Installation and User Guide

for

NILAN JVP2

Ground Source Heat Pump

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MARKEDSFØRENDE ERHVERVS- OG BOLIGVENTILATION MED VARMEGENVINDING

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General information before installation

Check that the following documents have been supplied with the system:

- *Installation Guide (this document)*
- *Electrical diagram*
- *Warranty documents*

We have tried to make the language in the Installation Guide as clear and unambiguous as possible. Should problems arise however in connection with the installation, you are naturally very welcome to contact us.

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Control of the system is done with a NILAN LMC220 controller, which offers a wide range of functions, for example, menu-driven control, summer/winter operation, outside compensated control, etc.

Safety

Always disconnect the electrical supply to the heat pump if any malfunction occurs that cannot be remedied via the control panel.

If any malfunction arises on the electrical part of the heat pump, a licensed electrician must always be contacted to repair the malfunction.

Avoid direct contact with the pipes in the heating system in the heat pump, as they can be very hot

Many types of antifreeze are injurious to health, dangerous when ignited and must be kept away from children.

To protect the heat pump from damage, it is supplied with the following safety equipment:

- Expansion system for central heating and heat source.
- Safety valves for central heating and brine/earth circulation system.
- Low and high pressure cut-off switches for compressor
- Brine pressure cut-off switch (legally mandatory environmental pressure switch)
- Minimum/freezing thermostat (cuts off the heat pump if the temperature becomes too low in the brine circulation system)

The heat pump must be subjected to a service inspection at least every 12 months according to the Danish Ministry of Employment and Social Affairs Order No. 539 § 15. In connection with the service inspection, all safety automation must be tested for function.

The responsibility for maintenance of the heat pump rests with the owner or user. The heat source contains anti-freeze, which can harm groundwater if spilled or leaked. Immediately contact an authorised VPO ("Danish Heat Pump Industry Quality Assurance Scheme") service technician if leaks are suspected in your ground source heat system.

System design

Electrical installation/power supply (including safety cut-offs) must be installed by an authorised electrician.
The system is connected according to the supplied electrical diagram.

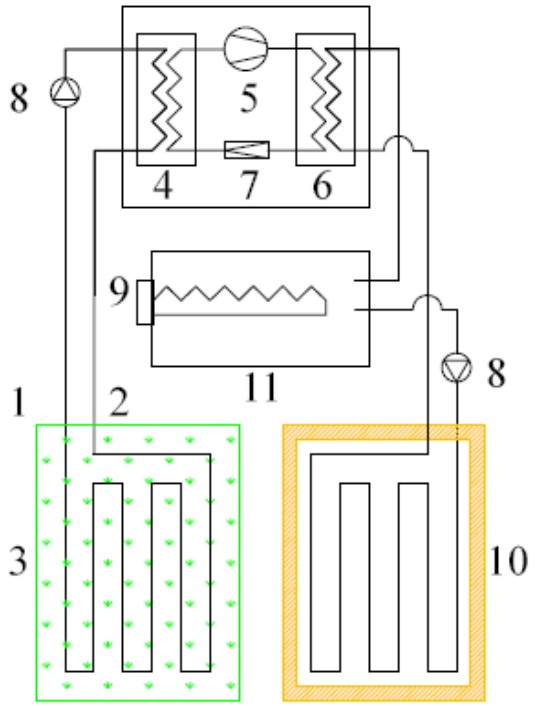

Figure 1: System design

Function of ground source heat system
The ground source heat system is used for heating of central heating water or for floor heating.

System components (function)
The ground source heat system obtains heat from the ground through *the earth tube system (3)*.
The ground stores heat which it accumulates from the sun in the summer and releases the heat to the earth tube system (3) in the winter. The temperature of the water/antifreeze mixture (= brine) out of the earth tube system (1) is 0-10°C. In order to utilise the energy in the brine, a heat pump is used which transports heat energy from a low temperature in the brine medium to a higher temperature in the central hot water. The warm central heating water is accumulated in a *buffer tank (11)* that stores heat in the event of large fluctuations in heat consumption. *Circulation pumps (8)* see to the fluid transport in both the earth tube system and the central heating/floor heating system (10).
The heat pump consists of an *evaporator(4), compressor (5), condenser (6)* and an *expansion valve (7)* that is combined with a refrigerant in a so-called closed cycle in a closed system. The brine from the earth tube (1) exchanges with the refrigerant in the evaporator by which the refrigerant is heated. After the evaporator the refrigerant is compressed in the compressor and the temperature and pressure of the refrigerant are increased. Upon exchanging in the condenser the refrigerant then releases heat energy to the central heating water, and the temperature of the central heating water rises. After the condenser the refrigerant pressure is reduced in an expansion valve, and the refrigerant continues into the evaporator where it cools the brine before the flow for the earth tube system (2).
A supplementary heating element is installed in the buffer tank (9) which can supplement the ground source heating system in the event of particularly high heating demand.

Operation and maintenance

During set up, future service and maintenance should be taken into account.
A minimum clearance in front of the system of at least 1mis recommended.

Starting the heat pump

Before starting the heat pump, check the following:

- The pressure in the central heating system, see 40, Figure 5
- The pressure in earth tubes, see 21, Figure 5
- That both the central heating system and the heating source are ventilated as described on page 9.

The heat pump can then be switched on at the safety switch.

The heat pump is stopped by the safety switch.

Figure 2: Ground source heat system without front panel.

Figure 2 shows connections on the ground source heat pump; central heating inflow 1, brine inflow 2, central heating return 3, brine return 4, earth tube pressure control 5.

Water pressure on central heating system

The water pressure must be checked carefully the first few days, even up to several times daily, and if necessary topped up with water to the system, see page 40, Figure 5.

The water pressure will be stabilised after a few days and the inspection can then be reduced to once a month. If water is added to the central heating system beyond the start-up phase, a check should be done for leaks.

It is important that the water pressure is correct, as the circulation pump will be damaged if the heat pump is started with insufficient water pressure.

Filling up central heating system with water

It is important that the heat pump and the circulation pump are switched off at the main switch while water is being added to the system.

- Water is added to the central heating system via a filler cock, see page 41, Figure 5, until the water pressure is correct, see page 40, Figure 5.
- There are automatic vents on the heat tank, central heating system, etc., that are activated automatically when water is added to the system.
- Water is added to the system until the water pressure is correct. If the water pressure disappears entirely during the filling, the filling must be restarted completely from the start.
- The heat pump is started again by switching on the main switch.

Dirt filter

Immediately after the heat pump is connected, there may be some dirt in the central heating system. The dirt filter is installed on the central heating line and the earth tube line on the outside of the heat pump as shown on Figure 5.
The filter must be checked and cleaned several times daily right after the installation of the heat pump until the filter remains clean. It is sufficient in normal operation of the heat pump to check the filter twice annually.

Cleaning of the dirt filter:

- The heat pump is switched off at the main switch.
- The shut off valves on each side of the filter are closed.
- The filter is pulled out and rinsed clean.
- The filter is put in place and the shut off valves are opened before the heat pump is switched on at the main switch.

Water pressure on heat source (earth tube)

The water pressure must be checked carefully the first few days up to several times daily and if necessary topped up with water to the system, see page 5,
Figure 2.

The water pressure will be stabilised after a few days and the inspection can then be reduced to once a month.

It is important that the water pressure is correct, as the circulation pump will be damaged if the heat pump is started with insufficient water pressure.

Water might have to be added a couple of times the first year in connection with ventilation of the heat source.

Topping up water on the heat source

The brine (the fluid) in the heat source consists of water mixed with antifreeze, so that the brine can become colder than 0°C without freezing solid.

The heat pump is equipped with a low pressure switch which ensures that the brine never becomes so cold that it freezes solid, and thus the heat source's heat exchanger is protected against frost damage.

The frost protection is geared to the temperatures in the heat source. It is very important to get the antifreeze and water thoroughly mixed when brine is to be added to the heat source, as no mixing occurs in the earth tubes. The heat pump risks freezing with consequent frost damage if it runs with water without antifreeze mixed in. Filling of brine should be done by an authorised VPO technician.

Topping up brine on the heat source is done this way:

- The heat pump and the circulation pump are switched off at the main switch before water is being added to the system
- Water is added to the heat source via filler cock, see page 13, Figure 5, until the water pressure is correct.
- Heat source and heat pump are ventilated via automatic vents.
- Top up brine on the heat source until the water pressure is correct.

If brine must be added to the heat source several times, it indicates leakage in the earth tubes. Immediately contact an authorised VPO service installer/technician if you suspect leakage.

Cleaning of fluid in heat source

There may be dirt in the heat source after installation and the heat source and its fluid must therefore be cleaned before connecting to heat pump. Dirt filters should be installed on earth tubes.

Operation

Nilan JVP is equipped with the control panel below.

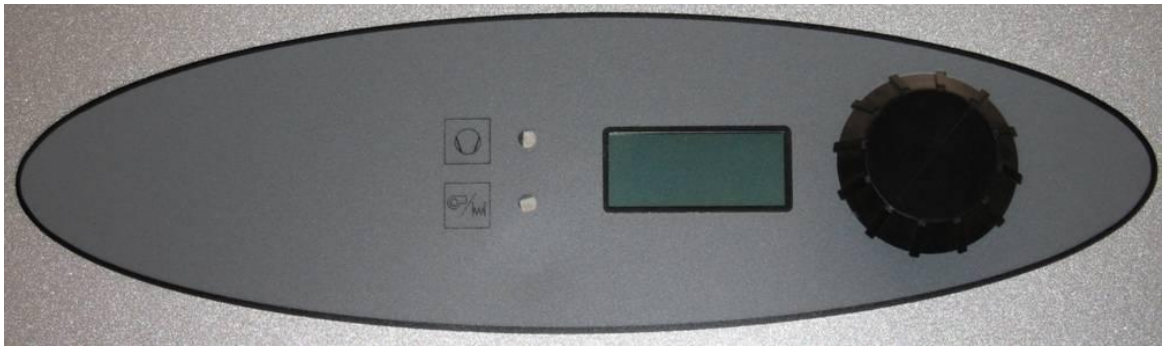

Figure 3: Nilan LMC220 Control panel.

The control panel is used to control the heat pump's operation.
The control has 2 diodes to the left of the display:

- the upper is illuminated when the heat pump is operating.
- the lower is illuminated when the supplementary heating is operating.

The backlight in the display blinks if the system has gone into alarm condition.

Nilan LMC220 control panel is controlled solely via the adjusting knob to the right of the display. The adjusting knob has 3 functions:

- Turn clockwise: Go to next menu item or increase the last value in the display.
- Turn counter-clockwise: Go to previous menu item or reduce the last value in the display.
- Press: Select sub-menu, activate adjustment of value or approve the last value.

The light in the display will be lit when the panel is being operated. The light is turned off if the panel is not operated for 30 seconds. If the panel is not operated for 5 minutes, the control will return to the main menu's initial window: the status menu.

Selection of menu

Switching between the various menus is done by turning the knob.

Menus with an arrow underneath to the right have in addition a sub-menu, which is activated by pressing once on the knob. Switching between the sub-menu's items is done by turning the knob. The sub-menu is left by turning forward or back until "Menu up" is shown in the display and then pressing on the knob.

Service menu

The sub-items in the service menu are not accessible during normal operation, as they can only be used in connection with installation and service.

Setting values

Setting values in the display is done in the following way:

- Turn the knob until the value that you wish to change is shown in the display.

- Press the knob to activate the value. The value will blink, so long as it can be changed
- It is now possible to change the value by turning the knob.
- Press the knob to accept the last value. The value will stop blinking.

Language

At the bottom of the service menu it is possible to select among various languages in the control panel:

- Turn the knob clockwise until the service menu is displayed.
- Press the knob to activate the service menu.
- Turn the knob until the menu LANGUAGE is shown in the display.
- Press the knob. The text in the display will blink.
- Turn the knob forward or back until the desired language is displayed.
- Press once on the knob to approve the language. The text will stop blinking.

Menu summary

Operating status menu

The system's current operating status is displayed as the first screen image in the main menus.

OFF	The system has been switched off. No functions are active apart from: - Alarm from earth tube environmental pressure switch - Circulation pump running and frost protection
START	Start up of heat pump. Circulation pumps are started. After short period switched to operation
READY	The system is switched on but there is no current heat demand
HEAT	Space heating. The house's return temperature is maintained at the desired value
WATER	Production of domestic hot water
MANUAL	The user has activated manual operation via Service menu
ALARM	Active. The system is still operating but with reduced function
STOP	The system stopped because of a critical malfunction

Operating mode menus

In the menu "OPERATION", the following operating modes can be selected from:

OFF	No heating functions are active
SUMMER	Normal condition is domestic water, central heating is not active
WINTER	Normal condition is central heating, which is switched to domestic water as needed
AUTO	The system selects on its own operating mode on the basis of average of outside temperature, the set summer temperature and a neutral zone of 4 °C - Winter : After 24 hours under summer temperature minus neutral zone - Summer : After 24 hours above summer temperature

Main menus

HEATING STATUS		Readout of current operation status text This is the main screen image
OPERATE AUTO		The apparatus's main switches and selection of overriding operating mode [OFF, SUMMER, WINTER, AUTO]
HOT WATER SET 45°C		Setting of set point for hot water production. [5..60] Menu only visible if hot water production selected
OUTSIDE CURVE +/- 0°C		Setting for displacement of outside curve [-9..9]. Menu only visible if outside compensation selected
T ROOM SET 20°C		Set point for activation of central heating room compensation [5..30] Menu only visible if room compensation selected
READOUT ↓		Sub-menu for display of current sensor and control data
	T WATER 45°C	Domestic water maintains temperature
	T OPERATE CURRENT	Central heating temperature

	32°C		
	T OPERATE SET 52°C		Current set point for central heating temperature Calculated from the selected temperature compensation functions
	T OUTSIDE 12°C		Outside temperature
	T ROOM 20°C		Room temperature
ADJUST ↓			
	HEAT PUMP↓		
		SUPPLEM OFF	Supplementary heating release for operation (for both domestic water and central heating) [OFF, ON]
		DELAY SUP 0m	Delayed connection of supplementary heating gives heat pump a better chance to meet demand [0..60]
		RESTART CP 20m	Compressor restart time for ensuring against unnecessary wear (between two starts, one following on the other) [2..60] minutes
		COMPRES S MAX 60°C	Maximum return temperature for allowing compressor operation (stop at this on grounds of condenser pressure) [40..80]
		T SUMMER 15°C	Switching point for the automatic summer/winter operation switch (see page 17 Condenser and warm circulation pump) [0..30]
	DOMESTIC WATER↓		
		HEAT HP+SUPP L	Heat source selection for domestic water production [OFF, HP, SUPPLEM, HP+SUPPL]
		MINIMUM 35°C	Temperature set point for supplementary heating (if released and selected) [5..80]
		SET POINT 45°C	Temperature set point for heat pump compressor [5..60]
		T DIFF 3°C	Temperature difference for connecting. Heating starts at entered set point minus this value [1..9]
		LEGIO DAYS OFF	Legionella function's frequency (supplementary heating must be released for operation) [OFF, 7..30] days
	CENTRAL HEAT↓		
		HEAT HP+SUPP L	Heat source selection for space heating [OFF, HP, SUPPLEM, HP+SUPPL]
		T OPERATE MIN 30°C	Minimum allowed set point for the house's return/feed temperature and supplementary heating set point [5..60]
		T OPERATE MAX 60°C	Maximum allowed set point for the house's return/feed temperature [5..60]
		T DIFF 4°C	Temperature difference for connecting. Heating starts at entered set point minus this value [1..9]
		TEMPCNT RL OUT	Central heating temperature control function [MIN, OUT, ROOM, OUT+ROOM](when ROOM is selected, room temperature set point is displayed in main menu)

		CURVE SELECTION 5	Outside temperature compensation curve see Figure 4 (curve menus are shown only if OUT selected under menu TEMPCNTRL) [DEF, 1..10]
		CURVE +/- 0°C	Raises or lowers the calculated curve set point a fixed number of degrees [-9..9]
		CURVE -20 DEF 50°C	Self-defined out/in curve at -20, -10, 0, 10 and 20 °C for return temperature [5..60]
		CURVE -10 DEF 45°C	
		CURVE -0 DEF 40°C	
		CURVE +10 DEF 35°C	
		CURVE +20 DEF 30°C	
		ROOM COMP MAX 10°C	Highest allowed return temperature increase from room compensation (shown if room compensation is selected) [0..20]
ALARMS ↓			
	ALARM 0 NONE		Display of up to 3 current alarms A code and a text are read out for each alarm line. Resets in event of power outage
	ALARM LOG ↓		Alarm log which stores and displays the last 16 active alarms Does NOT reset in event of power outage
		AL 0: 13 T2 SHORT	Most recent active alarm
		AL 1: 20 PRESSURE	Next most recent active alarm

Service menu is activated with key combination:

SERVICE ↓			Service menu for set up, test and troubleshooting
	LMC220 VER 1.03		Apparatus type identification and software version's number
	RESTART CP 914s		Seconds until release of compressor restart Can be reset for purposes of service
	MANUAL↓		Manual activation of outlet relay
		ACTIVATE NO	Activation of manual operation [NO, YES]
		COMPRESS OFF	Start compressor [OFF, ON]
		SUPPLEM OFF	Start supplementary heating [OFF, ON]
		3-WAY OFF	Activate 3-way valve for domestic water [OFF, ON]
		BRINEPMP OFF	Start earth tube brine pump [OFF, ON]
		CIRCPUMP OFF	Start central heating circulation pump [OFF, ON]
	OPERTIME ↓		Operating hours counter
		HEATPMP 8206h	Indicates how long the heat pump has been switched on
		COMPRESS	Compressor

	2184h	
	SUPPLEM 514h	Supplementary heating
	3-WAY 964h	3-way valve for domestic water
	BRINEPMP 4740h	Earth tube brine pump
	CIRCPMP 2948h	Central heating circulation pump
SETUP GUIDE ↓		Menu which leads the user through the selections that are to be made in setting up the system
	...	
LANGUAGE DANISH		Section of user interface language [ENGLISH, DANISH]

Function description

Heat pump's compressor

The compressor's capacity is adjusted by connecting and disconnecting the compressor in so-called modulated on/off operation.

The system is protected with high and low pressure switches that can stop the compressor and issue an alarm.

In the event of heating demand, the heat pump's compressor is started. When the compressor is operating, the central heating temperature is raised to the respective set point before it is shut off. This occurs independently of the neutral zone to avoid unnecessary start/stop.

Earth tube and brine

The brine pump always runs together with the compressor and starts 1 minute before and runs 1 minute longer. After a week of inactivity, the pump is started briefly to prevent blockage.

An environmental pressure switch is connected that gives an alarm and stops the system if the brine system is leaking.

Condenser and warm circulation pump

The system has a water-cooled condenser with an associated circulation pump.

Excessive condenser pressure in the event of failure of the high pressure switch is prevented by circulating hot water in the central heating system, until the temperature is below the set maximum value for the compressor, before the compressor is started.

After a week of inactivity, the circulation pump is started briefly to run it.
In addition the pump has these operating modes, which depend on the overriding control condition:

- Winter operation: The pump runs constantly.
- Summer operation: The pump is stopped when it is not being run.

Supplementary heating

A 1.5 kW electric water heater is connected as a supplement to the heat pump in those instances where it cannot supply the desired heating, for example, in cold and blustery weather.

The supplementary heating must be released for operation by the user. The supplementary heating is activated if the return water falls below the minimum value set (minus neutral zone). In this way it is ensured that the heat pump supplies the greatest share of energy, at the same time as the user, even during extraordinary demand, is ensured a well-defined comfort.

The supplementary heating will also be used as supply security and maintenance of normal comfort in situations where the heat is out of operation because of installation work, defects or the like. In these instances the compressor's set points are overridden, so that the supplementary heating is not controlled here according to minimum values.

Central heating

During regular pump operation, the compressor capacity is adjusted so that a predetermined temperature is maintained on the house's return. The necessary temperature on the return depends on the house's heating demand, which depends on size, insulation and outside temperature. Several different modes for temperature compensation can be selected, which can each be active simultaneously.

Curve management via outside temperature

It is possible to pre-program the set point for the house's return depending on the outside temperature. The desired return temperature is set for outside temperatures at -20°C, -10°C, 0°C, 10°C and 20°C. On the basis of these temperatures, return temperatures are calculated for the current outside temperature with the help of interpolation between the given points in Figure 4. For outside temperatures under -20°C and over 20°C, the programmed return temperature is used for -20°C and 20°C respectively.

You can select 10 pre-programmed curves or a self-defined one.

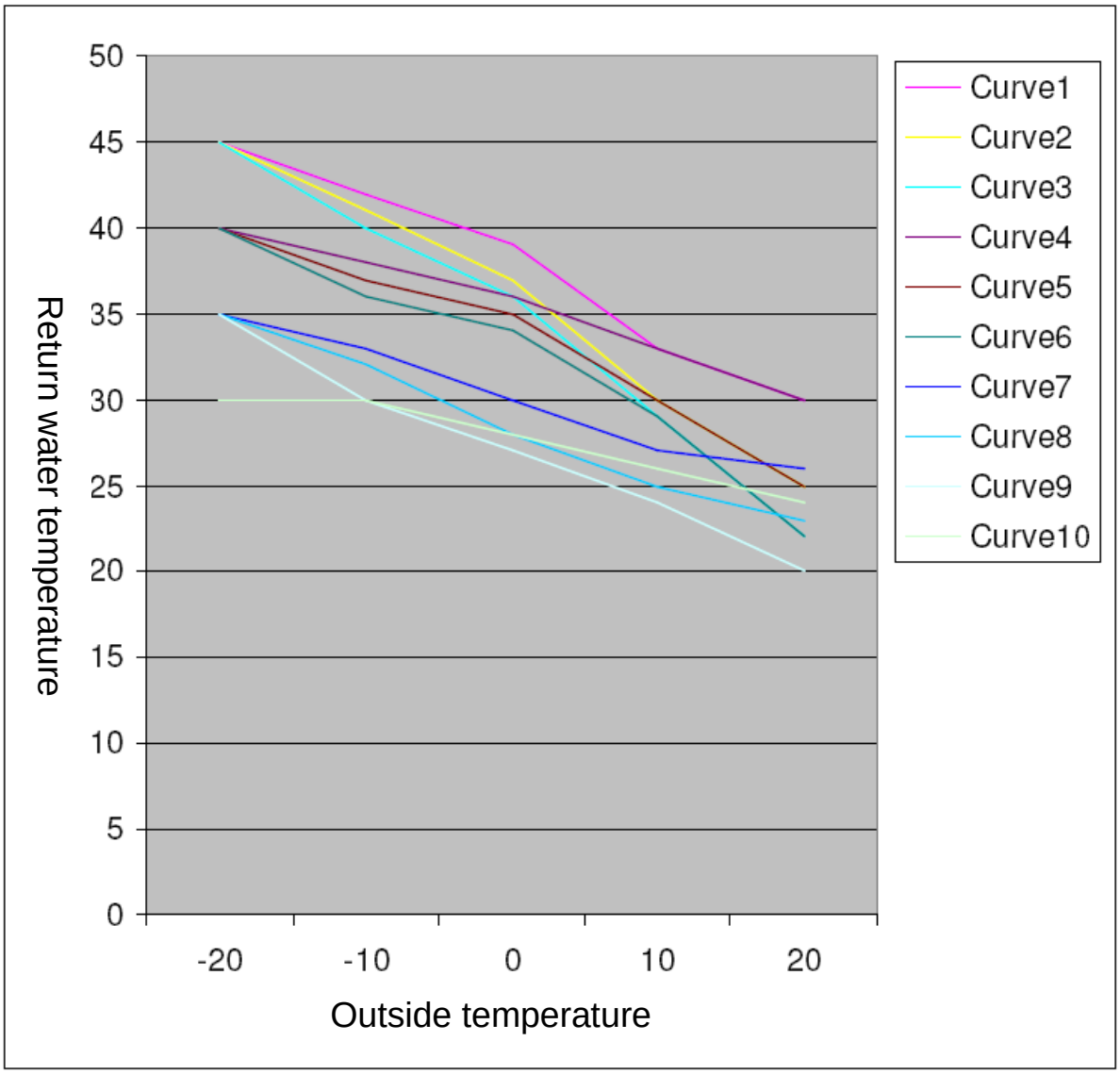

Figure 4: Curve selection for outside temperature compensation

Room temperature compensation

Compensation of the return temperature according to outside temperature is not available, as wind effect and sunshine can affect the heating demand significantly. Room temperature compensation provides an opportunity for ensuring the maintenance of the room temperature in a selected representative room where the best possible comfort is desired.

The room temperature compensation functions by increasing the return temperature if the room temperature in the representative room cannot be maintained. The room temperature compensation has 2 settings, partly the temperature that is desired in the room, partly the maximum number of degrees the return temperature may be increased in order to maintain the desired room temperature. Typical values are 20°C for room temperature and 10°C for maximum increase of return temperature.

The room temperature compensation can only increase the return temperature according to the return temperature provided by the outside temperature compensation. It is therefore important that the outside temperature compensation is set at minimum values for return temperature.

Frost protection

In order to prevent possible freezing damage, a number of preventive functions are built into the system which will always be active regardless of which operating modes and settings may be selected (including OFF). Any missing or defective temperature sensors or other system components will naturally be able to damage this protection:

- If the outside temperature falls below 2°C, the central heating's circulation pump is started. With that, any space between the roof and the ceiling and any attic space is secured, along with it being possible to monitor the water temperature.
- If the central heating or room sensors fall below 2°C, all circulation pumps are started, along with the heat pump and supplementary heating, and the temperatures involved are raised to 5°C, if this is possible.

"Alarms" menu

The menu "Alarms" displays any alarms and alarm overview for the last 16 alarms.

In the event of an alarm, the backlighting of the display blinks. Operating status switches to ALARM or STOP. The cause for the alarm can be read in the sub-menu ALARM.

Along with the alarm, an alarm code is displayed. When the cause for the alarm disappears, the alarm switches automatically from active to inactive and the backlight blinking ceases.

To acknowledge an alarm, press on the control knob in the sub-menu ALARM when the alarm is displayed. With that, the alarm disappears from the alarm log.

Active alarms cannot be acknowledged before the system has registered that the alarm cause no longer is present.

There are 3 alarm levels:

INFO : General information for the user that does not affect the operation.
WARNING : Given in the event of alarms which allow continued operation with small inconveniences.
CRITICAL : This type of alarm means that operation stops entirely or is significantly reduced.

High pressure alarm

The refrigerant pressure is too high in the condenser, which is due to the fact that the heat pump cannot get rid of the heat it is producing. The central heating water is circulating too slowly.

Possible causes:

1. The dirt filter in the central heating system is clogged up
2. There is air in the central heating system – vent the system
3. There is insufficient water in the central heating system
4. "Hot pump" to central heating system is not running. The pump will whir a bit while operating

Check 1-4 and correct the error. Acknowledge the alarm by pressing on the control knob in the sub-menu Alarms when the alarm is displayed.

Low pressure malfunction

The refrigerant pressure is too low in the evaporator, which is due to the fact that there is not enough heat coming from the heat source. Either the brine is circulating too slowly or the brine is too cold when it is returning from the earth tubes.

Possible causes:

1. There is air in the earth tubes – vent the heat source/earth tubes
2. There is insufficient water in the earth tubes
3. The brine has frozen in the heat exchanger. "Cold pump" will feel very hot
4. "Cold pump" to earth tubes/heat source is not running. The pump will whir a little while operating

Check 1-4 and correct the error. Acknowledge the alarm by pressing on the control knob in the sub-menu Alarms when the alarm is displayed. Contact a service technician if the low pressure

switch operates again after a few minutes. There is a danger of freeze damage to the heat pump's evaporator, if one tries repeatedly to start the system.

Leakage

The pressure is too low in the earth tubes/heat source. It might mean that the earth tubes have started to leak.

Check the following:

1. Are all cocks open that should be open?
2. Is there enough brine in the system? Top off as needed

Check 1-2 and correct the error. Acknowledge the alarm by pressing on the control knob in the sub-menu Alarms when the alarm is displayed. Call a service technician if you cannot find the error yourself.

No.	Text	Type	Action	Description
5	DATA BASE	I	--	The control has been reset to the factory setting and requires a renewed default setting. This occurs, for example, if software is updated with a new program that differs significantly from the old - Make the desired settings via menu system
10	T1 DISABL	C	STOP	Return temperature sensor disabled - Check connection. Switch any sensor needed
11	T1 SHORT	C	STOP	Return temperature sensor short-circuited - Check connection. Switch any sensor needed
12	T2 DISABL	C	STOP	Domestic water temperature sensor disabled - Check connection. Switch any sensor needed
13	T2 SHORT	C	STOP	Domestic water temperature sensor short-circuited - Check connection. Switch any sensor needed
14	T3 DISABL	W	7°C is presumed	Outside temperature sensor disabled - Check connection. Switch any sensor needed
15	T3 SHORT	W	7°C is presumed	Outside temperature sensor short-circuited - Check connection. Switch any sensor needed
16	T4 DISABL	W	Deactivate room control	Room temperature sensor disabled - Check connection. Switch any sensor needed
17	T4 SHORT	W	Deactivate room control	Room temperature sensor short-circuited - Check connection. Switch any sensor needed
32	LOWPRESS		Stop compressor supplementary heating is taking over heating	Low pressure alarm. The heat pump will start automatically 2 minutes after the alarm has disappeared.
33	HIGHPRES S		Stop compressor supplementary heating is taking over heating	High pressure alarm. The heat pump will start automatically 2 minutes after the alarm has disappeared. See also Alarm 34.
34	HIGHPRES S		Stop compressor supplementary heating is taking over heating	After 3 high pressure alarms (33) within 12 hours Alarm34 will come. Alarm 34 has a manual reset and must be acknowledged from the Alarm menu in order to start the compressor again.
34	COMPRESS	W	Supplementary heating takes over after 5 minutes.	Safety shut off from compressor high pressure and low pressure - Compressor restarts when user acknowledges the alarm
50	FREEZE	W	Circulation pump are started	Temperature for domestic water, central heating or room sensor has been below 2°C for more than 2 hours. The freeze protection function is active
53	LEAKAGE	W	Supplementary heating takes over after 5 minutes.	Earth tube environmental pressure switch - Check system for leaks
54	OVERHEAT	C	STOP	Return or domestic water overheated to 90°C or more - Check relays and contacts to compressor and supplementary heating
70	LEGIO	I	--	The Legionella function has not been able to be performed within the time deadline for two successive weeks. - Energy supply is lacking from brine or supplementary loop

Table 1: Alarm list

The "Service" menu

The Service menu is only accessible via keying of a code and should only be performed by a VPO service technician.

Installation

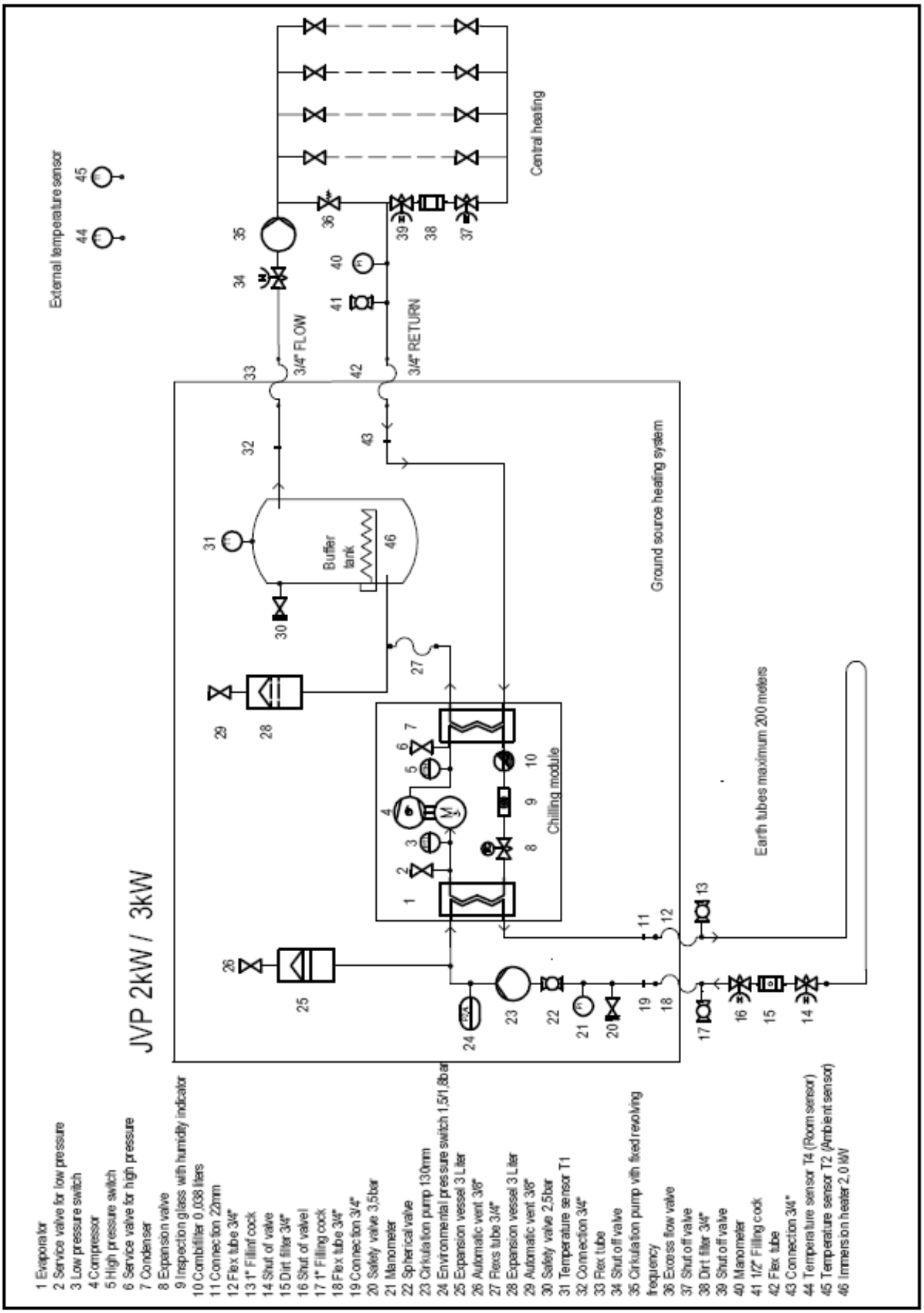

Figure 5: Schematic for ground source heat pump system design.

Electrical connection

The heat pump is connected to electrical installation by an authorised electrician.

Pipe connections

Earth tubes and central heating system are installed on the ground source heat system's rubber tubes that run out through holes in the side panel farthest back on the system. A coupling is used with 3/4" and 22mm pipe and a clamp respectively.

Floor heating loop

IMPORTANT: An overflow valve must be installed (Position 36) in the floor heating loop with a circulation pump with a fixed speed. Alternatively, individual thermostats are installed so that sufficient flow is ensured.

Earth tube routing

Legislation that concerns ground source heat systems includes: Order no. 1203 of 20 November 2006 (applicable) and Order no. 522 of 2 December 1980 (historical). The latter is a good guide to establishing ground source heat systems. The municipal council shall be applied to for authorisation for establishing a ground source heat system. Approval of system shall occur before the construction work is begun. It is the municipality which determines the requirements for the ground source heat system. Authorisation will not be granted for establishing a ground source heat system closer than 300 metres from a public water extraction installation and 50 metres from other water extraction installations. The separation requirements can be reduced if the hydrogeological conditions make it likely that there is no increased risk for contamination of the groundwater.

Area requirements:

Earth tube lines that are placed less than 1.5 metres from the building's footing and less than 1.5 metres from waterlines and sewer pipes must be isolated with impervious insulation. Earth tube lines must be placed a minimum of 0.6 metres from neighbouring boundary lines.

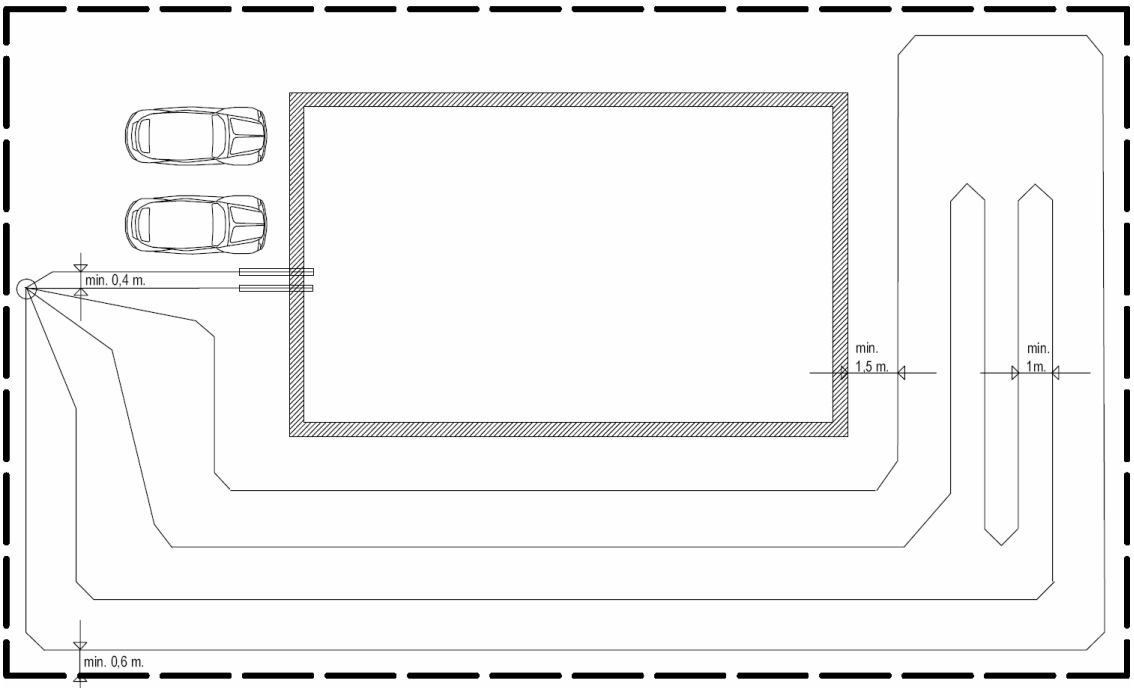

Figure 6: Example of layout of earth tubes in collector.

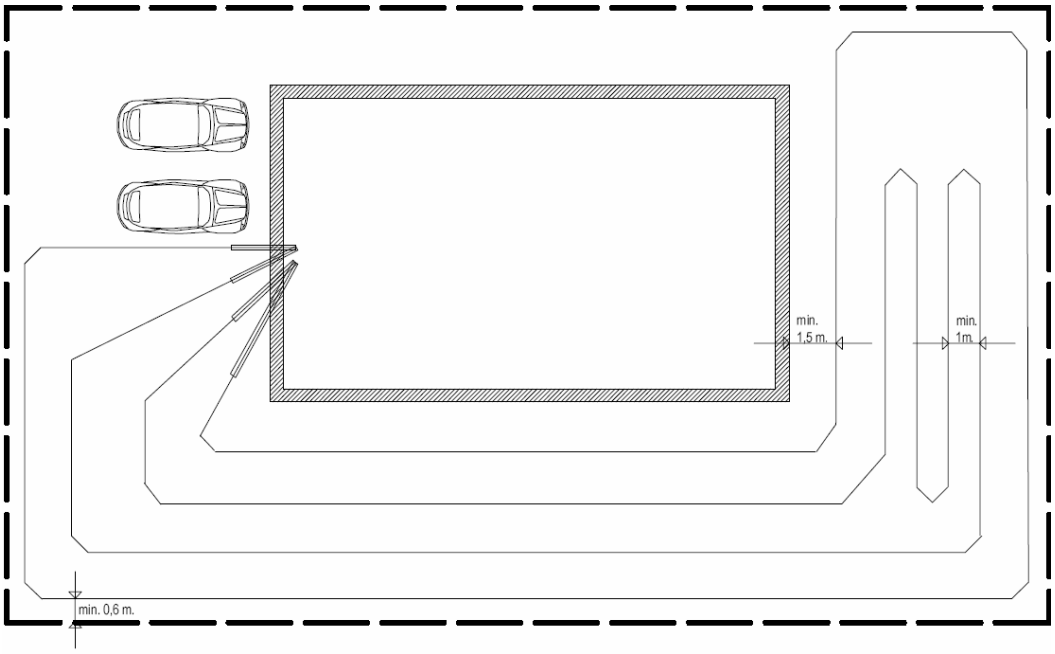

Figure 7: Example of layout of earth tubes with collection inside footing.

Earth tube pipe is laid out in loops that are collected in a manifold in the inspection well, see Figure 6. Alternatively, earth tubes can be collected within the house footing on condition that the pipes are isolated, see Figure 7. All connections must be resistant to tension and done with access for inspection inside or outside the building. Pipe connections that are performed in connection with repairs must be resistant to tension connections for PN6 pipe that have been approved pursuant to the Danish Code of Practice for Domestic Water-Supply Installations. Connections must be marked on the line diagram. All loops must have the same length ±5%. The combined length of the earth tube pipe must be as a starting point 35-40metres of earth tube per kW of dimensioned heat loss in the house (at -12°C outside temperature). The tube length per loop should be greater than 100 metres or less than 150 metres.
The tube length MUST always be dimensioned for the system, but generally one can say that it is always better to have a tube slightly too long than one that is too short.
A tube that is too short will chill the ground too much and the efficiency will decrease on the system.
A tube that is too long for each 180° hose turn will mean that the circulation pump must work too much and the efficiency will decrease on the system.
A tube that is slightly too long will ensure that the flow temperature into the heat pump will never go below zero degrees, and the efficiency (COP) on the system will remain at a satisfactory level - even during a severe winter.

The necessary earth tube length depends on:

- Distance between tubes
- Burial depth
- Tube diameter
- Material thickness of tube
- Soil type – clay – sand – topsoil
- Water content in the soil
- Distance down to groundwater
- Slope of the ground
- Sunshine/shade
- Snow cover in the winter
- Outside temperature

- Correctly dimensioned heat pump/tube length
- Correctly set speed on circulation pump

Clay and watery soil provide better heat transfer than dry and sandy soil. On wet soil therefore the tube length can be dimensioned shorter. Earth tubes are buried to a frost-free depth 0.7-0.9metres (maximum 1-1.2metres). Burying too deep increases the risk of permafrost. The tubes must be buried on the same contour line to avoid air pockets that can be difficult to vent. The highest point for the earth tubes must be at the manifold so that venting can be done through venting valve placed close by. The distance between ground source heating pipes must be at least 1.0 m. preferably more. If for one reason or another it is not possible to meet the separation requirement of 1 metre between the tubes, for example, at lead into collector, it is better to insulate the tubes involved instead of risking short-circuiting or permafrost in the ground. Distance to trees minimum 2 metres. If these directions are followed, there is good security against damage to lawn or plants in the garden resulting from the ground source heating system. Bending radius no less than 15 times the pipe's outside diameter or according to the pipe manufacturer's directions. When burying at bending it is important to take into account any contraction while cooling. The pipes must therefore not be anchored in the ground with stones and the like, as this can result in pulling and cracking of the pipes as a result of temperature-dependent density changes.
From the manifold the pipes are run to two main lines through the base of the heat pump.
Insulation of main lines within the base to avoid condensation. *Note impervious insulation a minimum of 1.5 metres from base or water-bearing system and insulation between pipes if the distance is less than 1 metre.*

Materials:
The pipes must be approved by Danish Standards and marked with DS2119. Earth tubes are done with PEL (polyethylene) pipe type PEL 40x4 PN6.3, i.e., Ø40 mm external, material thickness 4 mm approved for pressure of 6.3 bar. Alternatively, PEM 40x2.4 PN6.3 can be selected. A smaller thickness provides a better heat transfer and lower pump energy consumption (better COP) but pressure requirements must be met. In addition, thinner pipes, even if they meet the pressure requirements, can be more sensitive to external influences and bending during handling and installation. The pipes are supplied with dust caps which must not be removed before immediately being installed on the manifold. Dirt which collects in the pipe can result in clogging of filters, pumps and exchangers.
The manifold can be done in PVC fittings according to the parts list below. When using PVC fittings for the manifold, the collector must be isolated so that ice does not form on the exterior of the manifold. Ice formation can result in freeze damage to the PVC material.

			Pieces by number of pipe layers.		
PVC fittings	Producer product no.	Producer name	1	2	3
Ballcock 1½"	10502391	Plast-line A/S	2	4	6
Transition compression fitting ø40x1½"	13010170	Plast-line A/S	2	2	2
T piece 1½"	10500385	Plast-line A/S	2	2	2
90° angle 1½"	10500195	Plast-line A/S	2	4	6
Pipe PVC1½" for joining	10507100	Plast-line A/S	1 m	1 m	1 m
Transition compression fitting ø50x1½"	13010175	Plast-line A/S	2	2	2
End sleeve 1½" with venting valve (Schrader)	10501396	Plast-line A/S	2	2	2

Table 2: Manifold parts list

The manifold can also be done in steel fittings.

Fill medium (brine):
The water in the earth tubes/heat source must be protected against freezing, so that the heat pump's evaporators do not burst, if the brine freezes to ice. The minimum sensor stops the compressor at the set value. The low pressure switch stops the heat pump if the brine becomes colder than the set value.

Frost protection can be adapted to the earth tubes'/heat source's operating conditions. Water is used as the transfer medium in the earth tubes with antifreeze added (brine). The antifreeze can be glycols, salts or alcohols, for example, ethylene glycol, propylene glycol, sodium chloride (table salt), or mixtures of calcium chloride and magnesium chloride betaine or methylated spirit (denatured alcohol). The label below shows the freezing point for various brines.

Antifreeze concentration	*Percentage by weight*	*0*	*10*	*20*	*30*	*40*
Ethylene glycol	*°C*	*0*	*-3*	*-8*	*-14*	*-22*
Propylene glycol	*°C*	*0*	*-3*	*-8*	*-13*	*-21*
Methylated spirit (Denatured alcohol)	*°C*	*0*	*-4*	*-15*	*-22*	
Sodium chloride	*°C*	*0*	*-6*	*-16*		
Calcium chloride/ Magnesium chloride	*°C*	*0*	*-5*	*-18*	*-46*	

Table 3: Freezing point of brine (water/antifreeze).

Source: 2005 ASHRAE Handbook of fundamentals

Advantage and disadvantages in selection of various types of brine:

Ethylene glycol	*Methylated spirit (Denatured alcohol)*	*Calcium chloride*
Advantage	*Advantage*	*Advantage*
No degreasing effect	*Non-toxic in the environment*	
Disadvantages	*Disadvantages*	*Disadvantages*
Not Classified *Corrosion risk (see)* *Risk for aquatic environment contamination in event of leakage.*	*Classified as Class 3 Packing Group II* *Effective degreasing agent* *Degreasing of bearings in pumps* *Requires approval by the Danish Central Tax and Customs Administration* *Fire hazard in event of spill* *Corrosion risk* *Increased pump energy consumption*	

Table 4: Advantage and disadvantages with selection of various refrigerants

The antifreeze must not be mixed beyond what is specified above, as this makes determination of the water's freezing point more difficult. It is important not to overdose addition of antifreeze, as this results in changes in thermodynamic properties of water and resulting reduction in heat transfer ability. Anticorrosives may be used in the proportions indicated below:

Antifreeze	*Corrosion-reducing substance*	*Concentration % of weight*
Ethylene glycol	*Sodium nitrite* *Sodium benzoate* *Borax* *Benzotriazole*	*0.4* *4* *4* *0.2*
Propylene glycol	*Sodium nitrite* *Sodium benzoate* *Borax* *Benzotriazole*	*0.4* *4* *4* *0.2*
Sodium chloride	*Sodium carbonate*	
Calcium chloride/Magnesium chloride	*Sodium hydroxide*	

Table 5: Refrigerant/water proportions.

Source: Order no. 1203 of 20 November 2006

The quantity of brine depends on the pipe length. The table below can be used to calculate fill quantity per pipe type depending on internal pipe diameter and antifreeze concentration.

Tube type	*Quantity*	*Tube length per piece*	*Internal diameter.*	*Antifreeze concentration.*	*Antifreeze per tube*
	Pieces	*m*	*mm*	*% vol*	*l*
Symbol	***a***	***l***	***d***	***c***	*Vf=3,14*a*l*d/2*d/2*c/100000*
Earth tube					
Earth tube					
Main line					
Main line					
Main line					
In all (the sum of Vf for all pipes)					

Table 6: Calculation table for fill quantity of antifreeze.

PEL 40x4PN6.3 has, for example, an inside pipe diameter of 40-4-4=32 mm and fill quantity of 1.244 m/l or 0.8038 l/m.
Water quantity Vv for the measured out quantity of antifreeze Vf in the concentration c is: Vv=Vf/(c/100)-Vf.
REMEMBER! The warranty does not cover freeze damage in heat exchanger/heat pump if water/brine inside has not been freeze protected to the low pressure switch's setting, -20°C.

Tightness testing:
It is important to pressure test the pipes for tightness individually immediately before covering with earth as during handling/transport cracks can arise in the pipes.
The earth tubes/heat source must be tested for tightness in accordance with applicable legal provisions: The Danish Ministry of the Environment's Order no. 522 of 2 December 1980.

- Report the pressure testing to the municipal council no later than 3 days before testing
- Fill the heat source with tap water and vent thoroughly
- Fill with water until the test pressure is 1.5 times the differential pressure, but a minimum 400kPa ≈ 4bar
- Top up with water every three months until the pressure does not fall below the test pressure level for three months

- The system can be recommended for approval if it can maintain the test pressure for 1 hour

Filling of brine
After a completed and demonstrated tightness test, the system can be filled with brine. Filling of brine should be done by an authorised VPO technician. Brine can be purchased ready mixed with corrosion inhibitors (used also as coolant for vehicles) or can be mixed immediately before filling. In the case of ready-mixed brine, safety data sheets are enclosed which document the composition of the brine. Brine and water must be mixed thoroughly before filling; a Palletank can be used for this, for example. The water should be free of corrosive substances, use distilled water perhaps. Use a powerful pump to empty the earth tubes of air pockets before filling with brine. Calculate the pumping time for filling the system at an established pumping stage; it shall take the calculated pumping time to fill the system with brine. Be careful that air does not enter the earth tubes during filling.

Safety:
The ground source heating pipes are equipped with a low pressure switch which gives an alarm in the event of falling pressure in the earth tube. In the event of an alarm, the system must be disconnected and must not be able to start automatically again. The earth tube system must be dimensioned as a closed system with a resting pressure of 150-250 kPa.
According to guidelines issued by the municipal council, owners of ground source heat systems must arrange annually for an inspection by someone competent in ground source heat systems. Documentation for the inspection must be kept by the owner of the ground source heat system for at least 10 years and must on request be shown to the municipal council.

Installation and removal

Isolation of pipes
All pipes to and from earth tubes/heat source must be isolated entirely right in to the heat pump, if it is possible, so that condensate does form on the cold pipes.

Base under heat pump
It can be advantageous to establish a drain for condensate from the heat pump and water from the safety valve under the heat pump.

Disposal of the heat pump
Contact your municipality or an authorised VPO technician when the heat pump is to be disposed of, as the heat pump and brine must be disposed of in accordance with applicable legal provisions.

Shipping settings.

Energy conservation tips for operation

The flow temperature for floor heating or central heating must be as low as possible.

Dirt filters must be checked and possibly cleaned, as a dirty filter increases the pump energy consumption for circulation of central heating water or brine.

The ground source heat pump and the heating system should be set so that there are as few start-ups as possible.