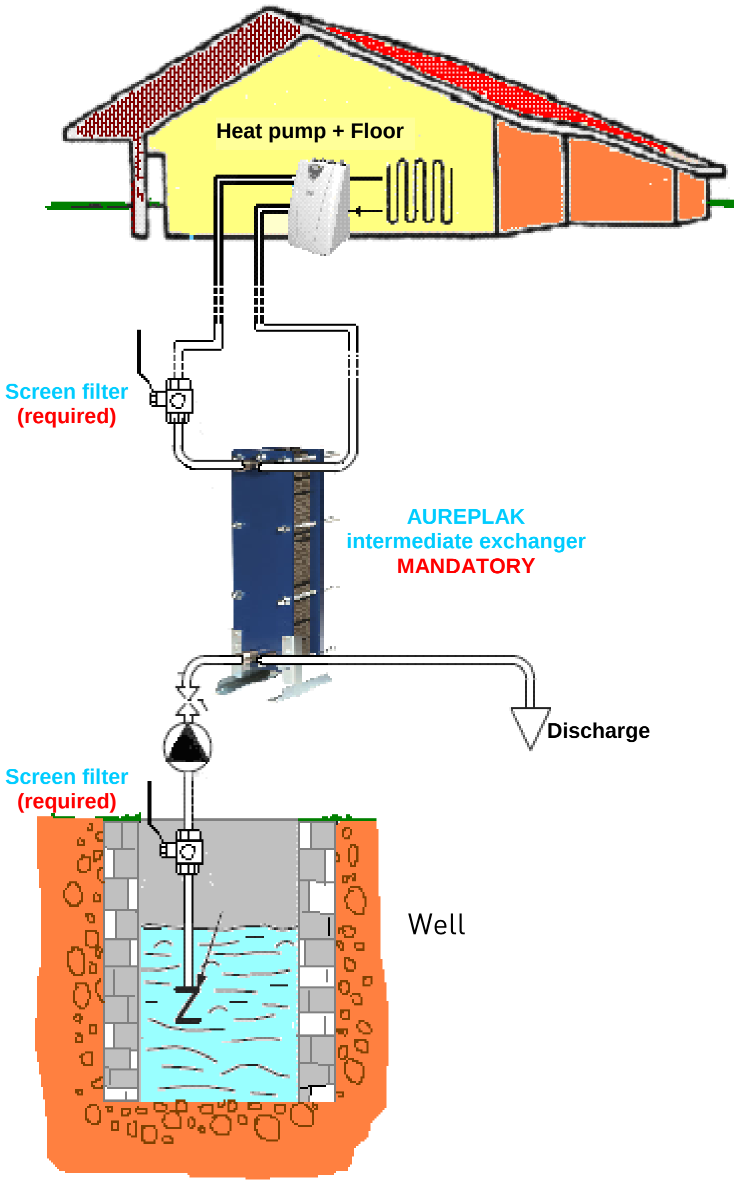
4.1.2 WATER TEMPERATURES



4.1.3 WATER-SOURCE COUPLING SYSTEM: SINGLE WELL LOOP

IMPORTANT:

Not all old wells are supplied by an aquifer; some are fed by springs, seepage or rainwater runoff from roofs. In the latter case it is highly unlikely that the flow of water will be sufficient to supply a heat pump. Only wells that extend down into an aquifer may be therefore used. As a result, it is important to verify that the well provides a sufficient supply before embarking on a study.



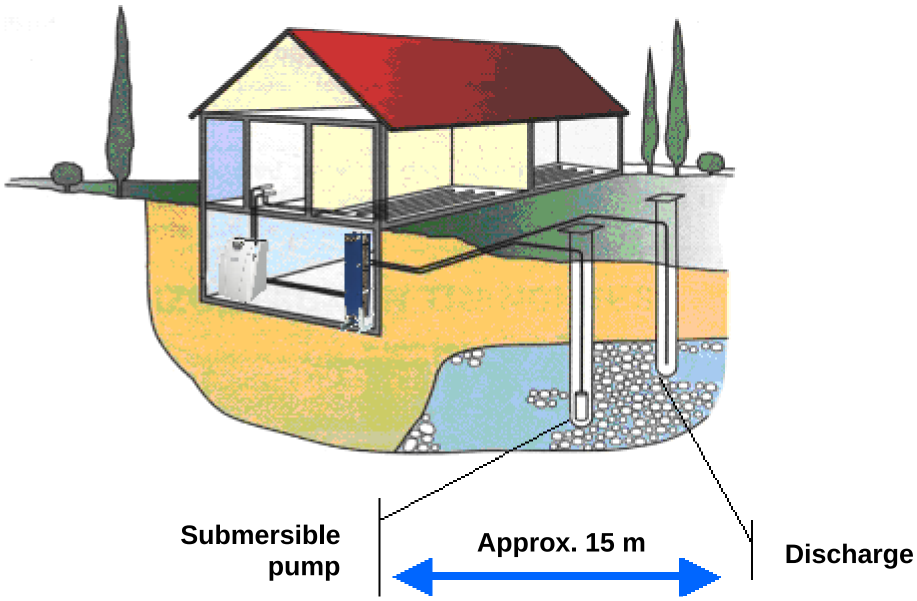
- The first thing to do is to contact any neighbours who have a similar heat pump and/or coupling system in order to learn from their experience.

- Next, the well must be tested. This consists of using a surface pump or a submersible pump powerful enough to provide the flow rate needed for the project at hand (1.5 to 3 m^3/h on average for a detached house). When the pump starts, the water level in the well may quickly drop then settle after a few minutes. Once this occurs, measure the water level then allow the pumping to continue. Measure the water level again once every 15 minutes; it should remain the same.

- If the heat pump will be supplied directly by the well, the well pump must not circulate any sand or mud. An intermediate heat exchanger (e.g. AUREPLAK, with plates that can be removed for cleaning) and a screen filter (maximum mesh opening size of 600 µm and cleanable) must be installed between the heat pump and the well pump to protect the heat pump's heat exchanger from particles that could clog it. *See Section 4.1.4*

Groundwater is pumped from a well and discharged to surface water

4.1.4 WATER-SOURCE COUPLING SYSTEM: DOUBLE WELL LOOP



Groundwater is pumped from one well and discharged to another

- It is always a good idea to contact any neighbours who have a similar heat pump and/or coupling system in order to learn from their experience.

- If the heat pump will be supplied directly by the well, the well pump must not circulate any sand or mud. An intermediate heat exchanger (e.g. AUREPLAK, with plates that can be removed for cleaning) and a screen filter (maximum mesh opening size of 600 µm and cleanable) must be installed between the heat pump and the well pump to protect the heat pump's heat exchanger from particles that could clog it. *See Section 4.1.4*

4.1.5 WATER QUALITY

Whenever a groundwater heat pump with intermediate heat exchanger is used, the physical and chemical properties and the microbiological content of the water must be analysed.

The following properties must be analysed:

- **Hardness:** presence of calcium (risk of clogging)
- **Aggressiveness:** presence of iron, manganese or chlorine (risk of corrosion and deposits)
- **Turbidity:** presence of fine suspended solids (risk of clogging)

The results of the analysis will make it possible to determine which materials should be used for the strainer and the intermediate exchanger (304L or 316L stainless steel, or titanium in the presence of sea water) and the future rate of maintenance.

4.1.6 INTERMEDIATE HEAT EXCHANGER - AUREPLAK

Easy to dismantle and clean, this heat exchanger is mandatory on all systems that use water from an aquifer or groundwater. It must be indoors to protect it from freezing temperatures and placed in an easy-to-access location to facilitate maintenance.

⚠ IMPORTANT:

To protect the system from any risk of freezing if the heating system is turned off or in the event of a power outage, we recommend protecting the hydraulic circuits (outdoors and/or indoors depending on the altitude) with a mix of water, antifreeze and corrosion inhibitor.

Two types of solution can be used:

- A ready-to-use product containing 40% monopropylene glycol (MPG) and corrosion inhibitor.
- A concentrate to be diluted.

NOTE: Do not use products made with monoethylene glycol, which is toxic. Always follow the recommendations in our technical documentation.

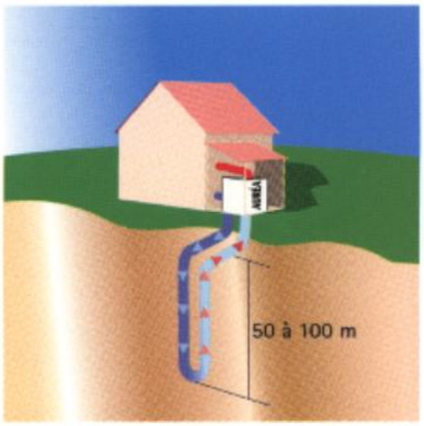
4.1.7 SELECTING AN AUREPLAK PLATE HEAT EXCHANGER

AGEO	Cooling capacity (kW)	Available pressure in heat pump and heat exchanger circuit (kPa)	AUREPLAK SELECTION	Primary operation water 10 / 6°C		Secondary operation 20% MPG water 4 / 8°C
				Water flow rate (m³/h)	Pressure drop (kPa)	Water flow rate (m³/h)
20 H(T)	5	36	AUREPLAK 7	1.2	6	1.2
30 H(T)	7.2	27	AUREPLAK 7	1.55	12	1.55
40 H(T)	9.7	38	AUREPLAK 11	2.1	11	2.15
50 H(T)	12.9	33	AUREPLAK 14	2.8	10	2.86
65 HT	15.6	55	AUREPLAK 14	3.35	15	3.45
80 HT	19.2	45	AUREPLAK 17	4.1	16	4.25
100 HT	24.2	26	AUREPLAK 21	5.2	17	5.36
120 HT	28	15	AUREPLAK 30	6	12	6.2
AGEO CALEO						
50 H(T)	12.9	33	AUREPLAK 14	2.8	10	2.86
65HT	15.6	55	AUREPLAK 14	3.35	15	3.45
80HT	19.2	45	AUREPLAK 17	4.1	16	4.25

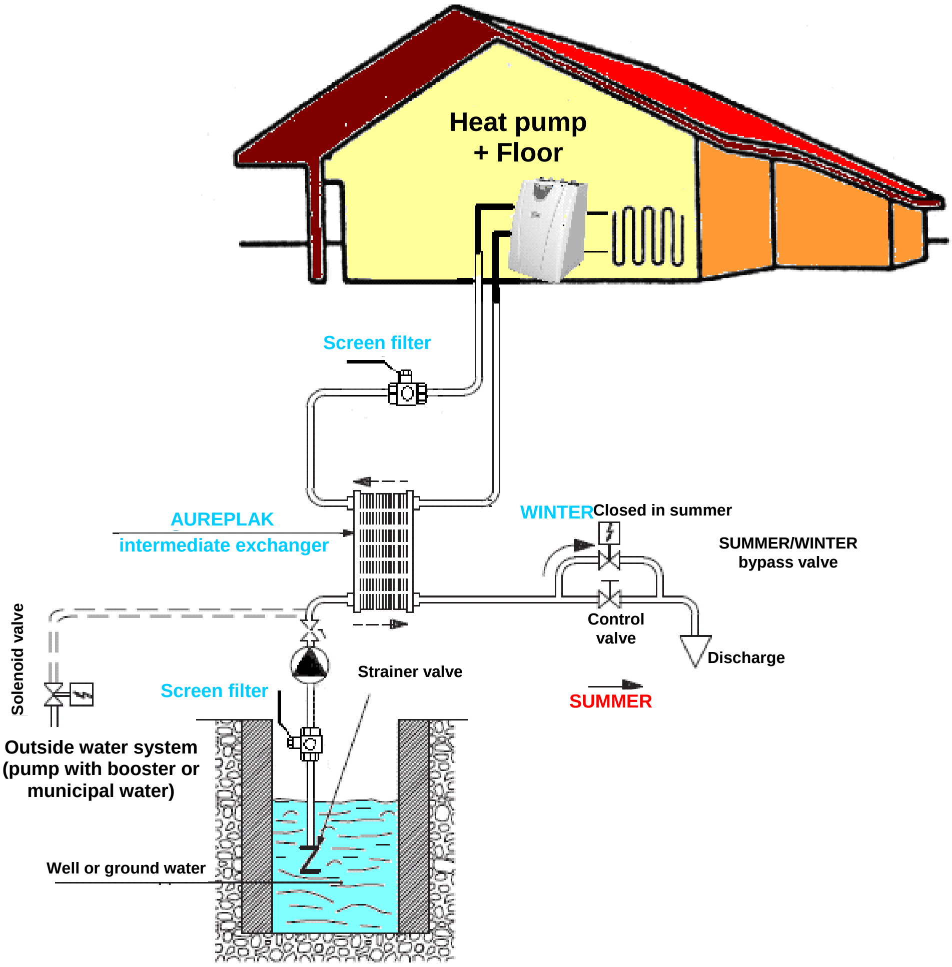
4.1.8 INSTALLING THE SYSTEM

It is important that the supply and discharge wells are separated by a **distance of at least 15 m**. Furthermore, if the water is to be pumped from an aquifer supplying a stream or river, **the discharge well must be placed downstream** of the supply well as the direction of flow in the aquifer is, of course, the same as that of the stream or river it supplies.

Check with the municipal authorities for information on all applicable local regulations.



4.1.9 COUPLING SYSTEM DIAGRAM



4.1.10 SUMMARY OF ADVICE

- Before installing a system, check with the municipal authorities for information on the locations of aquifers and approximate flow rates.
- Apply for a permit to pump water from the aquifer.
- An AUREPLAK intermediate heat exchanger and a filter (particle size < 600 µm)

are mandatory for water-to-water systems.

- If the aquifer temperature is below 8°C, it is better to opt for a horizontal or vertical ground loop or an air-source heat pump.
- The flow rate of the primary circuit must be at least 1.5 m^3/h.

4.2 HORIZONTAL GROUND LOOPS

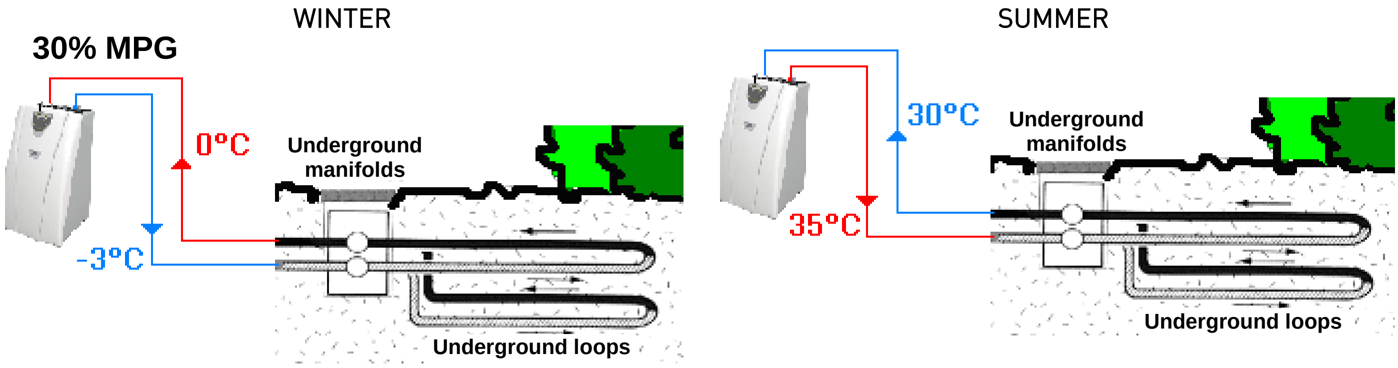
4.2.1 PRINCIPLE

The sun and rain provide the ground with renewable heat energy that can be harnessed with a geothermal heat pump.

The operating principle behind a ground-source heat pump is simple: heat is collected by a heat-transfer fluid circulating through a system of underground pipes. The main advantage of ground-source heat pumps over air-source heat pumps is the fact that the ground remains at a steadier temperature than the air. As a result, they provide greater and more uniform heat output and thus a higher annual COP.

- A mix of water and monopropylene glycol (brine – 15°C) is used as the heat-transfer medium.)
- Although the ground stores most of its heat in the summer, it also gains heat all year long during sunny or rainy periods.

4.2.2 WATER TEMPERATURES



4.2.3 TYPES OF HORIZONTAL LOOP

Three types of horizontal loop are generally used:

Single level = shallow trench	Two-pipe trench	Four-pipe trench

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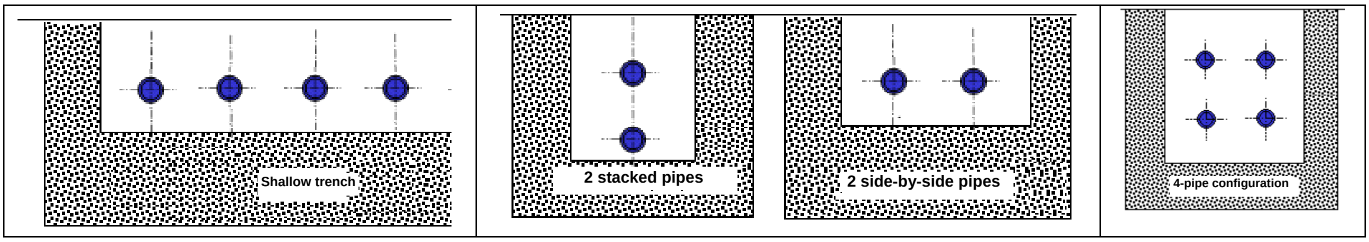

Shallow trench
2 stacked pipes
2 side-by-side pipes
4-pipe configuration

The amount of heat collected varies with each type of horizontal loop:

Average amount of heat collected by each type of horizontal loop			
Arrangement	*Per metre of trench (W/ml)*	*Per metre of pipe (W/ml)*	*Per square metre of land (W/m²)*
Shallow trench*	-	15*	37*
Two-pipe loop*	30	15*	30*
Four-pipe loop	44	11	37

(*) In areas where the outdoor temperature can drop to below –10°C, these values are 12 W/ml an 30 W/m², respectively.

4.2.4 LOOP MATERIALS

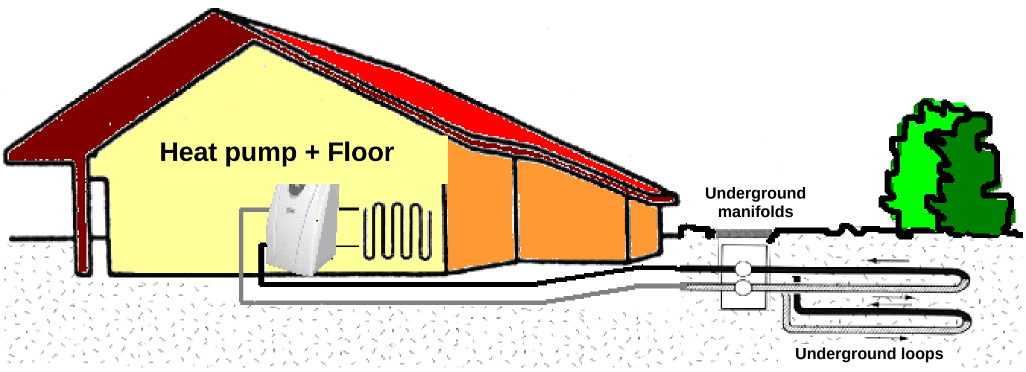
The pipes must be made of a synthetic material that is inert to chemicals found in the soil and in the anti-freeze):

- Loop pipes are made of the following materials:
    - High Density Polyethylene (HDPE),
    - Cross-Linked Polyethylene (PEX),
    - Low Density Polyethylene (LDPE),
    - Polybutylene (PB)
- Diameters: 20 to 40 mm
- Minimum thickness: 1.9 mm
- Temperature range: -3°C / 0°C

4.2.5 LOOP SIZING

The first thing to know when sizing a loop is that the loop must be installed in an area at least twice the size of the floor area to be heated.

Example: → 200 to 260 m² of land will be needed to heat a floor area of 130 m² in a detached house



4.2.5.1 SITE STUDY

The first thing to do is to calculate the heat losses in the house (in order to calculate the necessary lengths), the type of land and the available area, and the construction equipment that will be needed.

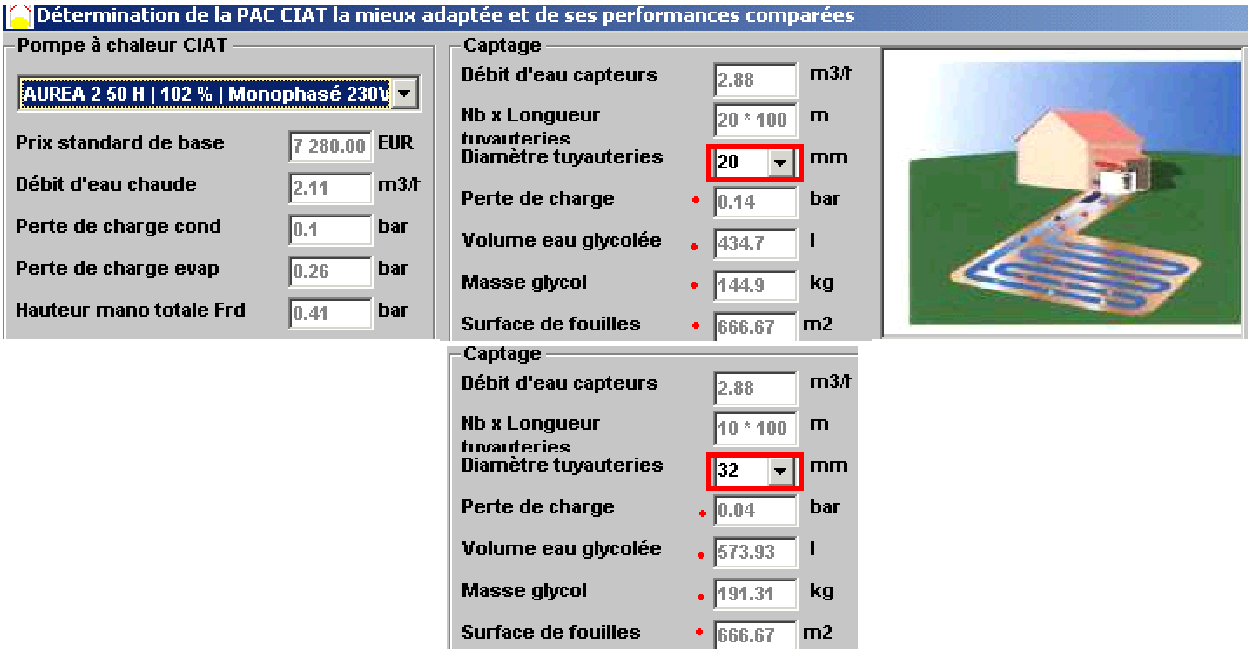
To do so:

- Determine the soil type (stratification).
- Design the path of the loop so that it does not run into obstacles and maintains the minimum spacing (trees, underground pipes, etc.). The larger the loop, the higher the efficiency of the system.

Bear in mind that the soil above a loop must remain permeable (no patios, asphalt or concrete slabs) and must not be crossed by water pipes (risk of freezing). Loops must be installed away from trees. However, grass, flowers and small shrubs may be planted above them.

4.2.5.2 USING GEOCONFORT TO DESIGN A HORIZONTAL LOOP

During the final selection process, the Geoconfort selection software for residential heat pumps contains a Loop section:



4.2.5.3 INFLUENTIAL FACTORS

The amount of heat absorbed by the loop depends on a number of factors:

- Moisture content: the moister the soil, the more efficient the loop,
- Mineral content (e.g. quartz),
- Proportion and size of water-saturated pores,
- Soil consistency: more heat is exchanged in moist topsoil than in rocky soil,
- Exposure of the land: land facing due south will absorb heat faster than land facing north,
- Cast shadows: the heat in shady soil is replenished slowly,
- The soil type:

Soil type	*Input power*
Rocky, dry soil	8 to 12 W/m²
Moist clay	20 to 30 W/m²
Moist sand	30 to 40 W/m²

4.2.6 INSTALLATION – LAYING THE LOOP

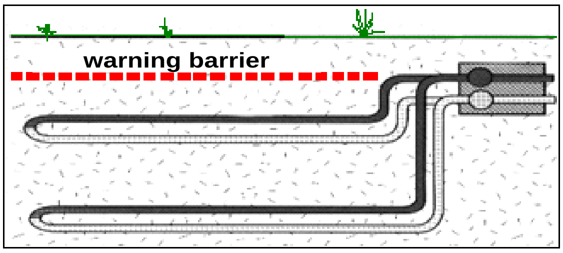
When joined together, the pipes in a horizontal loop extend several hundred metres in length. If a shallow trunch is dug, the pipes are unrolled in coils spaced at least 40 cm apart to avoid collecting too much heat (risk of the ground freezing). **This type of system provides up to 30 W/m2.**

Indicative values

 **Trench** Depth: 0.6 to 1.20 m Max. length trench: 50 m Trench spacing: 0.6 m Ratio: approx. 2 m of pipe per m² of graded land.	 **A shallow trench is dug** Depth: 0.8 m (below frost line). Minimum spacing: 0.4 m; dia. 25 mm pipes , Laid on a bed of sand Perimeter marked off.

A number of rules must be followed in order to use a horizontal loop:

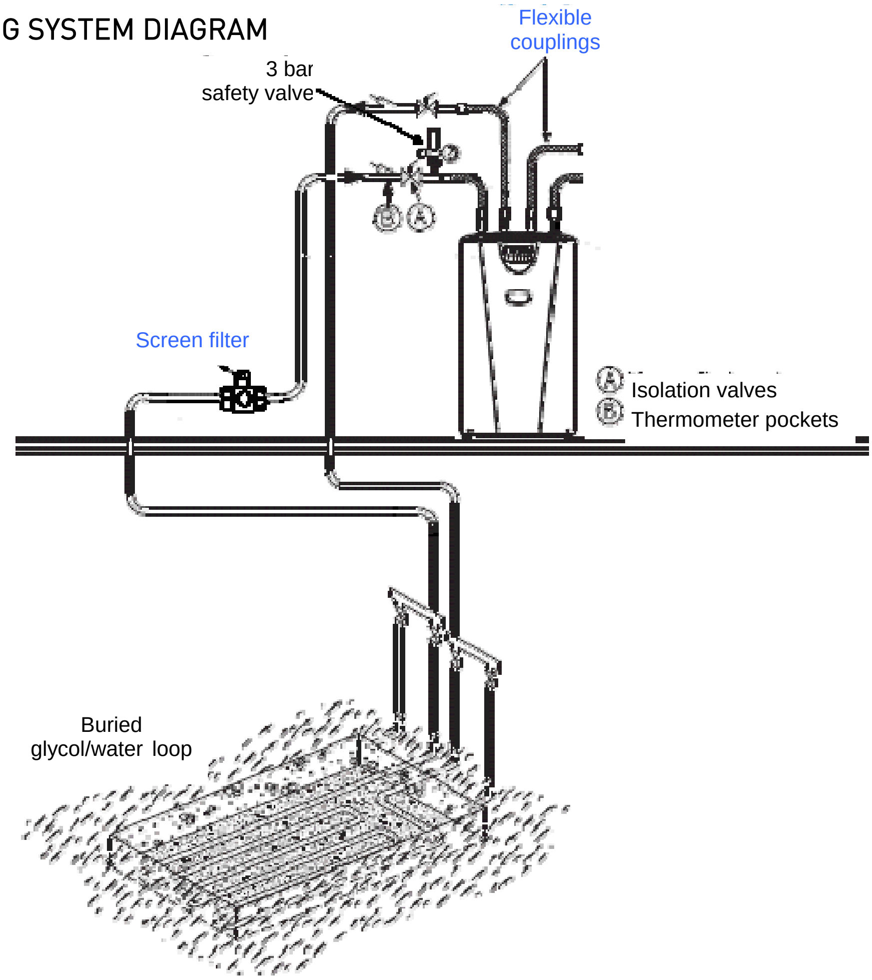
- Install the heat pump upstream of the loop to avoid any high points in the coupling system (otherwise install a drain at the high point of the system).
- Cover with a bed of sand (150 mm) if the pipes risk breaking under the weight of the soil and earth.
- The entire loop should be aligned perpendicular to the home so that the supply and return lines are equally long.
- Each pipe run in the loop should be of the same length in order to have identical pressure drops,
- Check that the hydrostatic pressure in the least favourable circuit is within the pipe's service limits,
- Add isolating valves and drains on the headers for easier loop filling,
- Two things must be done prior to backfilling:
  - draw up a diagram of the loop showing its location in relation to the structure (house),
  - take a set of photos.
- The flow of water through the loop must not exceed a linear pressure drop of between 100 and 150 Pa/ml (or 10 to 15 mm CE/ml)



Mandatory minimum spacing:

Obstacles	Minimum distance, in metres
Trees	2
Underground power lines	1.5
Foundations, wells, septic tanks, drains, etc.	3
Between the pipes	**Minimum distance, in metres**
Normal trench	0.6
Shallow trench	0.4
Between trenches	**Minimum distance, in metres**
Two pipes per trench	1
Four pipes per trench	1.2

4.2.7 COUPLING SYSTEM DIAGRAM



4.3 VERTICAL GROUND LOOPS (GEOTHERMAL LOOPS)

4.3.1 PRINCIPLE

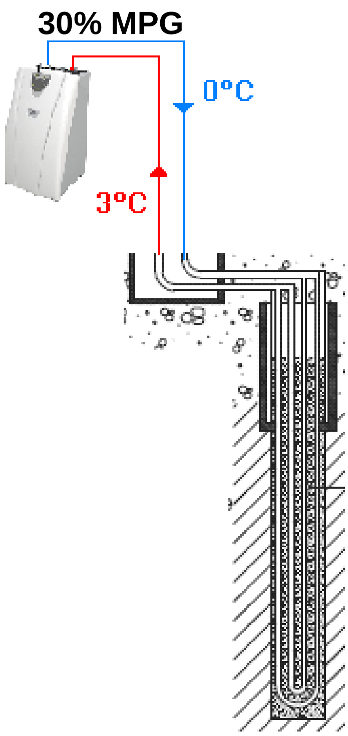
A vertical ground loop is just like a horizontal loop: heat is collected by refrigerant that is circulated through a network of buried pipes and taken all the way to the heat pump. The difference is that part of the heat is absorbed from deep below ground and another part is collected just below the soil surface.

Vertical loops consist of one or two U-shaped pipes inserted into boreholes extending 100 m below ground. A mix of water and monopropylene glycol (brine – 15°C) is circulated through the pipes.

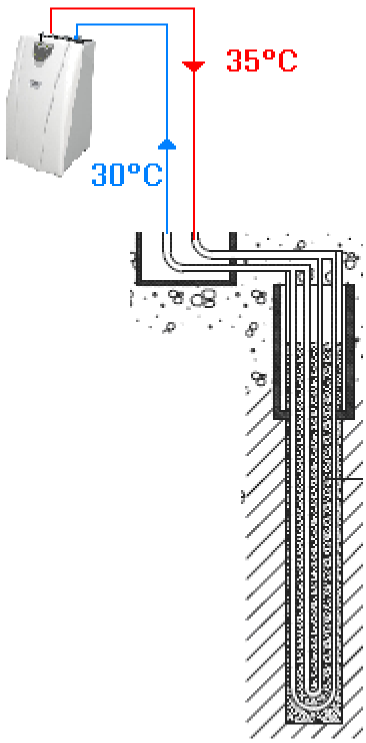
Each U-shaped loop of pipe is inserted in a vertical borehole drilled by a drilling company. The input power rate is 20 to 50 W per ml of borehole. This corresponds to an annual energy consumption rate of over 100 kWh per ml.

4.3.2 WATER TEMPERATURES

WINTER



SUMMER



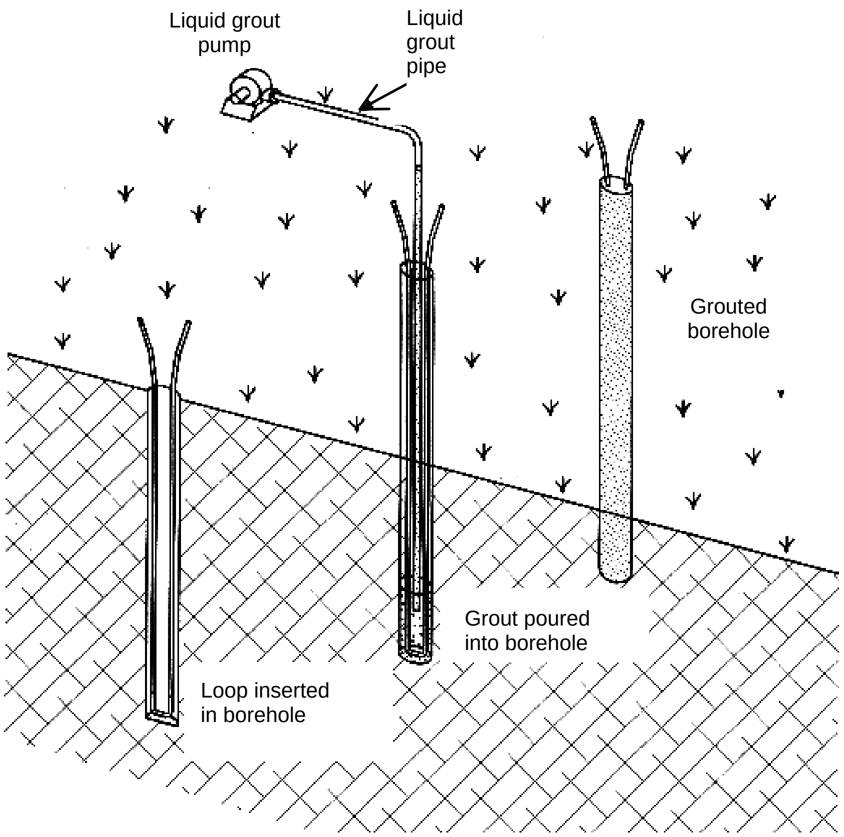
4.3.3 DESCRIPTION OF A VERTICAL LOOP

Loops are made of either high or low density polyethylene (HDPE or LDPE) pipes having a diameter of 25, 32 or 40 mm and a pressure rating of 12.5 bar. The loop must:

- Resist corrosion,
- Resist hot and cold temperatures,
- Resist impacts,
- Have a long service life (100 years),
- Have a low pressure drop,
- Be fused together and pressure tested,
- Have a temperature range of +3°C / 0°C

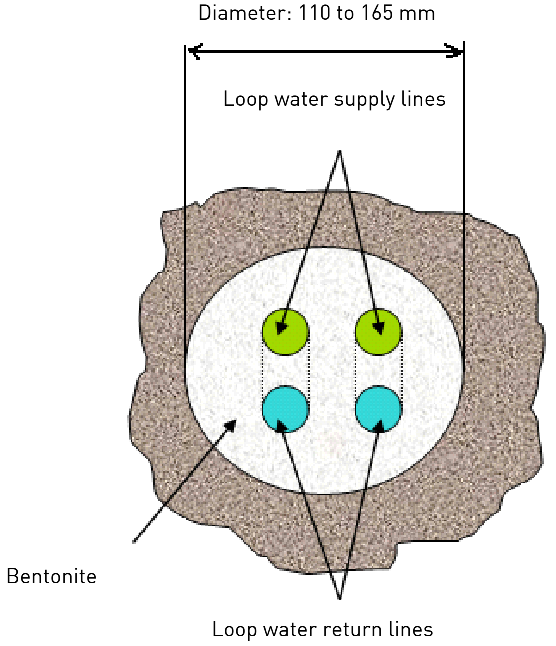
Two-pipe and four-pipe loop with weighted bottoms

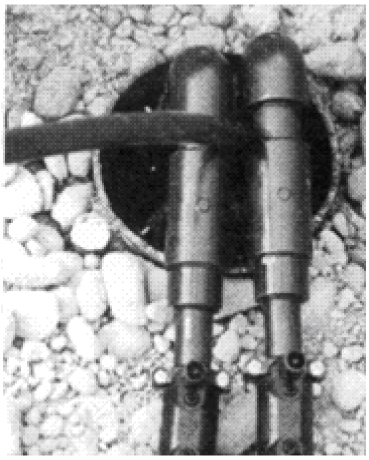
The bottom of each loop (loop foot) is weighted to ease insertion and placement. The boreholes are then grouted with a mixture of cement and bentonite (or a similar cellulose-based product) to hold the loops in their intended position.



The three steps in installing a vertical loop

Cutaway view of a vertical loop:





4.3.4 GEOTHERMAL LOOP SIZING

The following factors must be taken into account when designing a loop:

- Capacity of the heat pump (which varies based on the losses in the structure to be heated),
- Soil type,
- Type of heat-transfer fluid that will be circulated through the loop (glycol/water mix and glycol content).

4.3.4.1 SITE STUDY

- Perform a survey to determine the soil type. The geological profile of the ground must be determined every 5 to 10 m in order to estimate the conductivity.
- Take core samples, indicating their locations and depths.

Table of potential input power rates (in Watts per metre of loop) using a 15% glycol/water mix and with an average minimum temperature of 0°C .

Soil type	*Input power*
Dry sand	20 W/m
Clay	30 to 40 W/m
Basalt	35 to 55 W/m
Moist sand	55 to 65 W/m

4.3.5 BOREHOLE DRILLING

Obstacles	Minimum distance, in metres
Trees	5
Underground power lines	1.5
Foundations, wells, septic tanks, drains, etc.	3

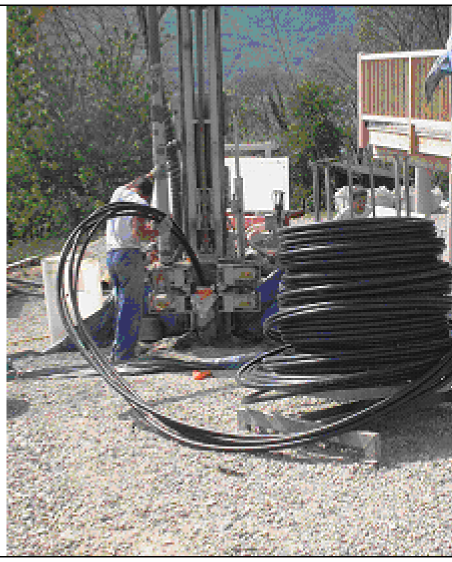
IMPORTANT

The contractor or drilling company in charge of drilling the boreholes, supplying and inserting the pipes, and backfilling the boreholes must:

- Design the loop based on the energy requirements and ensure that it maintains a pressure drop of 100 to 150 Pa/m,
- Ensure a maximum borehole drilling deviation of 2%,
- Create a slope leading back to the header to facilitate draining of the loop,
- Check that the static pressure at the end of the loop is within the usage limits for the pipe.

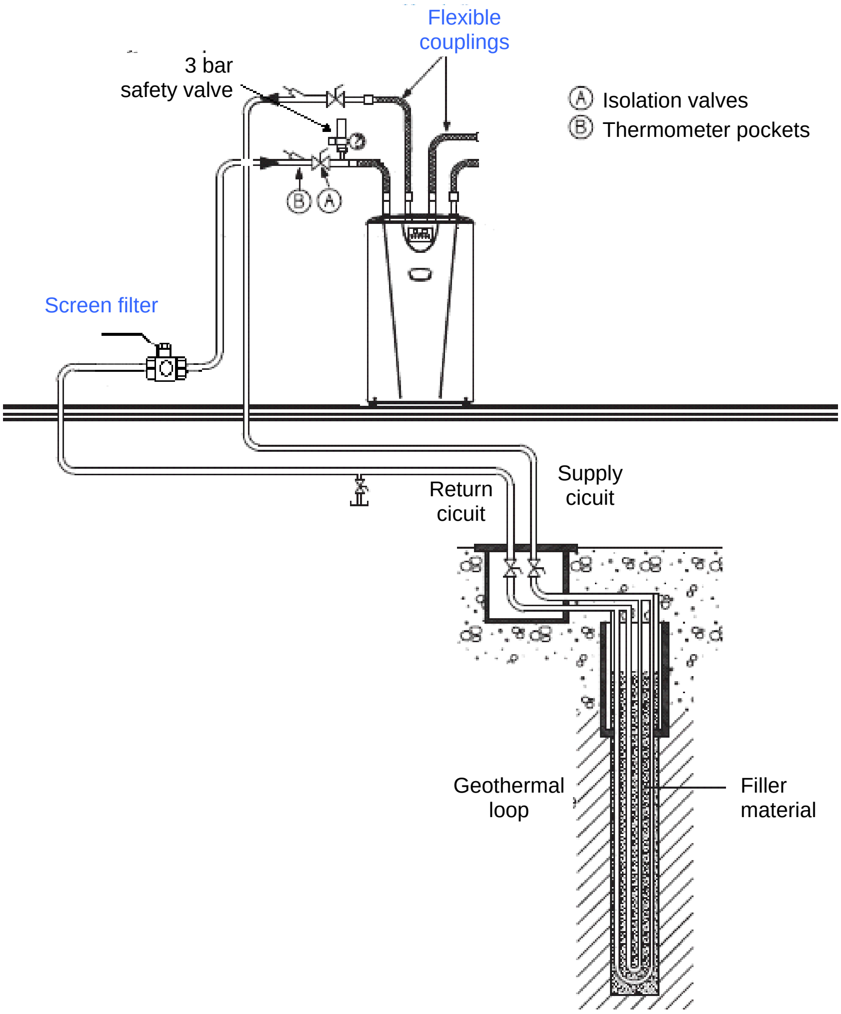
Photos:

Boreholes being drilled



Pipe being inserted into borehole

4.3.6 COUPLING SYSTEM DIAGRAM


Flexible
couplings
3 bar
safety valve
Ⓐ Isolation valves
Ⓑ Thermometer pockets
B
A
Screen filter
Return
cicuit
Supply
cicuit
Geothermal
loop
Filler
material

4.4 SIZING A GEOTHERMAL HEAT PUMP

A heat pump's heating output is determined for a value between 80% and 120% of the losses in the space to be heated by the heat pump.

$$0.8 \times \text{Losses} < P_b < 1.2 \times \text{Losses}$$

P_d = Heat output of the heat pump transferred at the outdoor design temperature.

For a more in-depth study, use the Geoconfort equipment selection software.

4.5 SIZING THE AUXILIARY HEATING DEVICE

Loop heaters (or electric heating elements) are optional on CIAT AGEO and AGEO CALEO so that installers may choose to select them or not.

In the case of a heat pump in which the heat-transfer medium is water or a glycol/water mix, the total capacity of the heat pump with the auxiliary electric heating device must be equal to at least 1.2 times the losses calcualted at the outdoor design temperature for the space to be heated by the heat pump.

$$C(\text{HP} + \text{auxiliary}) = 1.2 \times \text{Losses}$$

IMPORTANT

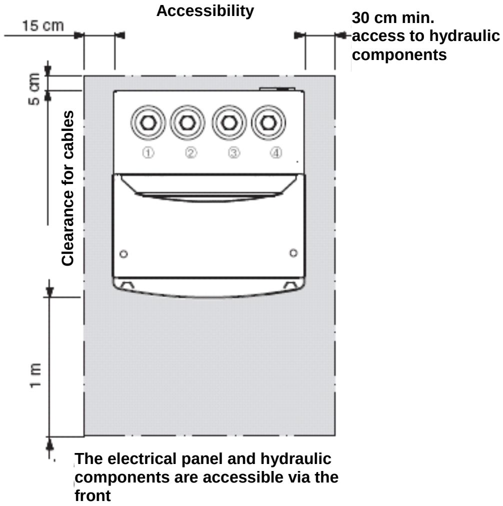
- Unless they have not been designed to cover a structure's entire heat losses, water-to-water heat pumps and ground-to-water heat pump are seldom used with auxiliary electric heating devices.
- If an auxiliary electric heating device is necessary, it must always be connected in series with and downstream of the heat pump so that the heat pump may operate at low temperature and always override the auxiliary.
- The heat pump must always be installed at the lowest temperature point.

4.6 SITING

Geothermal heat pumps are generally installed in a room that is completely or at least partially enclosed. CIAT has taken every measure to ensure that its heat pumps operate as quietly as possible.

Nevertheless, they should be installed in a room located as far as possible from other rooms in a home. The room in which a heat pump is installed may be insulated to prevent the transmission of noise throughout the home or outdoors. Main factors to bear in mind:

- The room in which a heat pump is installed must be sufficiently far from bedrooms, which are the most susceptible to noise.
- If need be, insulate the rooms in the house and the machine in order to prevent the transmission of noise (sound jacket on compressor, honeycomb insulation on walls, etc.).
- Maintain the minimum required spacing:



- **Flexible connections:** Use flexible connections to create U bends at the heat pump outlet to limit the transmission of vibrations to the heating circuit.
- **Screen filter:** Install the 600 µm filter on the water return line to protect the heat pump's heat exchanger from clogs.

- Use pipes and hoses having the recommended minimum diameters.
- Remember to make sure that the system contains the minimum volume of water needed for the heat pump to operate properly.

Heat pumps must be installed as instructed in the CIAT technical documentation.

4.7 INSTALLATION IN AN ENCLOSED ROOM

Depending on the country, there may not be any regulations on the ventilation of spaces intended to house small systems using group 1 refrigerants (non-flammable and slightly toxic or non-toxic, such as R407C and R410A).

However, the following standards can be met:

$$M < L \times V$$

M = weight of the refrigerant
L = maximum concentration, in kg/m^3 (0.31 for R407C; 0.44 for R410A)
V = volume of the space in which the heat pump is installed, in m^3.

Thus, for a 3.1 kg charge of R407C, a space with a minimum volume of 10 m^3 is required.

If the charge of refrigerant is higher than the maximum concentrations given above, the standard allows the use of exhaust methods provided that, in the event of a leak, the actual effective concentration remains below the aforementioned maximum concentrations. Air must be drawn immediately above the floor, either at its lowest point if refrigerants that are heavier than air are used, or just below the ceiling in the case of refrigerants that are lighter than air.

Natural ventilation
The cross-section of the opening used for natural ventilation in the equipment room must be at least:

$$A = 0.14 \times m^{0.5}$$

A = surface area of the opening, in m^2
m = weight, in kg, of the refrigerant charge in the system.

Mechanical ventilation:
Centrifugal or propeller fans should be used for mechanical ventilation. The exhaust duct should be made of non-flammable material and be airtight. The exhaust outlet should be positioned such that the exiting gases cannot pose a health hazard. All practical means should be taken to prevent them creating a nuisance for the surrounding area.
The flow rate of the mechanical ventilation system must at least be:

$$Q = 14 \times m^{2/3}$$

Q = air flow rate, in l/s
m = weight, in kg, of the refrigerant charge in the system.

5 CIAT GEOTHERMAL HEAT PUMPS

CIAT's range of geothermal heat pumps suit a broad range of applications and can be used with a glycol/water mix or simply with water. There are two types of heat pump in this range:

- low-temperature heat pumps,
- high-temperature heat pumps.

Specifications shared by both types:

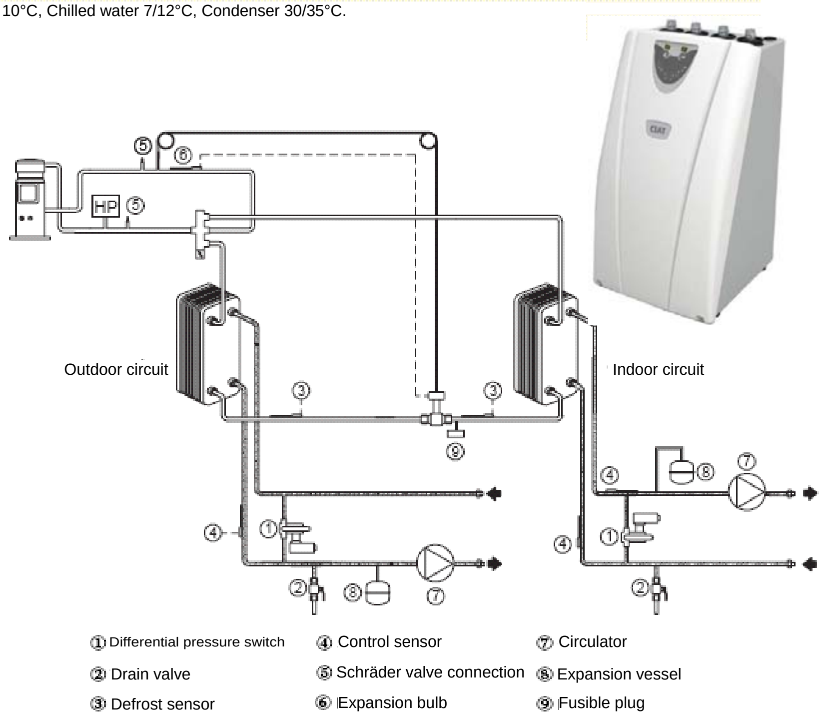
- Easy installation in equipment rooms, easy and quick servicing,
- Top hydraulic inlet port,
- Scroll compressor with R410A refrigerant,
- Domestic hot water production possible,
- Water law as a function of the outdoor temperature.

AGEO – 12 models (20H to 120HT) – Max. water outlet temp.: 55°C

- Heating capacity: 6.8 to 36.3 kW
- Cooling capacity: 5.0 to 27.6 kW
- Summer/winter changeover via a four-way valve on refrigeration circuit,
- Eurovent and NF PAC certifications.

AUREA 2		20H	30H	40H	50H	20HT	30HT	40HT	50HT	65HT	80HT	100HT	120HT
Heating capacity *	kW	6,8	9.4	12.1	15.3	6,8	9,5	12.2	16	19,8	24,5	31,0	36,3
Input power *	kW	1,5	2	2.4	2.9	1,4	2,0	2.5	3.1	3,7	4,6	5,5	6,6
COP		4,70	4,70	5,00	5,30	4,80	5,00	5,00	5.2	5,30	5,30	5,60	5,40
Cooling capacity *	kW	5,0	6,9	9,2	11,3	5,0	6,7	9,2	12,7	15,5	18,4	23,2	27,6
Input power *	kW	1,6	2,1	2,6	3,1	1,5	2,0	2,6	3,2	3,9	4,8	5,8	6,9
Energy efficiency rating (EER)		3,16	3.31	3,52	3,65	3,35	3,4	3,92	3,89	3,98	3,84	4	3,97
Sound pressure **	dB(A)	34	34	34	36	34	34	34	36	39		41	44
Electrical power supply		230 V - 1 phase - 50Hz				400 V - 3 phases - 50Hz							
Electrical wiring (not supplied), mm²	230V	3G4	3G4	3G6	3G10	-	-	-	-	-	-	-	-
	400V	-	-	-	-	5G2,5	5G2,5	5G2,5	5G4	5G4	5G4	5G6	5G6

* Based on EUROVENT conditions - Hot water 35/30°C, Evaporator 10°C, Chilled water 7/12°C, Condenser 30/35°C.
** 5 m from unit, 1.5 m from floor, free field, directivity 2



Refrigeration circuit of an Aurea 2 heat pump

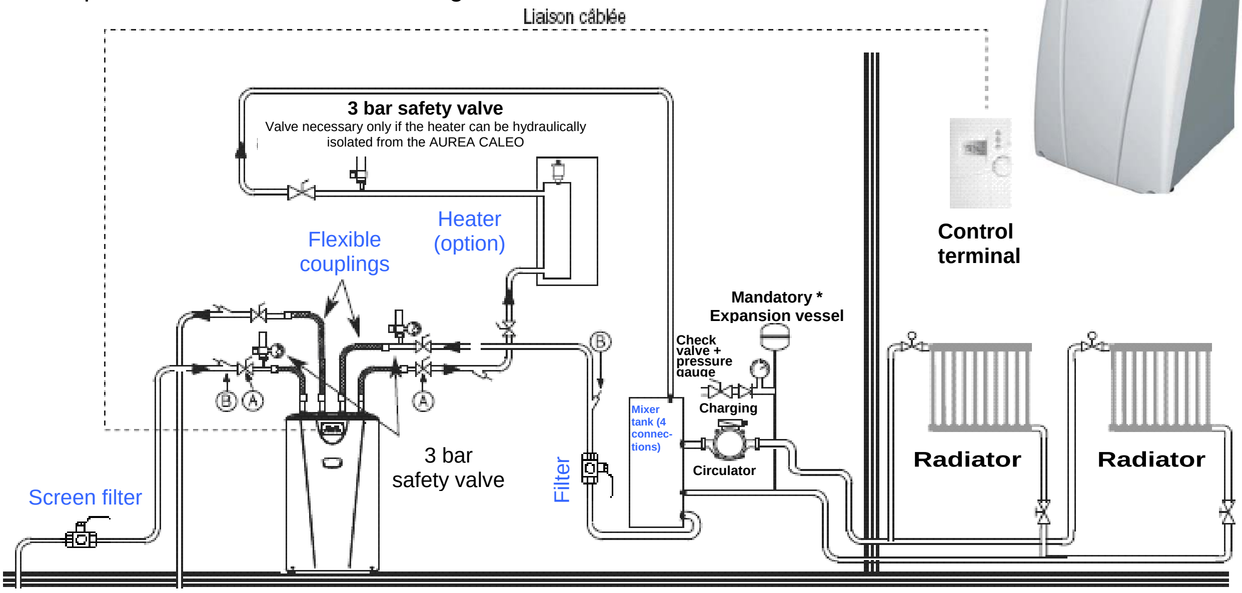
AGEO CALEO – 4 models (50H to 80HT) – Max. water outlet temp.: 65°C

- Heating capacity: 16.6 to 25.2 kW
- Not reversible
- Water outlet temperature of 65°C with a ΔT of 20 K.

AUREA Caleo		50H	50HT	65HT	80HT
Heating capacity *	kW	16,6	17,4	20,6	25,2
Input power *	kW	3,2	3,5	4,1	5.0
COP		5,10	5.0	5.0	5.0
Sound pressure **	dB(A)	34		36	
Electrical power supply		230 V - 1 ph - 50Hz	400 V - 3 ph - 50Hz		
Electrical wiring (not supplied), mm²	230V	3G10	-		
	400V	-	5G4		

* Heating capacities given for hot water at 45/25°C and an evaporator temperature of 10°C
** 5 m from unit, 1.5 m from floor, free field, directivity 2

Example of an installation configuration:

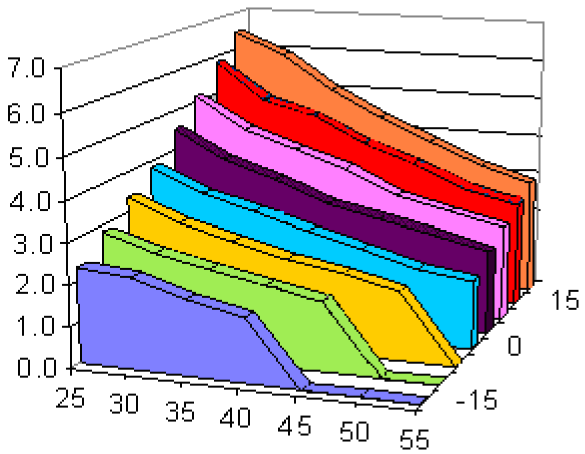


6 AIR-SOURCE HEATING

6.1 PRINCIPLE

The outdoor air contains a huge amount of heat that is constantly replenished by the sun and rain. Stored in the air at temperatures that vary from 30°C in the summer and -10°C in the winter, this heat can be harvested by a heat pump, converted to higher-temperature heat, and transferred indoors.

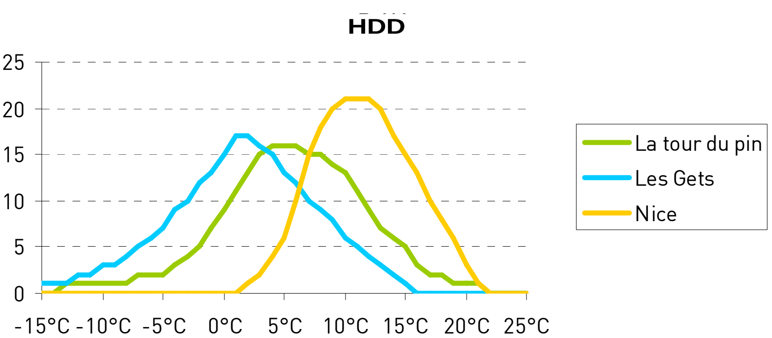
The coefficient of performance (COP) of an air-to-water heat pump varies depending on the outdoor temperature and the temperature of the water used to heat the structure. The less the difference between these two temperatures, the higher a heat pump's COP.



Air-to-water heat pump - Change in COP based on the water temperature of the heating system and the outdoor temperature

The COP varies constantly and changes with the outdoor temperature. It goes without saying that an air-to-water heat pump will not work as well in extremely cold climates as in temperate ones. Although it is important to know the extreme temperatures in an area, it is even more important to know how often they occur.

This is where heating-degree days (HDD) come in. Based on a 30-year average, they indicate the amount of heat required in areas during the heating season (1 October to 20 May in France) and are available in the Geoconfort calculation software (see Section 7.2.2).



CIAT HABITAT

6.2 ACOUSTIC ASPECTS OF AIR-TO-WATER HEAT PUMPS

6.2.1 SOLUTIONS

To determine whether a noise barrier is needed, one must look at three factors: the sound power level of the outdoor unit, the background noise of the prospective location and the distance between the source of noise and the surrounding area.

For example, the following distances apply for a 65 dB(A) unit:

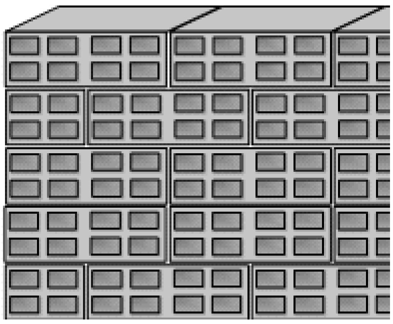
- no noise barriers are needed for distances beyond 20 m,
- noise barriers are required for distances between 12 and 20 m,
- noise barriers are virtually insufficient for distances of less than 12 m.

IMPORTANT

Noise barriers must be placed as close as possible to the source of noise source and provide sufficient space for air to circulate freely through the heat pump. Hedges will hide a heat pump but will not provide any acoustic protection.

Concrete blocks laid with their openings facing the heat pump are an effective and cost-efficient solution.

Example of a noise barrier made of concrete blocks



Example of a wooden noise barrier

Placing a heat pump behind a mound can also be a wise choice for two reasons:

- They are very effective noise barriers,
- They conceal heat pumps from view.

IMPORTANT

A number of precautions must always be taken in order to satisfy both the customer and his/her neighbours. Maintain the recommended minimum distances. ***See Section 6.4.***

6.3 SIZING AN AIR-TO-WATER HEAT PUMP

The performance of an air-to-water heat pump will vary depending on a number of important factors:

- Heat losses inside the structure,
- The water temperature set by the distribution system (reversible radiant floor, fan coil units, radiators).
- The geographic location of the structure to be heated (the outdoor air temperature varies throughout the heating season and depending on the geographic location of the structure to be heated).

To save energy, it is best to opt for a radiant floor (water temperature range of approx. 30/35°C) or fan coils (40/45°C) instead of radiators, which require a higher water temperature range. Furthermore, air-to-water heat pumps are best suited to temperate climates. However, they should not be used at high altitude (800-1000 m).

Heat pumps are generally sized to cover 60 to 80% of the heat losses in a home at the outdoor design temperature in order to avoid any short cycles (undersizing or oversizing will cause the unit to start and stop more often, resulting in higher energy consumption and accelerated wear of the start-up parts).

$$60\% \text{ Losses} < P_{heat\ pump} \text{ at } T_D < 80\% \text{ Losses.}$$

$P_{heat\ pump}$ = Heat output of heat pump

T_D = Outdoor design temperature

An auxiliary heating device is therefore necessary to provide heat during extremely cold periods. Auxiliary heaters are usually electric. However, they can be wood stoves, fireplaces or boilers (in boiler backup mode, supplementary heat is provided by the boiler either alone or alongside the heat pump).

6.3.1 CALCULATING HEAT LOSSES

Heat losses in the volume to be heated by a heat pump must be calculated at the outdoor design temperature T_D so that heating is provided when the indoor temperature drops to 19 C (average for homes). This calculation is based on data from regulatory calculations (heat loss rules) and, in particular, the Ustru coefficient on losses through structural walls and the type of ventilation.

$$\text{Losses}_{TD} = Dp \times (19 - T_D)$$

and

$$Dp = (U_{stru} \times S_{loss}) + (R \times V_h)$$

Dp = heat loss coefficient of structure [W/K]

U_{stru} = heat loss coefficient via walls of structure [W/m².K]

S_{loss} = total area of wall through which heat is lost [m²]

V_l = living space inside heated volume [m³]

R = coefficient based on type of ventilation

- Self-regulating cmV R = 0.2
- Humidity-sensitive cmV A R = 0.14
- Humidity-sensitive cmV B R = 0.12

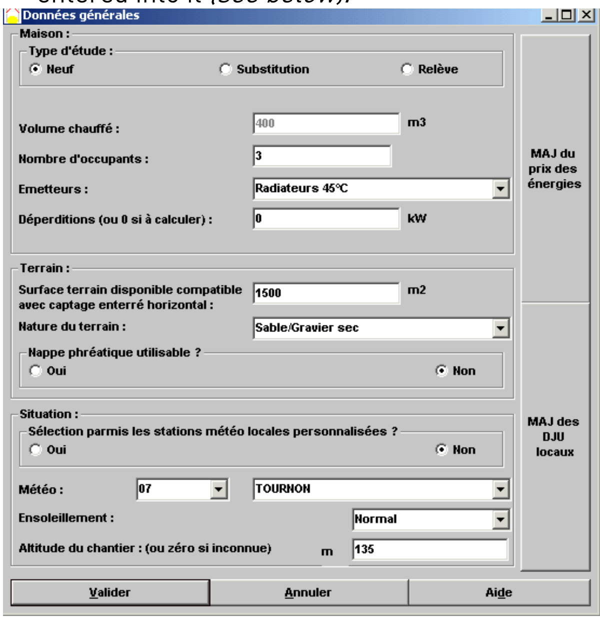
IMPORTANT

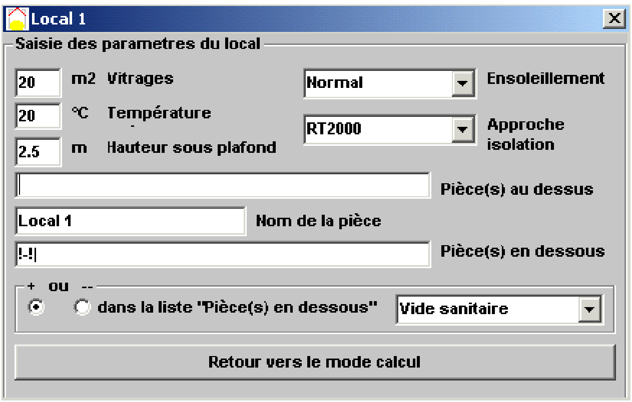
- To avoid the problem of short cycles, an air-to-water heat pump is never designed to cover more than 80% of the total heat loss in a structure.
- The auxiliary heating device must always be connected in series with and downstream of the heat pump so that the heat pump may operate at low temperature and always override the auxiliary.
- The heat pump must always run at the lowest temperature of the system.

6.3.2 TWO EXAMPLES OF HOW THE GEOCONFORT SOFTWARE AIDS IN SELECTING AN AIR-TO-WATER HEAT PUMP

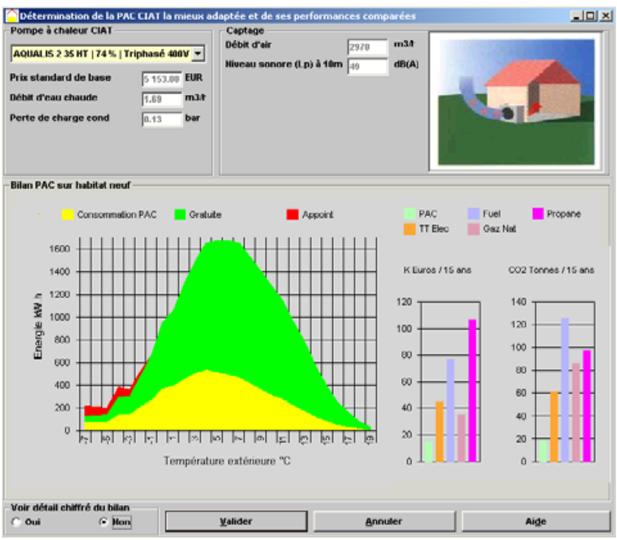
The Geoconfort software can be used to calculate a home's heat losses, match them with most appropriate heat pump, and estimate the related investment cost.

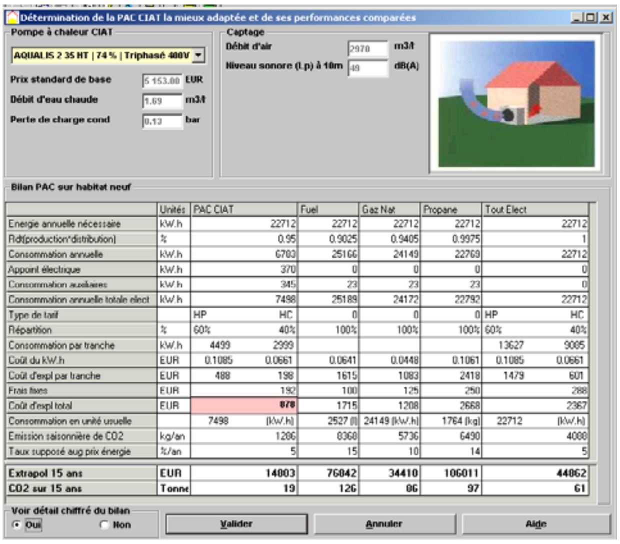
In the screen shots below, the software calculates heat losses for a new home based on information entered into it *(see below)*.





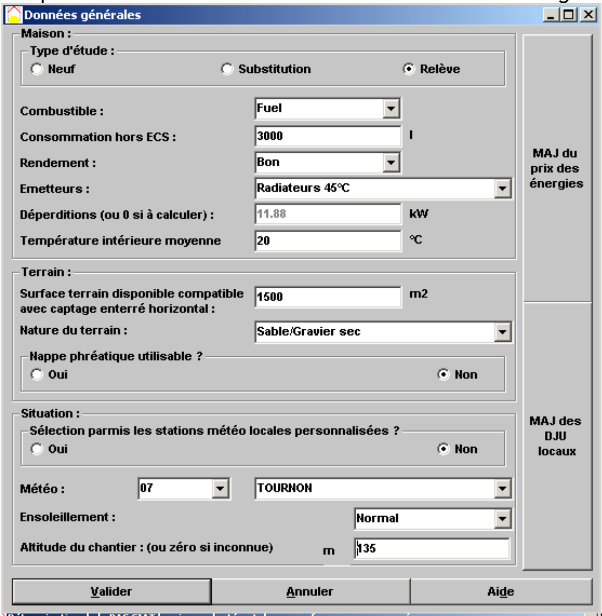
The software preselects a number of machines and shows exactly which areas require an auxiliary heating device.

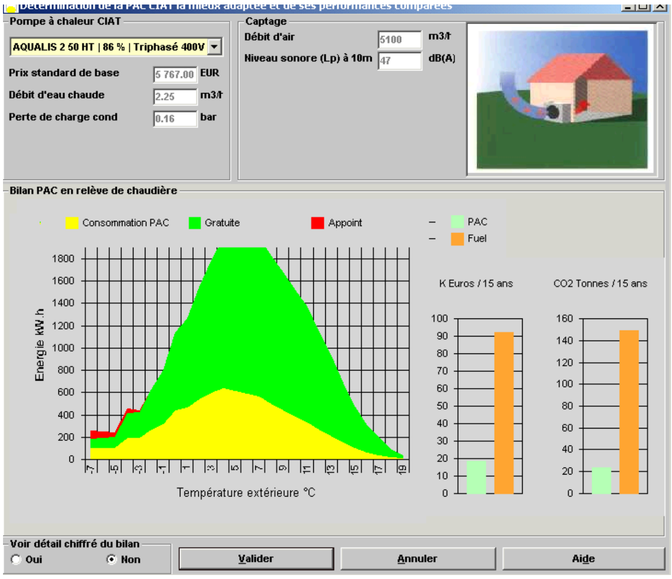


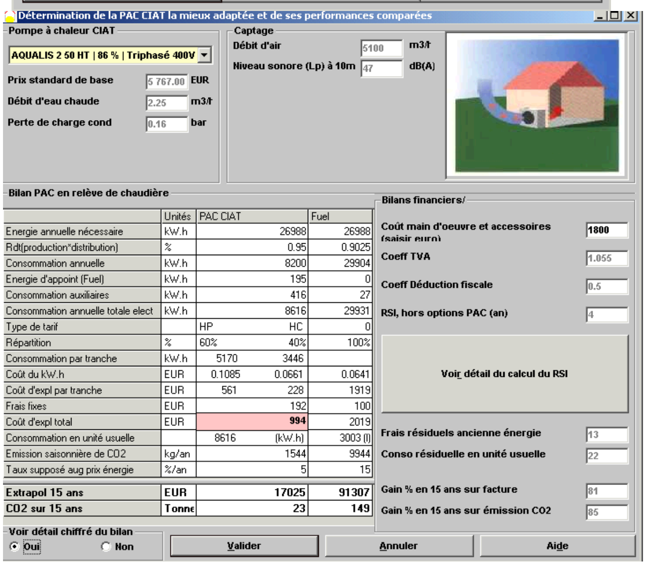


	Unités	PAC CIAT		Fuel	Gaz Nat	Propane	Tout Elect	
Energie annuelle nécessaire	kW.h		22712	22712	22712	22712		22712
Rdt(production*distribution)	%		0.95	0.9025	0.9405	0.9975		1
Consommation annuelle	kW.h		6703	25166	24149	22769		22712
Appoint électrique	kW.h		370	0	0	0		0
Consommation auxiliaires	kW.h		345	23	23	23		0
Consommation annuelle totale elect	kW.h		7498	25189	24172	22792		22712
Type de tarif		HP	HC	0	0	0	HP	HC
Répartition	%	60%	40%	100%	100%	100%	60%	40%
Consommation par tranche	kW.h	4499	2999				13627	9085
Coût du kW.h	EUR	0.1085	0.0661	0.0641	0.0448	0.1061	0.1085	0.0661
Coût d'expl par tranche	EUR	488	198	1615	1083	2418	1479	601
Frais fixes	EUR		192	100	125	250		288
Coût d'expl total	EUR		878	1715	1208	2668		2367
Consommation en unité usuelle		7498	(kW.h)	2527 (l)	24149 (kW.h)	1764 (kg)	22712	(kW.h)
Emission saisonnière de CO2	kg/an		1206	8368	5736	6490		4088
Taux supposé aug prix énergie	%/an		5	15	10	14		5
Extrapol 15 ans	EUR		14003	76042	34410	106011		44062
CO2 sur 15 ans	Tonne		19	126	86	97		61

In the 'boiler backup' example below, the heat losses are estimated based on the consumption of fuel oil, the temperature of the terminal units and the average indoor temperature.







	Unités	PAC CIAT		Fuel
Energie annuelle nécessaire	kW.h		26988	26988
Rdt(production*distribution)	%		0.95	0.9025
Consommation annuelle	kW.h		8200	29904
Energie d'appoint (Fuel)	kW.h		195	0
Consommation auxiliaires	kW.h		416	27
Consommation annuelle totale elect	kW.h		8616	29931
Type de tarif		HP	HC	0
Répartition	%	60%	40%	100%
Consommation par tranche	kW.h	5170	3446	
Coût du kW.h	EUR	0.1085	0.0661	0.0641
Coût d'expl par tranche	EUR	561	228	1919
Frais fixes	EUR		192	100
Coût d'expl total	EUR		**994**	2019
Consommation en unité usuelle		8616	(kW.h)	3003 (l)
Emission saisonnière de CO2	kg/an		1544	9944
Taux supposé aug prix énergie	%/an		5	15
Extrapol 15 ans	**EUR**		**17025**	**91307**
CO2 sur 15 ans	**Tonne**		**23**	**149**

The software preselects a number of machines and shows exactly which areas require an auxiliary heating device.

6.4 INSTALLATION

A properly installed heat pump will provide pleasing warmth indoors without disturbing nearby neighbours. By following a few simple rules, unwanted noise, vibrations and malfunctions can be prevented.

6.4.1 SITING

6.4.1.1 NEIGHBOURS

The purpose of a heat pump is to provide indoor comfort. On no account should it be a nuisance for neighbours.
The mere sight of one often elicits a psychological reaction that can be summed up by the sentence "If it can be seen, it will be heard". Certain people claim that they hear a heat pump operating while it is off! To prevent this, it is important to either conceal the area with a temporary wall before commencing installation or, once the heat pump has

been installed, invite the neighbours over to hear for themselves that it does not created any significant noise.

Once this issue has been resolved, a few rules must be followed:

- Do not install a heat pump in immediate proximity of neighbouring homes and businesses,
- Where possible, install a heat pump at a location already protected by a natural noise barrier or install a noise barrier between the heat pump and the home's immediate neighbours,
- Do not install a heat pump in a location that could cause the noise to echo.
- Etc.

6.4.1.2 CUSTOMERS

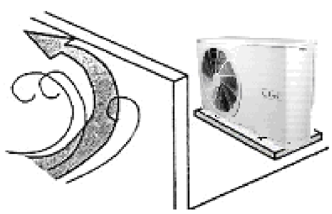
This criterion depends on what the owner considers to be acoustic and visual nuisances.

- Avoid placing heat pumps near living areas such as living rooms (and primarily bedrooms, which are much more susceptible to noise when surroundings are quiet) or in front of a patio (for aesthetic reasons).
- Avoid placing heat pumps near windows.
- Opt for installing heat pumps near walls without openings or only with openings that lead to traffic areas inside the home (bathroom, walk-in closet, closet space, etc.).

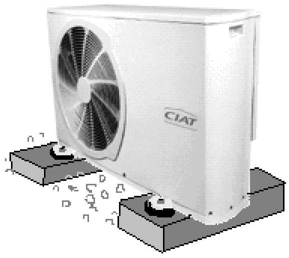
If a heat pump is installed in a traffic area, install guards to protect it from potential impacts.

6.4.1.3 TECHNICAL ASPECTS

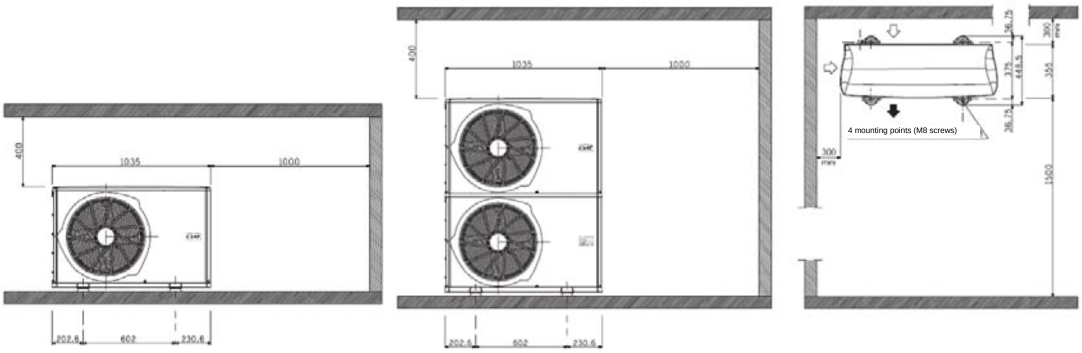
- To benefit most from the sun's rays in defrosting mode, heat pumps should be installed in a location exposed to the sun rather than one facing north (no direct sunlight). Whether shaded or exposed to the sun, the air drawn in by a heat pump is at virtually the same temperature. Do the opposite if the customer places more importance on cooling.



- Avoid installing heat pumps in locations exposed to prevailing winds (risk of damage to the motor).



- To avoid transmitting vibrations, place heat pumps on a concrete slab separated from the walls of a house (slab, anti-vibration mounts, boards).
- Heat pumps should be placed above flood and snow levels.
- Connect the condensate drain to the nearest drain (pipe not bonded to trap) or allow the condensate to drain onto a bed of gravel (caution: risk of ice forming in traffic areas).
- Do not install a heat pump too far from or below the level of the house otherwise pressure drops and heat losses will have to be compensated for.
- Heat pumps may be sheltered (canopy, under eaves) provided the covering does not prevent the renewal of air (or allow warm intake air and cool discharge air to mix)
- Maintain the minimum required spacing:



Heat pumps must be installed as instructed in the CIAT technical documentation.

6.4.2 INSTALLATION

After a heat pump has been installed in its place of use, a few more principles come into play:

Mandatory accessories:

- **Anti-vibration mounts:** Place them beneath the heat pump to prevent the transmission of vibrations.
- **Flexible connections:** Use flexible connections to create U bends at the heat pump outlet to limit the transmission of vibrations to the heating circuit. They should not be routed through the walls of a house (connect them to rigid pipe).

Screen filter: Install a 600 µm filter on the water return line (preferably indoors) to protect the heat pump's heat exchanger from clogs. If it is installed outdoors, it must be insulated to protect it from freezing temperatures.

Other precautions to be taken during installation:

- Use pipes and hoses having the recommended minimum diameters.
- Insulate pipes wherever they enter walls (foam, insulated pipe clips, etc.).
- Remember to make sure that the system contains the minimum volume of water needed for the heat pump to operate properly.

6.5 INSTALLING A HEAT PUMP FOR USE WITH A BACKUP BOILER

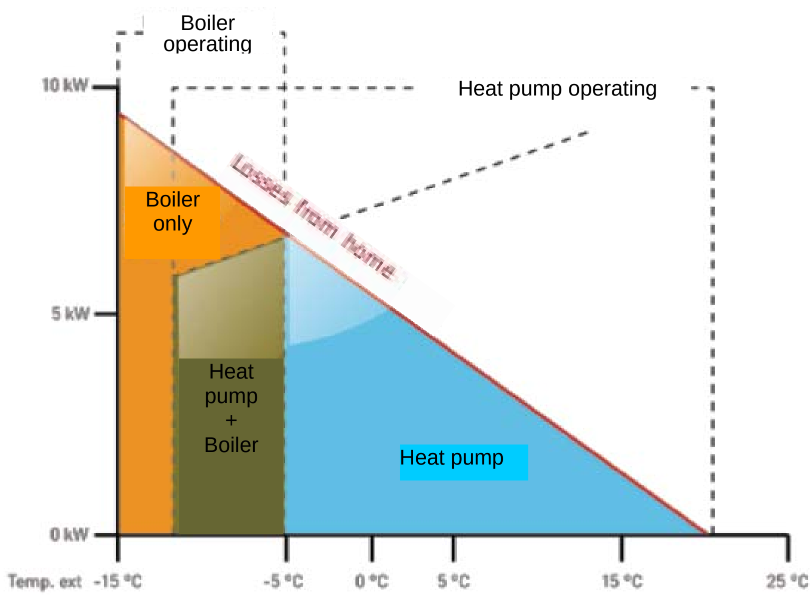
6.5.1 PRINCIPLE

Using a boiler as a backup is a good idea for several reasons:

- If the boiler is recent,
- If the outdoor temperatures often fall below zero,
- And, last but not least: just in case...

6.5.2 INSTALLATION

A boiler can be run alternately (On/Off operation) or simultaneously with the heat pump. In the diagram below, the boiler operates at the same time as the heat pump when the temperature drops to -5°C. Once the temperature drops lower, the heat pump shuts off and the boiler operates alone. In an On/Off configuration, the boiler fires only when the heat pump turns off.



The MicroConnect terminal parameters will vary slightly depending on whether the boiler control system is advanced or not.

The following parameters come into play when a boiler is used as a backup:

- P1: glycol/water mix or not
- P3: TU or RRF
- P6: type of auxiliary/load shedding
- P7: minimum outdoor temp. at which the auxiliaries turn on (P9 to 24°C)
- P9: changeover temperature (min. outdoor temp. for heat pump up to 24°)
- P15: water comfort setpoint (20°C to P19)
- P16: water economy setpoint (20°C to P19)
- P19: max. heating drift setpoint (water return temp. + differential P20)
- P34: heat pump circulator pump control
- P36: cooling mode authorised or prohibited

For more information on using a heat pump with backup boiler, refer to the heat pump with backup boiler manual.

7 CIAT AIR-SOURCE HEAT PUMPS

CIAT's range of air-source heat pumps is divided into two types:

- low-temperature heat pumps,
- high-temperature heat pumps (Caleo).

Specifications shared by both types:

- Easy installation, quick and easy servicing,
- Rear hydraulic supply port,
- Domestic hot water production possible,
- Water law as a function of the outdoor temperature.

AQUALIS 2 – 14 models (20H to 75HT) – Max . water outlet temp.: 55°C

- Heating capacity: 6.1 to 19.4 kW
- Cooling capacity: 5.3 to 17.5 kW
- Scroll compressor with R410A refrigerant
- Summer/winter changeover via a four-way valve on the refrigeration circuit,
- Eurovent certification,

AQUALIS 2 - Reversible		20H	28H	35H	50H	20HT	28HT	35HT	50HT	65HT	75HT
Heating capacity *	kW	6,1	8,3	10,2	13,1	6,1	8,4	10,2	13,8	17,2	19,4
Input power *	kW	1,7	2,2	2,8	2,9	1,6	2,0	2,6	3,5	4,2	4,8
COP		3,6	3,8	3,6	4,2	3,8	4,1	3,9	4,0	4,1	4,1
AQUALIS 2 – Cooling only		-	-	-	-	-	-	35T	50T	65T	75T
Cooling capacity *	kW	5,3	7,1	8,5	13,7	5,1	7,0	8,5	11,8	14,7	17,5
Input power *	kW	2,0	2,7	3,7	4,0	2,6	2,5	3,4	4,4	5,0	6,4
Energy efficiency rating (EER)		2,65	2,67	2,32	3,43	2,0	2,8	2,5	2,62	2,95	2,74
Sound pressure ***	dB(A)	41	46	47	45	41	46	47	45	48	50
Electrical power supply		230 V - 1 phase - 50Hz				400 V - 3 phases - 50Hz					
Electrical wiring (not supplied), mm^2		3G4		3G6	3G6 (1)	5G1,5		5G4			

* Based on EUROVENT conditions - Water 7/12, Air 35°C - Water 35/30, Air 7°DB/6°WB
Heating capacities not including defrosting cycles.
** If a larger capacity is needed, install an additional expansion vessel or a larger one.
*** 5 m from unit, 1.5 m from floor, free field, directivity 2
[1] Use high temperature cables, type PVC-V2-K or PR (maximum length = 50 m)

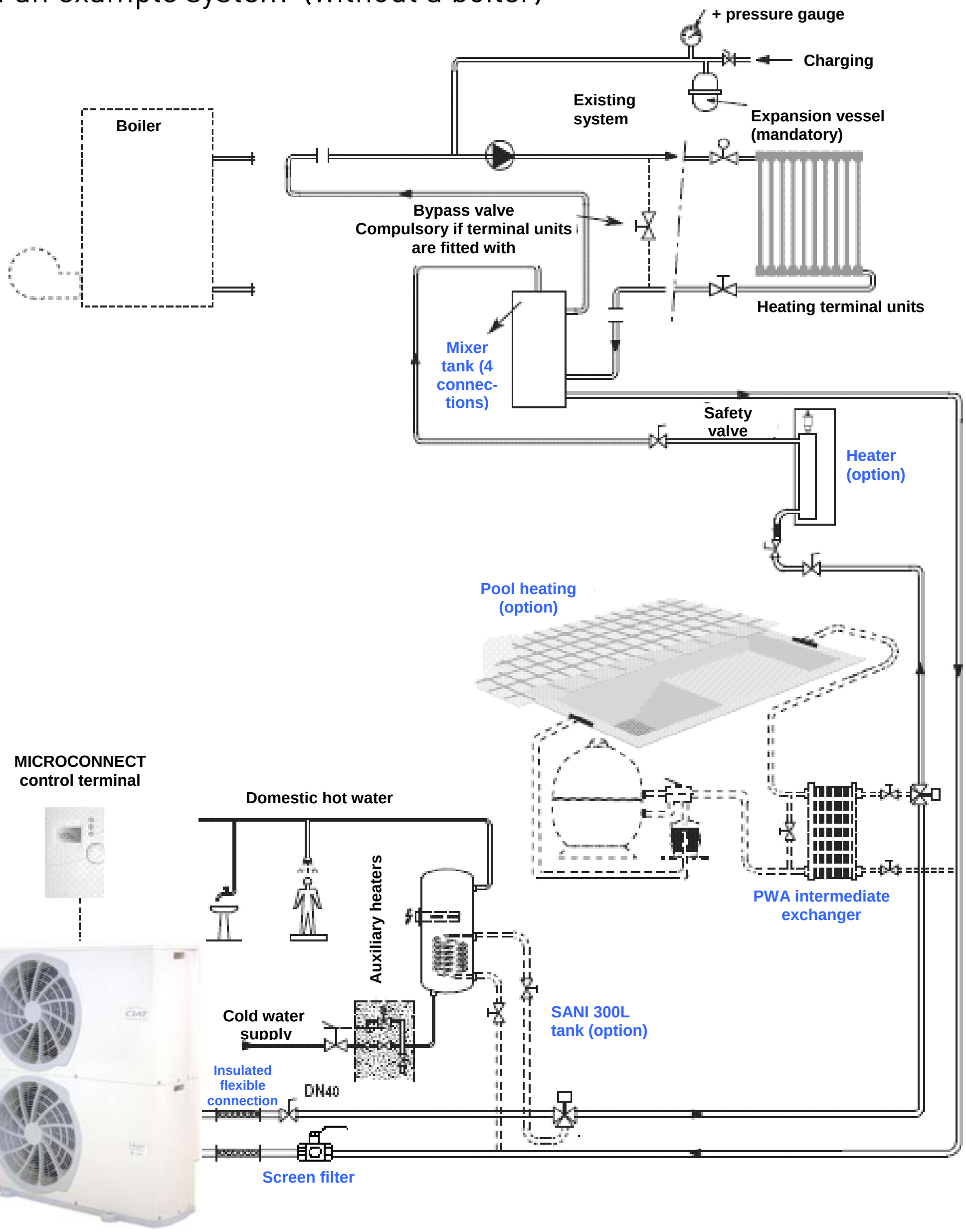
AQUALIS CALEO – 3 models (60H to 70HT) – Max. water outlet temp.: 65°C

- Heating capacity: 13.7 to 19.4 kW
- Not reversible
- Scroll compressor with R407C refrigerant
- 65°C water outlet temperature

AQUALIS Caleo		60H	60HT	70HT
Heating capacity *	kW	13,7	13,7	19,4
Input power *	kW	3,8	3,3	4,9
COP		3,64	4,14	4,00
Sound pressure ***	dB(A)	47		55
Electrical power supply		230 V - 1 ph - 50 Hz	400 V - 3 ph - 50 Hz	
Electrical wiring (not supplied) [1], mm^2		3G10	5G2.5	5G4

* Based on EUROVENT conditions: Water 35/30, Air 7°DB/6°WB.
Heating capacities not including defrosting cycles.
*** 5 m from unit, 1.5 m from floor, free field, directivity 2
[1] Use high temperature cables, type PVC-V2-K or PR (maximum length = 50 m)

Diagram of an example system (without a boiler)



8 DISTRIBUTION OF HEAT.

8.1 HEAT DISTRIBUTION SYSTEMS

The types of terminal unit used with water-to-water and air-to-water heat pumps can be split into three main categories:

- Medium and high-temperature radiators (50 to 65°C)

In use until the 1990s, 'conventional' radiators require high temperatures and cannot be used for cooling purposes (formation of condensation). CIAT's Caleo heat pumps make it possible to combine renewable energies with radiators. As a result, they are ideal for renovation projects.

- Fan coil units, or FCUs (40-45°C)

Quick warm-up

Convenient and more economical than radiators, fan coil units heat (or cool) spaces uniformly and quickly. They can be adjusted differently room by room and remain a good compromise between radiators and a radiant floor.

- Reversible Radiant Floor, or RRF (30-35°C)

Radiative heating and cooling

When combined together, a reversible radiant floor and a heat pump form the ideal heating pair. Together, they raise the COP to optimum levels and thus enable significant savings in heating costs. Although a UFHC system provides a high level of comfort in the winter, it will not dehumidify spaces.

- Mixed systems: RRF + fan coil unit or RRF + radiators

Often used in partial renovation projects (extensions, addition of a storey, etc.), mixed systems consist of a heating system or a heating/cooling system comprising several types of terminal unit located in different zones (such as the ground floor or storeys).

IMPORTANT

To obtain the best COP, choose terminal heating units that can deliver comfortable temperatures (e.g. 20°C) using the outdoor design temperature and at the lowest water temperature possible.

8.2 RADIATORS

IMPORTANT

Radiators may be used with heating-only systems only; they cannot be used to provide cooling.

8.2.1 DESCRIPTION

Radiators and convectors come in various forms and materials:

- convector,
- steel panels,
- aluminium alloy or extruded,
- cast iron,
- tubular steel,
- flat or round-tube towel warmers (steel or aluminium),

etc.

8.2.2 SIZING AND SELECTION

The heat emitted by a radiator is equal to 1.2 times the heat losses of a space, at the outdoor design temperature, calculated using various methods (TH-D, AICVF or COSTIC in France) and taking into account the temperature of the supply water (40°C or 45°C in the case of a heat pump. The installer must provide the design calculations for the radiators and convectors so that the system may be adjusted correctly.

The capacity of a hot water radiator is determined by looking at the mean temperature difference:

$$\text{Mean difference} = \frac{Ti + To}{2} - Tr$$

Ti = Water temperature at the inlet of the heat source,
To = Water temperature at the outlet of the heat source,
Tr = Reference temperature of the air at the centre of the space and 75 cm above the floor.

8.3 FAN COIL UNITS

8.3.1 STANDARDS AND CERTIFICATION

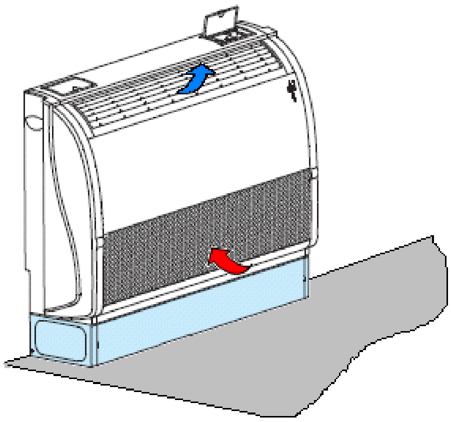
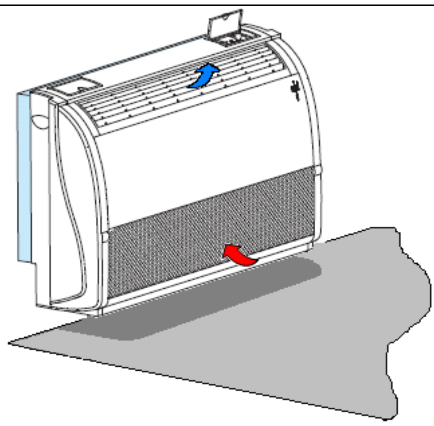
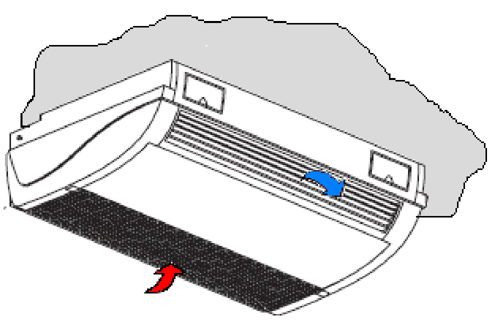
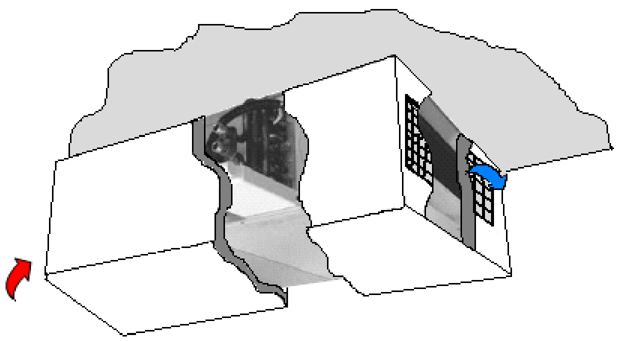
The thermal and acoustic performances of fan coil units (also called terminal units) are certified by Eurovent.
All the technical and performance specifications for the heating and cooling modes are provided in our catalogues.

8.3.2 DESCRIPTION

Terminal units come in various types:

- recessed cassette units with air diffusers on one side or all four sides,
- cased, uncased or ductable ceiling units,
- cased or uncased under-window units,
- vertical cased or recessed console units.

Examples of water terminal units

	
Console	Under-window
	
Ceiling-concealed	Recessed cassette

8.3.3 SIZING

8.3.4 SELECTION

Three factors go into the selection of a terminal unit:

- heating capacity,
- cooling capacity,
- required sound level.

8.3.4.1 HEATING CAPACITIES

- The indoor unit selected must meet the required (sensible or total) heating capacity and cooling capacity.
- The heating capacity must be greater than or equal to that obtained at sizing.
- Select the units based on their capacity at medium speed (low speed for two-speed units).
- It is recommended to use a water temperature of 45°C/40°C to determine the heating capacity of indoor units, and a water temperature of 7°C/12°C to determine their cooling capacity.

8.3.4.2 SOUND LEVEL

A fan coil unit must not exceed a sound pressure level of 35 dB(A) in main living areas and 50 dB(A) in kitchens (40 dB(A) in the case of open-plan kitchens).

This level must be measured at medium speed (low speed for two-speed units).

8.3.4.3 FILTRATION

Filters serve two purposes: they protect occupants from dust and protect equipment from fouling or damaging particles.

Filters used in homes must have a minimum class of G2 (Eurovent EU2 standard) and a minimum gravimetric efficiency of 65%.

They must be easily accessible for periodic checks and cleaning. The frequency of these checks and cleaning will depend on the amount of fouling. It is a good idea to have a set of replacement filters on hand so that the original filters can be replaced at the end of the installation of the system.

8.3.5 INSTALLATION

Terminal units must be installed in accordance with the instructions in our technical specifications and installation manuals.
If these documents are not available, use the following rules as guidelines.

8.3.5.1 INSTALLATION PRECAUTIONS

- Hydraulic connections

The coil manifold is fitted with a top air bleed valve and a bottom drain. In order for the system to be balanced correctly, each terminal unit must be fitted with an adjustment unit allowing:

- the flow to be measured,
- the flow to be adjusted,
- the adjustments to be locked and stored,

- Draining of condensate

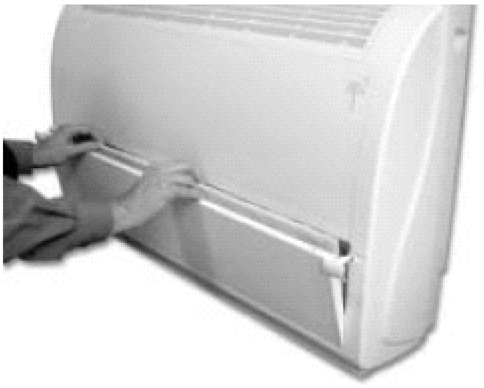
It is preferable to allow condensate to drain, via gravity, to the nearest drain line.
Drain pipes should be insulated (to avoid condensation and possible damage) and placed at a sufficient slope. Avoid using a condensate pump wherever possible (to limit noise).

Drain pipes can be concealed in a variety of ways:

- inside a soffit,
- inside skirting trunking,
- above a suspended ceiling,
- beneath floorboards,
- behind a false panel.

Install a trap upstream of the sewer connection to prevent waste gases leaching indoors. Do not bond the pipe to the trap.

8.3.5.2 VERTICAL TERMINAL UNITS



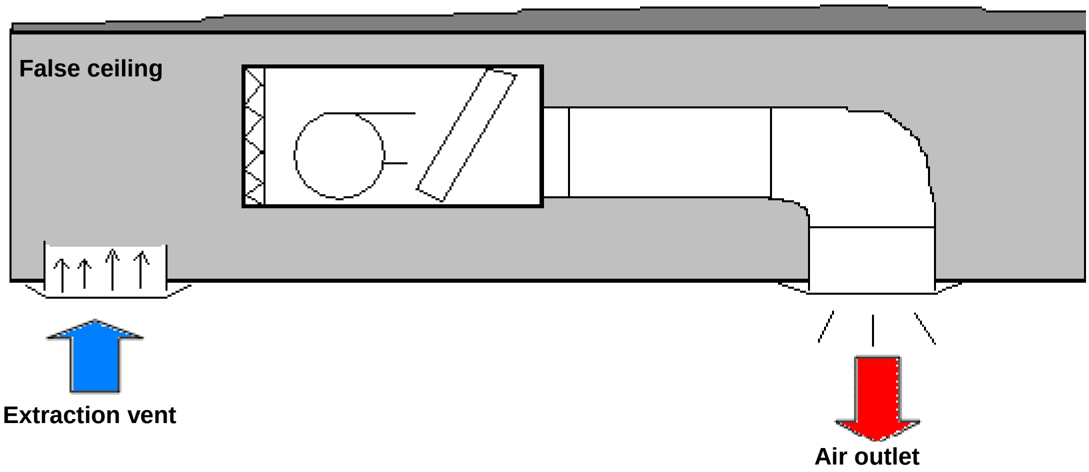
Changing the air filter in a terminal unit

8.3.5.3 HORIZONTAL TERMINAL UNITS

Horizontal terminal units are suspended from a ceiling. It is strongly recommended to place them at a slight incline to facilitate the flow of condensate.

If a distribution duct is installed between the horizontal unit and the air diffuser, the cross-section of the duct must be at least equal to that of the terminal unit's discharge duct.

A ceiling-concealed terminal unit connected to a supply duct.



The pressure drop in any supply and return ducts must be the lowest possible (less than 40 Pa). These aspects must be taken into account when selecting a terminal unit.

Major 2
Under-window fan coil unit

Residenciat
Ceiling-concealed fan coil unit

8.4 REVERSIBLE RADIANT FLOORS

Reversible radiant floors (RRF) are the most popular means of heating in new homes. Many advances have been made in their technology, and more are still to come.

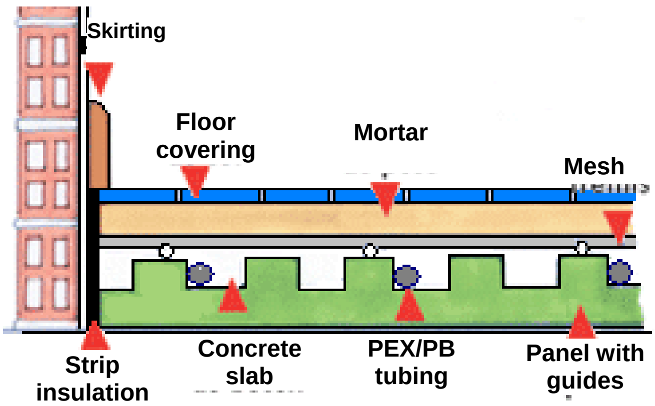
8.4.1.1 TECHNICAL APPROVALS

Tubing and fittings made of synthetic materials used in a radiant floor must have at least class 2 type approval. Tubing to be embedded in a concrete slab or covered with a thin layer of concrete must be insulated and have the necessary technical approval.

Refer to the supplier's documentation to make sure that the materials to be used have the necessary technical approval.

8.4.2 PRINCIPLE

In a reversible radiant floor, heat is radiated through the floor. The system consists of components placed on top of a structural floor:



Cutaway view of a typical radiant floor

The sealing layers must be designed by the contractor and installed prior to the components of the radiant floor:

- A bottom layer of insulation or underside insulation (e.g. extruded polystyrene, rock wool or polyurethane foam).

- Strip insulation along the peripheral edges. This insulation must be at least 5 mm thick, extend from the structural floor to the floor covering, and allow the slab to shift by 5 mm. It can be made of such materials as polystyrene or polyethylene.

- A protective covering placed over the insulation. This protective layer must extend past the top of the strip insulation. In the case of a non-reversible radiant floor (designed solely for heating), polyethylene sheeting measuring at least 0.15 mm thick is a sufficient type of insulation. It is not, however, a vapour barrier.

If a radiant floor is reversible (designed for both heating and cooling), the protective layer can also serve as a vapour barrier. Roofing felt is an example of a good protective layer for such a system.

- The tubing in a radiant floor may be made of annealed copper. However, synthetic materials (PEX, PB or PEX-Al-PEX) are more common. The tubing must extend from the supply manifold to the return manifold in a single circuit; no connections may be used in between.
  The tubing may be placed on preformed insulating panels with guides.

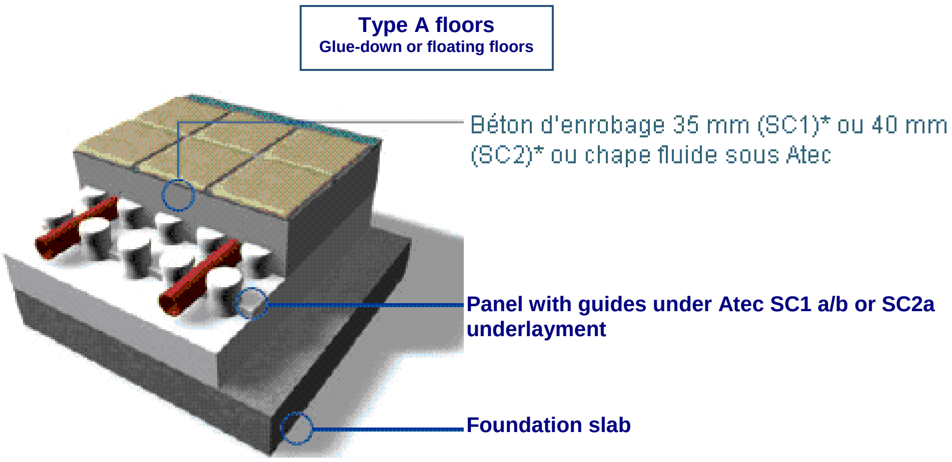
  To avoid excessive pressure drops and an excessive imbalance in the system, circuits measuring 16 × 1.5 mm in diameter (13 mm ID) should have a maximum length of approx. 120 m.

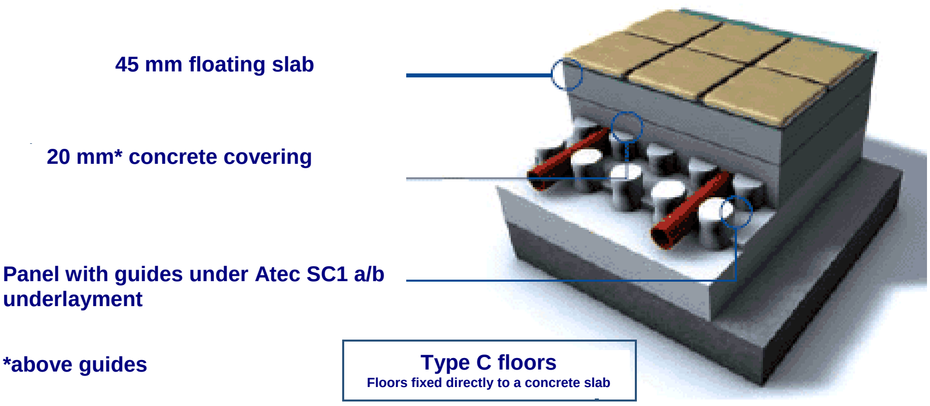
- A metal reinforcing mesh (usually provided by the masonry contractor; minimum aperture size of 50 mm × 50 mm). This reinforcing mesh is not mandatory and is seldom used with tubing secured to preformed panels.

- A levelling layer for lightweight floors.

A concrete cover.

- A floor covering (embedded or bonded).





8.4.3 PRECAUTIONS TO BE TAKEN WITH NON-REVERSIBLE RADIANT FLOORS

8.4.3.1 MAXIMUM SURFACE TEMPERATURE

European standard EN 1264 sets the maximum surface temperature at 29°C. A temperature of 35°C is tolerated within peripheral zones only.

In the case of wooden floors, this temperature must not exceed 26°C.

8.4.3.2 WATER SUPPLY TEMPERATURE

For a heat pump to operate efficiently, the water supply temperature should be between 35°C and 40°C and no more than 50°C. In heating mode, the difference between the supply and return temperatures must be no more than 7 K.

8.4.3.3 SAFETY DEVICES

Safety devices are mandatory and must be independent from the control system. The water circulating inside the floor is limited to a maximum of 60°C. The temperature limiter is a manually reset device (e.g. CIAT's optional radiant floor limit thermostat).

8.4.4 PRECAUTIONS TO BE TAKEN WITH REVERSIBLE RADIANT FLOORS

- Where possible, there should be fewer indoor and outdoor (sun) auxiliary heat sources. Shutters, awnings and other door and window covering should be used during the summer.
- Remember that buildings with low thermal inertia (e.g. dual skin siding) are not conducive to radiant floor cooling.
- Concrete slabs or screeds must not have too much thermal inertia. Therefore, their surface density (weight measured above the insulation), added with that of the floor covering, must be no more than 160 kg/m².

8.4.4.1 ROOM TEMPERATURE

There is no cooling temperature setpoint for reversible radiant floors.

8.4.4.2 SURFACE TEMPERATURE

The surface temperature of a reversible radiant floor must be at least 23 to 24°C in order to maintain comfort (indoor environment, difference with the outdoor temperature, foot-level air temperature, etc.) and limit the risks of condensation.

8.4.4.3 WATER SUPPLY TEMPERATURE

To avoid the risk of condensation, the circuit should be fitted with a device that limits the temperature of the water supplied to the floor. This device may be integral to the control system.
The minimum supply temperature must be that specified in the technical requirements for the design and operation of reversible low-temperature hydronic radiant floors.

Geographic region (examples for France)	Supply temp.
Coastal regions of the English Channel, North Sea, Atlantic Ocean north of the Loire estuary. Width: 30 km.	19°C
Coastal region of the Atlantic Ocean south of the Loire estuary and north of the Garonne estuary. Width: 50 km.	20°C
Coastal region of the Atlantic Ocean south of the Garonne estuary. Width: 50 km.	21°C
Mediterranean coastal region. Width: 50 km.	22°C
Inland region.	18°C

Table of minimum floor water supply temperatures region by region

8.4.4.4 SAFETY DEVICES

A safety device for cutting off the supply of cold water to the floor when the water temperature reaches 12°C and independent from the control system must be fitted.

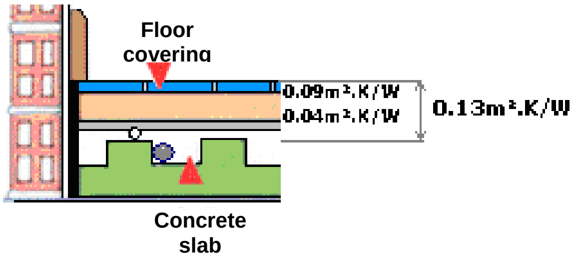
8.4.5 SPECIAL PRECAUTIONS: DAMP ROOMS

Bathrooms and kitchens (open-plan kitchens excepted) should be supplied by a specific loop with a manual or automatic device for shutting of the supply in the cooling mode (to prevent condensation).

Installing a humidity sensor will shut off the supply before condensation starts to form on the surface of the floor.

8.4.6 FLOOR COVERINGS

The thermal resistance must not exceed 0.15 m².K/W above a non-reversible radiant floor and 0.13 m².K/W above a reversible radiant floor.
The thermal resistance is limited to 0.09 m².K/W for floor coverings with or without acoustic insulation and 0.04m².K/W for concrete slabs.



The following floor coverings are the most common:

- Tiles R = 0.02 m².K/W,
- 10 mm glue-down wood flooring R = 0.08 m².K/W,
- 5 mm carpeting R = 0.075 m².K/W,
- 7 mm thick carpeting R = 0.10 m².K/W.

All these floor coatings must be installed after the slab has been allowed to warm up and the heating system has been turned off. Avoid combining different floor coverings (e.g. tiling and wood flooring) over a loop.

- Tiles made of a ceramic or similar material and bonded with mortar

These materials (e.g. ceramic tiles, natural stone tiles, vitreous mosaic tiles, enamel tiles) and the grout used to hold them in place must meet applicable standards and requirements (norme française à changer). The heating system must be left off while they are being laid and for one week afterward.

- Wood flooring

The heating system must be turned on three weeks before the wood flooring is laid. Two weeks prior to installation, the boards must be allowed to acclimatise with the installation environment. The heating system must be turned off while laying the wood flooring.

In all cases, the materials and any floor preparation products (levelling compound, smoothing compound, etc.) must meet applicable standards:

- Textile floor coverings

The materials, any floor preparation products (primers, levelling compound, smoothing compound, etc.) and the laying methods must meet (norme française à changer). If a smoothing compound is applied, the heating system must be shut off 48 hours beforehand and a maximum of 48 hours before the covering is laid.

- Plastic floor coverings

The materials, any floor preparation products (primers, levelling compound, smoothing compound, etc.) and the laying methods must meet (norme française à changer). If a smoothing compound is applied, the heating system must be shut off 48 hours beforehand and a maximum of 48 hours before the covering is laid.

⚠ IMPORTANT:

Never lay carpeting over a reversible radiant floor!!

8.4.7 SIZING A NON-REVERSIBLE RADIANT FLOOR

The purpose of designing a radiant floor is to determine the supply temperature and the spacing of the tubing in the embedded loop. The main factors are listed below:

- The required capacity (heat losses),
- The layout of each room/space,
- The floor construction (type and thickness of the concrete slab),
- The floor coverings,
- Regulatory restrictions, such as floor temperatures of less than 28°C and spacing of less than 35 cm..

This information is absolutely necessary in order to correctly design a radiant floor.

European standard EN 12831 (Heating systems in buildings. Method for calculation of the design heat load) is based in particular on standard EN 832 (Thermal performance of buildings. Calculation of energy use for heating. Residential buildings) as well as several draft standards prepared by the European Committee for Standardization (such as CEN/TC 89).

The heat emitted by a radiant floor must equal the nominal losses of the space it heats, for the minimum outdoor design temperature, calculated using various methods (TH-D, AICVF or COSTIC in France).
The installer must provide his/her design calculations for the radiant floor so that the system may be adjusted correctly.

8.4.8 SIZING A REVERSIBLE RADIANT FLOOR

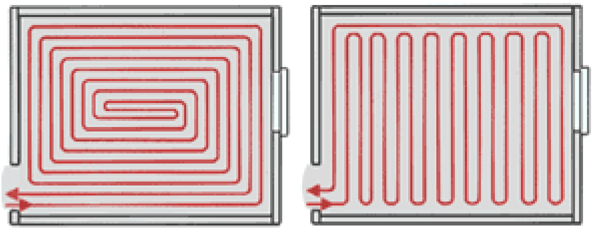
There currently is no recognised calculation method for designing a reversible radiant floor. An RRF must therefore be designed for heating and adjusted for cooling.

A tiled reversible radiant floor has a cooling capacity of approx. 25 W/m².

8.4.9 INSTALLATION

Radiant floors must be installed in accordance with applicable regulations and manufacturer recommendations.

The runs of tubing must be secured in place and at a specific pitch (spacing). The pitch varies depending on the thermal calculations for each room. In the case of a reversible radiant floor, it will be between 50 and 200 mm. In the case of a non-reversible radiant floor, a maximum pitch of 200 mm is recommended for maximum heat pump performance.



The tubing is arranged in either a serpentine or spiral pattern.

The tubing must not be placed within:

- 100mm of a finished wall or a covered surface (surface not in a heat-emitting zone, such as the footprint of a bathtub or an under-sink cabinet).
- 200 mm of flues or open fireplaces, open or plastered-over shafts, and lift shafts.
- 150 mm of the inner side of external walls, to prevent damaging the tubing during the hanging of curtain rods and the installation of formwork in a lower storey (ducts, roll-up shutters, etc.). This distance rises to 400 mm only in the case of a radiant floor in a solid floor.

The bend radius of the tubing must be no less than the minimum curve set out in the requirements of the technical approvals or in applicable product standards.
The tubing must be secured in place as instructed in the technical approvals using clips, ties, staples or other fasteners.
If preformed insulating panels are used, the tubing is simply inserted between the guides. With some floor types, the tubing can be clipped into tracks for a modular layout.
Whatever the method used, the fasteners must hold the tubing firmly in place but without damaging it (do not use any metal straps or wires) and allow the tubing to be placed at the appropriate pitch.

Always perform a pressure test before embedding the tubing in cement.

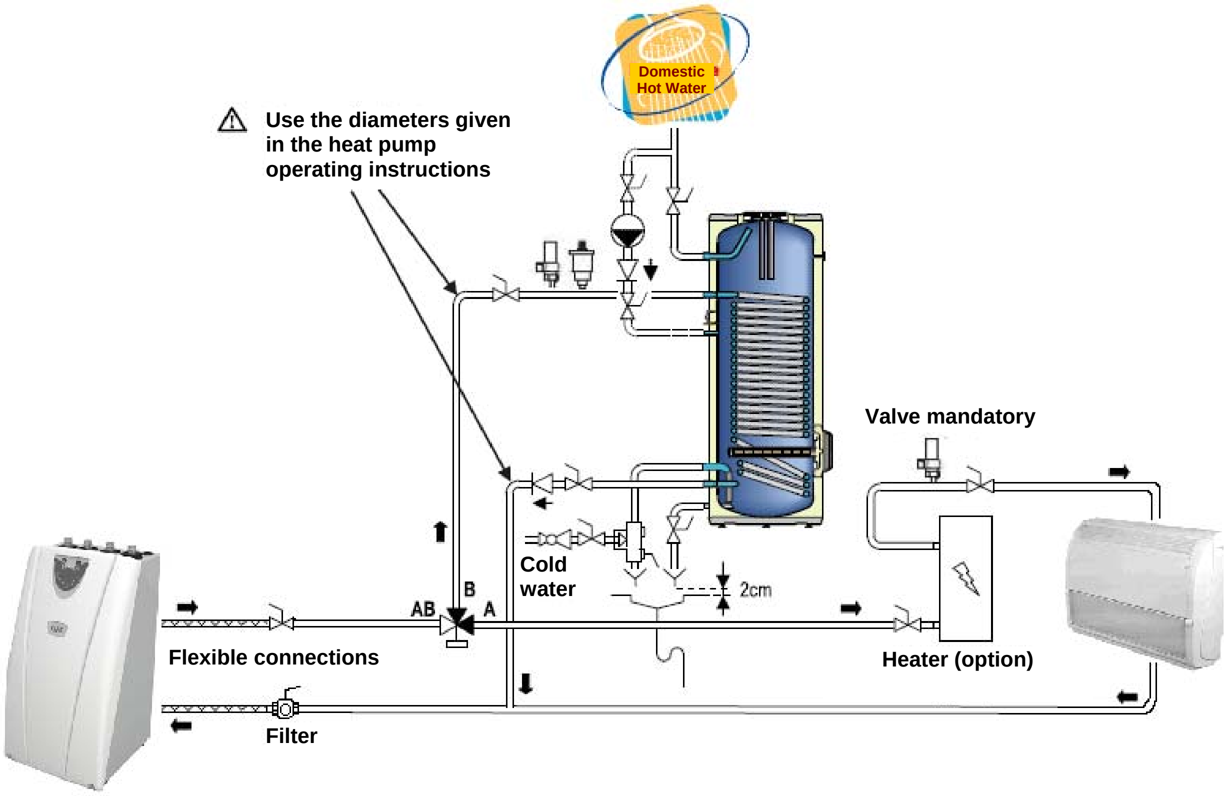
For further information, refer to the documents and guides provided by the various suppliers and manufacturers.

8.5 DOMESTIC HOT WATER

Domestic hot water can be provided by pairing any CIAT heat pump with the 300 l SANI DHW tank or simply with a conventional hot water tank 'retrofitted' for domestic hot water.

With this option, two daily heating cycles can be programmed.

Installation consists merely of connecting a three-way valve, actuator and additional control board.



8.6 POOL HEATING

Our residential heat pumps can be used to **heat swimming pools in the spring and autumn.** All that is needed is a pool kit (three-way valve and sensor) and an ITEX heat exchanger sized for the heat pump (or, if used on its own, sized to the volume of the pool). BEAR IN MIND that the heat pump cannot provide indoor heating or cooling when it is used to heat a swimming pool.

- Titanium plates
- Removable for easy cleaning

Table of correspondences between ITEX heat exchangers and Aqualis 2 heat pumps.

AQUALIS 2	Heating capacity 15°C outdoor temp. (kW)	Heat pump and heat exchanger circuit available pressure (1) (kPa)	SELECTED ITEX EXCHANGER	Primary operation 40% MPG, 40/33°C Water flow rate (m³/h)	Secondary operation 25/32°C pool water	
					Water flow rate (m³/h)	Pressure drop (kPa)
20 H(T)	6,9	34	PWA 6 11 / P7	0,9	0.85	10
28 H(T)	9,4	25	PWA 6 11 / P9	1,2	1.15	10
35 H(T)	11,8	21	PWA 6 11 / P9	1,5	1.50	15
50 H	15,8	61	PWA 6 11 / P11	2,1	1.95	17
50 HT	15,4	64	PWA 6 11 / P11	2	1.90	16
65 HT	19,2	44	PWA 6 11 / P11	2,5	2.40	24
75 HT	22	41	PWA 6 11 / P13	2,9	2.70	22

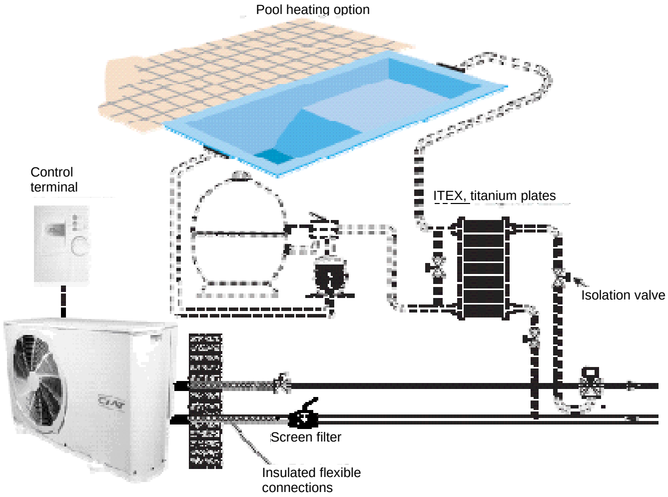
(1) la pression disponible tient compte de la perte de charge de la vanne (fournie avec le kit chauffage piscine) et de l'échangeur.
Plaques Titane : matière plaque compatible tout traitement eau de piscine (délai : 1 semaine départ usine à réception de commande)

Guidance table for selecting a heat pump (pool heating only) based on pool volume.

- Desired water temperature: 26°C
- Initial water temperature: 19°C
- Outdoor air temperature: 15°C
- Heating cycle: 72 hours
- Open air pool with thermal cover

AQUALIS 2	Heated pool volume (m³)	AQUALIS CALEO	Heated pool volume (m³)	AUREA 2	Heated pool volume (m³)
20 H	20 to 45	60 H	Up to 90	30 H	20 à 60
28 H	50 to 60	60 HT	Up to 90	40 H-HT	65 à 75
35 H	65 to 75	70 HT	90 to 130	50 H-HT	80 à 100
35 HT	65 to 75			65 HT	105 à 120
50 H-HT	75 to 90			80 HT	125 à 150
65 HT	90 to 110			100 HT	155 à 190
75 HT	110 to 130			120 HT	195 à 205

Pool heating option



CIAT HABITAT

8.7 HYDRAULIC SYSTEMS

Heat pump systems are commonly fitted with the same components as those found in water-based heating systems. A number of specific components are also used in heat pump systems, i.e.:

- circulators,
- expansion vessel with safety valve,
- fill valve with backflow preventer,
- drain valve,
- pressure gauges,
- differential water pressure switch,
- filter on the secondary system,
- buffer tank, if necessary,
- auxiliary heat source, if necessary (primarily for air-to-water heat pumps),
- filter on the primary system (for water-to-water heat pumps),
- water inlet and outlet thermometers,
- supply and return manifolds on the secondary circuit and equipped with isolation valves, control valves and flow meters, air vents, drain valves, etc.
- supply and return manifolds on the primary circuit of the water-to-water heat pumps and equipped with isolation valves, control valves, air vents, pressure gauges, drain valves, etc.

In some cases, some of these components may be integral to the heat pump or its associated hydraulic module.

8.7.1 CIRCULATORS

8.7.1.1 DESIGN AND SIZING

The size of the circulators (or circulating pumps) on our heat pumps will depend on the pressure drops in each heat pump and, in most cases, a system's head loss and flow rates. Nevertheless, they must be checked to make sure that they are suited to each individual system.

All the circulators used on our heat pumps are designed to operate indifferently with hot water, chilled water, plain water and glycol/water mix.

8.7.1.2 PRIMARY CIRCULATOR

The primary pump is sized based on the total heating capacity of the heat pump and the auxiliary heating device, with a maximum difference between the water supply/return temperatures of 7 K.

8.7.1.3 CASE OF SECONDARY CIRCULATORS

If secondary circulators need to be installed, their size will depend on the needs of the zone to be heated, with a maximum difference between the water supply/return temperatures of 7 K.

8.7.1.4 A REMINDER ON A FEW IMPORTANT RULES

- Whatever the operating point, the flow rate of the primary pump must always be higher (even slightly) than the combined flow rates of the secondary pumps.
- The primary circulator must run continuously and at a constant volume.
- To promote the exchange of heat, the circulator in the RRF circuit must run continuously.
- In order to meet heating and cooling needs, the circulator in the fan coil unit must run continuously.
- The pumps must be turned off when the system is not used to heat or cool.

If a two-way control valve is fitted on the fan coil units or if thermostatically controlled valves are fitted on the supply lines of a radiant floor, a valve or differential pressure switch must be fitted downstream of the pump and between the supply and return. Furthermore, one or two circuits must be left continuously open in order to maintain a minimum rate of flow in the pump if the control valves are closed.

A too-high or too-low flow of water through the circulator will result in poor diffusion of heat. Remember to adjust the flow to the correct rate!!

8.7.2 FILTER

All CIAT heat pumps are fitted with brazed-plate heat exchangers that are both compact and highly efficient during hot water production as well as chilled water production.
To keep them at optimum efficiency, <u>they must be protected with a screen filter</u> placed on their inlet (heating circuit return line and primary circuit supply line for water-to-water heat pump) and located in an area readily accessible for maintenance. The filter must remove particles over 600 microns in size and be cleaned periodically so as not to impede the flow rate.

8.7.3 PIPING/TUBING

8.7.3.1 DESIGN

- The hydraulic circuits must be made of the same, corrosion-resistant material.

For example, the hydraulic system must consist of tubing made of copper or a synthetic material (e.g. HDPE).

- The tubing must be connected to the heat pump via flexible connections to prevent the transfer of vibrations from the heat pump to the circuits.
- The tubing must be connected to the manifolds by means of mechanical fittings (compression, bush, crimping, with compression ring, or crimped).

8.7.3.2 SIZING

⚠ IMPORTANT

The flow of water through the tubing must ensure a linear pressure drop of between 100 and 150 Pa/m, i.e. between 10 and 15 mm/WC).

8.7.3.3 PIPE INSULATION

The entire supply line must be insulated. Pipes and tubing entering a structure must be covered with flexible closed-cell insulation, such as Armaflex. The minimum thickness of the insulation will depend on the diameter of the pipes or tubing:

- 9mm for outside diameters of up to 20 mm,
- 13mm for outside diameters of 25 mm and higher.

This insulation comes in the form of slit or unslit tubes.

Sections of pipe installed outdoors or in an unheated indoor space must be fitted with a heat trace cable if the system is not protected against freezing (for example, with glycol). Insulation with a minimum thickness of 13 mm must be used on these pipes. A minimum thickness of 25 mm is required if another type of tube insulation is used.

In all cases, this insulation must be adequately jacketed and protected up to a height of 2 m.

8.7.4 DISTRIBUTION MANIFOLDS

Manifolds must be installed indoors, preferably at a central point, and in a readily-accessible location. It is not recommended to install them in damp rooms (such as kitchens and bathrooms). Instead, install them in a corridor, closet, or a similar space. If a manifold is located hear a traffic area, it should be protected against potential damage to its components (flow meters, thermometers).
Manifolds come in pairs (with built-in valves or modular) and are made of brass or synthetic materials.

⚠ IMPORTANT

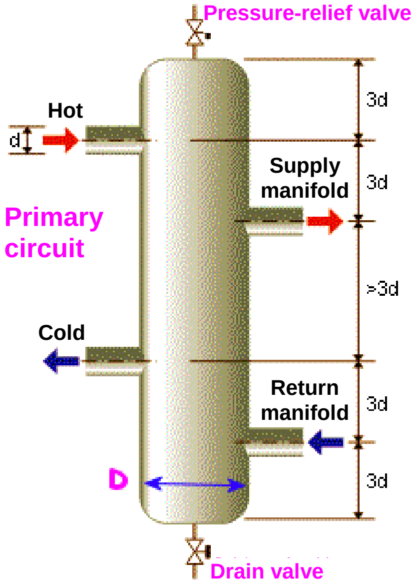
Isolate the circuits if the system is used in cooling mode. REMINDER: The manifold must be at least 60 cm above the floor.

8.7.5 BUFFER TANK

Virtually indispensable, buffer tanks are used to prevent short cycles (which could damage the compressor), facilitate defrosting (air-to-water heat pumps), and provide the minimum water capacity needed for the heat pump to operate correctly. Buffer tanks are installed on the water return line.

8.7.6 MIXING TANK

Mixing tanks are used to control two types of terminal unit, two temperatures, two ΔT or just two different flow rates. Mixing tanks are installed on the water supply line. Variable-flow circulators installed downstream of a mixing tank will make it possible to control various parameters.



Sizing:

d = inside diameter of water supply line (heat pump end)

D = inside diameter of mixing tank

D = √[(352 × Q) / V]

Q = flow, in m^3/h

V = rate through mixing tank, in m/s (usually 0.1 m/s)

8.7.7 DUO HYDRAULIC MODULE

The DUO hydraulic module makes controlling the water possible when the heat pump is used to supply two zones with two different types of terminal unit (radiant floor and radiators). The heat pump will supply the highest temperature to the radiators (55°C), while the hydraulic module will use its own water law to lower the temperature of the radiant floor supply to 35°C.

9 ELECTRICAL CONNECTIONS

The contractor must make all the electrical connections leading to the equipment it supplies. It must also earth all its equipment.
If all the controls, lights and electrical protections are located together on the same panel (cabinet or box), the panel must be sized to maintain its internal temperature at or below 35°C.. Twenty percent of the useful area must be left free.

The electrical power supply must meet the following requirements:

- Single-phase power supply:
  230 V $^{+6\% / -10\%}$ 50 Hz
- Three-phase power supply:
  400 V $^{+6\% / -10\%}$ 50 Hz
- All wiring must be performed in accordance with applicable local electrical codes and regulations.
- The wiring must be carefully selected based on the maximum current of the system (refer to the technical specifications tables at the back of our manuals), the distance separating the unit from the main power source, the upstream protection, and the neutral mode.
- Three-phase models must be connected to neutral.
- The system must be fitted with a main cut-off switch.

AQUALIS 2	20H	28H	35H	50H	20HT	28HT	35HT	50HT	65HT	75HT		
Recommended wiring	3G4	3G4	3G6	3G6 (1)	5G1.5	5G1.5	5G4	5G4	5G4	5G4		
AQUALIS CALEO	60H	60HT	70HT									
Recommended wiring	3G10 (1)	5G2.5 (1)	5G4 (1)									
AGEO	20H	30H	40H	50H	20HT	30HT	40HT	50HT	65HT	80HT	100HT	120HT
Recommended wiring	3G4	3G4	3G6	3G10	5G2.5	5G2.5	5G2.5	5G4	5G4	5G4	5G6	5G6
AGEO CALEO	50H	50HT	65HT	80HT								
Recommended wiring	3G10	5G4	5G4	5G4								

(1) Use high temperature cables, type PVC-V2-K or PR (maximum length = 50 m)

10 COMMISSIONING

A number of connections must be completed before a heat pump may be commissioned:

- electrical connections,
- hydraulic connections,
- filling with water,

Commissioning consists of the following steps:

- installation check,
- tests,
- adjustments,
- showing the homeowner how to operate the system.

IMPORTANT

At the end of each phase of commissioning, information about the system (products injected, test pressures, temperature, currents, etc.) must be noted on operating reading reports.

10.1 FILLING THE SYSTEM WITH WATER

Filling consists of three steps:

- cleaning,
- flushing,
- filling.

If antifreeze is used, the content must allow a minimum temperature that is consistent with the design temperature of the system's location. In all cases, it must provide protection at temperatures as low as –15°C. A premixed, ready-to-use antifreeze is preferable.
Use the following concentrations if monopropylene glycol is used as an antifreeze:

Antifreeze concentration (MPG)	Protection temperature
30%	-16°C
35%	-20°C
40%	-25°C
45%	-30°C

There is a risk of corrosion if the concentration of ethylene glycol is less than 30%.

IMPORTANT

Monopropylene glycol (MPG) must be used in underground loops so as not to pollute the aquifer.

The mix must be thoroughly blended before it is added to the system. The glycol content must be determined by gravimetric measurement or using an optical refractometer.

- The hydraulic circuits must be separate from the municipal water lines so as not to degrade the antifreeze when raw water is added.
- Isolation valves should preferably have a square drive and an outlet port with cap.
- In the case of an underground loop, the lines must be purged before being filled.

10.2 INSTALLATION CHECK

Once installation is complete, it is best to make a final check of a number of points before commissioning the system:

- Heat pump level and plumb,
- Anti-vibration mounts in place,
- Municipal water supply connection with check valve,
- Tightness of electrical connections,
- Power supply voltage same as that indicated on the data plates on the units (heat pump, circulator pump, auxiliary heating elements, etc.),
- Diameter of the power cables for the heat pump and the auxiliary heating device as recommended in the manufacturer's technical catalogues,
- Earthing connections correct,
- Breaking capacity of circuit breaker,
- No tools or objects left inside heat pump,
- Correct circulation of air through heat exchanger (air-to-water heat pump), air flow not obstructed, correct distance between heat pump and noise barrier (if installed),
- Sufficient space around heat pump to allow easy maintenance,
- Space for removing the exterior panels,
- No leaks at entry points of piping/tubing and cables in walls,
- Tightness of pipe clamps,
- Pipe fasteners and hangers securely in place,
- Refrigeration piping/tubing and water piping/tubing correctly insulated,
- Operation of drains at low points and air vents at high points,
- Brass caps on poppet valves (if Schräder valves).

10.3 TESTS AND CHECKS

10.3.1 HYDRAULIC PRESSURE TESTS

The entire system must be tested for water leaks. Pressure tests must be conducted during assembly, on each system or system section, prior to painting, lagging and weatherstripping of gaps.

The appropriate steps must be taken if there is a risk of freezing.

10.3.1.1 UNDERGROUND CIRCUIT

The loops must be tested before leaving the factory. In addition, a hydraulic pressure test (4 bar for 30 minutes) must be conducted once they have been installed and filled with water. This test must be conducted before the loop is covered with soil.

10.3.1.2 RADIANT FLOOR CIRCUIT

CHECK OF TUBING PRIOR TO POURING OF CONCRETE

Before the concrete slab or screed is poured, a hydraulic pressure test must be performed on the heating circuits to check for leaks. The test pressure must be at least twice the operating pressure (6 bar minimum). The pressure can be lowered to 3 bar (municipal water supply pressure) one or two hours after the start of the test.
Important: Replace the safety valves with Schräder valves on the manifolds before raising the pressure.

The system must be kept at the municipal water supply pressure (approx. 3 bar) during the pouring and curing of the concrete (concrete should not be poured unless the temperature remains at or above 5°C for at least three days).

AFTER POURING OF CONCRETE

There should be no leaks. This information and the test pressure must be recorded on a test report.
Sufficient measures, such as the use of antifreeze if there is a risk of freezing temperatures, must be taken. If antifreeze is no longer needed under normal operating conditions, the antifreeze must be drained and the system flushed three times with clean water.

10.3.2 CHECKS: HEAT PUMP

The following points must be always checked on a heat pump during commissioning:

- Absence of refrigerant leaks (Regulation (EC) 842/2006),
- Circulation of water through the heat pump while the circulator is running,
- Absence of air in the hydraulic circuit(s) (air vents),
- Tightness of electrical connections,
- Correct operation of all safety devices,
- Normal input current,
- Temperatures at various points along the refrigeration circuit,
- Temperatures at various points along the hydraulic circuit(s),
- Correct cycle changeover and (if possible) correct control of defrost cycle,
- Cycling on and off of the compressor when the heat pump setpoint is changed,
- High and low pressures (limit the number of pressure gauges in order to avoid refrigerant leaks),
- Input power levels of the compressor and the circulators.

The following points must be always checked on a air-to-water heat pump during commissioning:

- Direction of fan rotation,
- Air conditions at inlet and outlet of the heat exchanger,
- Input power of the fan.

10.3.3 CHECKS: HYDRONIC TERMINAL UNITS

The following points must be checked:

- switching of fan speeds,
- Direction of fan rotation,
- Air conditions at inlet and outlet of the heat exchanger,
- Correct operation of the temperature control,
- Correct operation of the control valve,
- Input current,
- Supply voltage,
- Input power of the fan,
- Correct drainage of condensate,
- Cleanliness of filters.

10.3.4 CHECKS: RADIATORS AND HYDRONIC CONVECTORS

The following points must be checked:

- Ambient temperature of the space,
- Correct operation of the thermostatically controlled valves.

10.4 ADJUSTMENTS AND BALANCING

Once the aforementioned tests and checks have been completed, each circuit's equipment must be adjusted following the manufacturer's instructions. In particular, the following are necessary:

- Water circuit: drain the water circuit and adjust the flow rate,
- Adjust the circulators on the heat pump and adjust the control devices on the secondary circuits.

10.4.1 DISTRIBUTION SYSTEM ADJUSTMENTS

As with the technical design stage, the installer must have a sufficient amount of information in order to correctly balance the system (number of turns of the control valves, etc.).

Balancing may require shutting off the circulator(s) and shifting a number of setpoints. All automatic control valves must be disconnected from their actuators.

As a general rule, disable the automatic control system if it is liable to cause changes to the flow rate during adjustment.

10.4.1.1 FLOOR

The tube diameter, the length of each loop and the flow rate in each are among the items of information needed in order to balance the system.

Balancing is divided into two steps:

Balance the flow of water in each loop via its manifold

- Calculate the flow rate and pressure drop for each loop. Based on the difference in pressure drop with the least favourable loop, calculate the extra pressure drop to be provided via the tee fitting on each loop's manifold.
- Adjust each loop by opening the adjustment tee on each loop by the number of turns given in a table provided by the manufacturer.

If a manifold is fitted with a flow meter, simply adjust the regulator until the corresponding flow rate is obtained.

Balance the manifolds

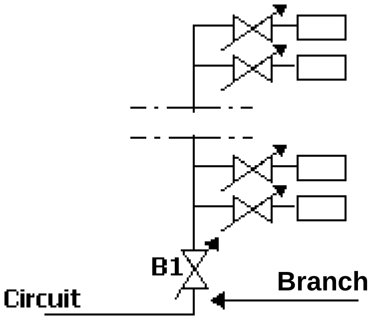
- For each manifold, calculate the flow rates of the loops and the maximum pressure drop. Depending on the system, and as described above, open the adjustment tee by the number of times indicated in the manufacturer's table.

10.4.1.2 HYDRONIC FAN COIL UNITS, RADIATORS AND CONVECTORS

Balancing is divided into several steps:

Balance the terminal units on each branch

- Adjust each module to the number of turns determined by a hydraulic calculation. If there is no such calculation, leave the modules at their pre-opening setting.
- Open the regulator on the selected branch fully (B1 in this example).

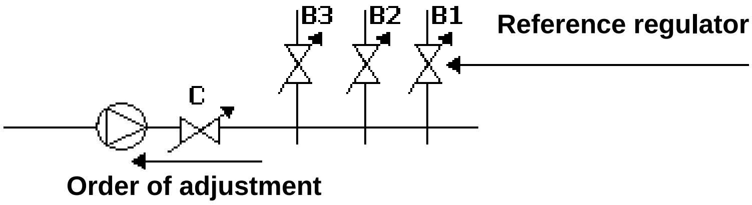


- Adjust each device, starting from the least favourable device and working your way back to the pump.
- Calculate the flow rate and pressure drop for each element in the circuit.
- Based on the difference in pressure drop with the least favourable loop, calculate the extra pressure drop to be adjusted on each device's regulator.
- Adjust each circuit by opening the regulator on each circuit by the number of turns given in a table provided by the manufacturer.
- If necessary, insert the tamper-proof seal.
- Do the same for the other branches.

Balance the branches

The procedure is the same as for the units.

- Look for the least favourable branch (usually the branch furthest from the pump).
- Adjust the regulator B1 (the furthest from the pump).
- Regulator B1 is the reference for adjusting the other regulators (from this point back towards the pump). Calculate the flow rate and pressure drop for each branch.
- Depending on the system, and as described above, open the regulators by the number of turns indicated in the manufacturer's table.



Branch adjustment order

Adjust the circuit flow rate

Adjust the total flow rate on the circulator. Use measuring instruments to check the flow rates, particularly the total flow rate.
The main regulator (C) features measurement points that make it possible to check the selected pump speed and adjust the total flow rate.

10.4.2 CONTROLLER ADJUSTMENT

All the control parameters must be known before the controller may be adjusted. The main settings to be made are as follows:

- selection of the slope for the water law,
- summer/winter setpoints,
- alarm thresholds.

10.5 TURNING ON A RADIANT FLOOR FOR THE FIRST TIME

A waiting period of at least 21 days (check the manufacturer's instructions for the exact period) after the concrete has been poured must elapse before this can be done. The temperature in the floor should rise steadily until it reaches 20–25°C and be left on at that temperature for three days.

IMPORTANT

- The commissioning and warm-up of a radiant floor must be described in a report.
- A reversible radiant floor must be turned on in the heating mode before being turned on in the cooling mode.

10.6 FINAL CHECK OF COMPLETE SYSTEM

Once the system has been tested and adjusted, it must be turned on and checked to make sure that it operates correctly. Check the following points:

- the temperature of the fluids in the system,
- the temperature of the spaces being heated,
- the noise level of the system (it should be quiet),
- the accuracy and correct operation of the measuring, safety and control devices,
- the settings of each control device.

If an underground loop is installed, a self-inspection certificate (stating the soil type, sizing, length of the pipes, pressure test results of each loop) must be provided to the homeowner (or the contractor).

Readings proving that the system operates correctly must be recorded on a start-up sheet. The results must be checked against the technical specifications.

IMPORTANT

These readings will be used during subsequent checks and must be used as a basis for the system's maintenance log.

10.7 HANDOVER OF SYSTEM

Once the system has been installed and operates correctly, the contractor must provide the following documents:

- final drawings indicating the locations of each system, equipment room, ductwork, piping and all installed equipment,
- drawings with photographs of the outdoor loops prior to backfilling,
- detailed wiring diagrams,
- technical documentation, in the user's language, for each device installed,
- start-up sheets,
- schematic diagram of the system,
- control system operating instructions (with slope and setpoints specified),
- clear and detailed instructions on operating the entire system,
- telephone number of the maintenance and customer-service company.

A qualified person who participated in installing the system must inform the user of the installation conditions and limits of use.

IMPORTANT

The system must be installed by a qualified company whose employees have received adequate training by CIAT on the products used.

It is best that commissioning is carried out by, or with, the maintenance company. For further information on CIAT's commissioning services, contact CIAT Service.

11 MAINTENANCE

Maintenance serves three purposes:

- Ensure that the system continues to run at optimum level,
- Extend the service life of the equipment,
- Ensure that the system continues to deliver optimum comfort.

Readings of the system's operation must be taken each time routine maintenance is performed. These readings must be recorded in the maintenance log and compared against those on the start-up sheet. All problems or changes must be reported.

Provided it is maintained throughout the life of the system, the maintenance log will provide useful information for diagnosing problems and performing maintenance.

11.1 MAINTENANCE CONTRACT

Taking out a maintenance contract is essential to ensuring that the system runs smoothly for years to come. This contract sets out:

- The number of visits per year: a visit must be scheduled during the cooling season to check the operation of the defrost cycle, the settings of the thermostats and safety devices, and the heating capacity by measuring the difference between the supply and return temperatures.
- The list of operations to be performed at each visit.

Types of maintenance

The maintenance performed on a heat pump can be split into three categories:

- preventive maintenance,
- minor servicing,
- repairs.

11.1.1 PREVENTIVE MAINTENANCE

The fan coil units require minor servicing by the user or cleaning staff at least once every three months:

- The filters must be replaced or cleaned (in warm water or with a vacuum cleaner) and put back in place correctly. The filters may be cleaned more often in highly dusty environments.
- The fan coil units must be dusted and cleaned (with a sponge or cloth, no water jets).

The operation of the entire system must be checked at least once a year by a maintenance technician, who:

- Makes sure that the pump turns off after tripping a safety device (fault light on),
- Cleans the 600 µm filter,
- Dusts and cleans the heat pump (with a sponge or cloth, no high-pressure cleaners),
- Checks the performance of the heat pump,
- Checks the correct draining of condensate from the heat pump and fan coil units, and cleans the condensate tray,
- Checks the various speeds of the fan coil units,
- Checks the operation of the control valves,
- Checks the manometric head of the circulator on the underground loops (if installed),
- Checks the system for unusual noise and damage (loose panels, insulation, water leaks, oil leaks, etc.),
- Regularly checks the antifreeze.

11.1.2 MINOR SERVICING

In addition to preventive maintenance, the following operations are performed by a maintenance technician at least once a year:

- Checks the electrical connections,
- Checks the correct operation of the functions in the control box,
- Changes all parts and wires found to be defective,
- Checks all nuts and bolts (fans, housings, mounts, etc.),

- Replaces all damaged insulation,
- Touches up paint on damaged sections.

11.1.3 REPAIRS

Repairs are also known as curative maintenance. **All repairs must be performed by qualified technicians, particularly in the case of repairs to the refrigeration circuit.**

The following must be performed when a symptom appears:

- Identify the location of the failure,
- Identify the possible causes or the defective equipment,
- Make the necessary checks,
- Take the appropriate corrective actions,
- Make sure that the system runs smoothly.