BAXI

Operation, Installation & Maintenance Instructions

Installation of Ground Array (Slinky®)

Horizontal Ground Coupling for Heat Pumps

Please keep these instructions safe in a safe place.
If you move house, please hand them over to the next occupier.

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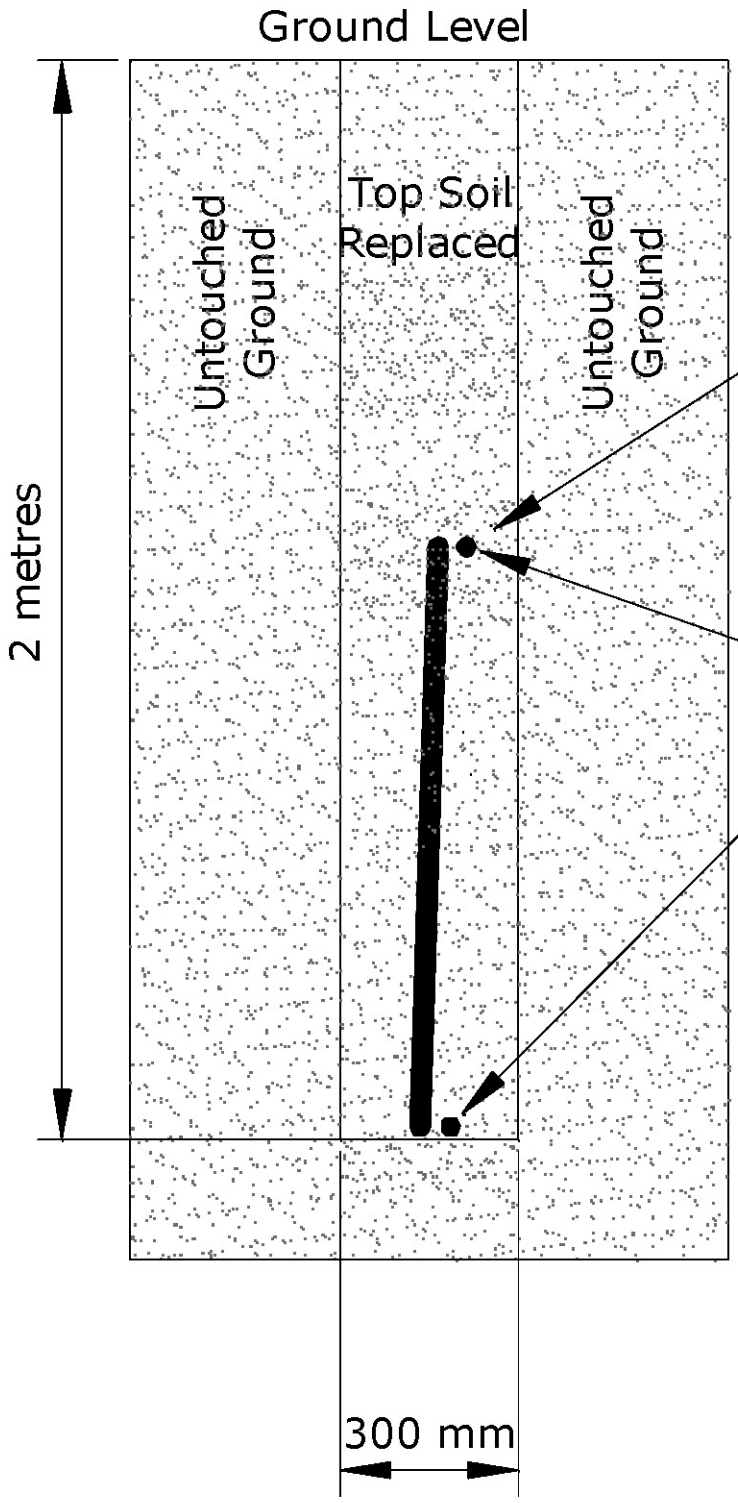
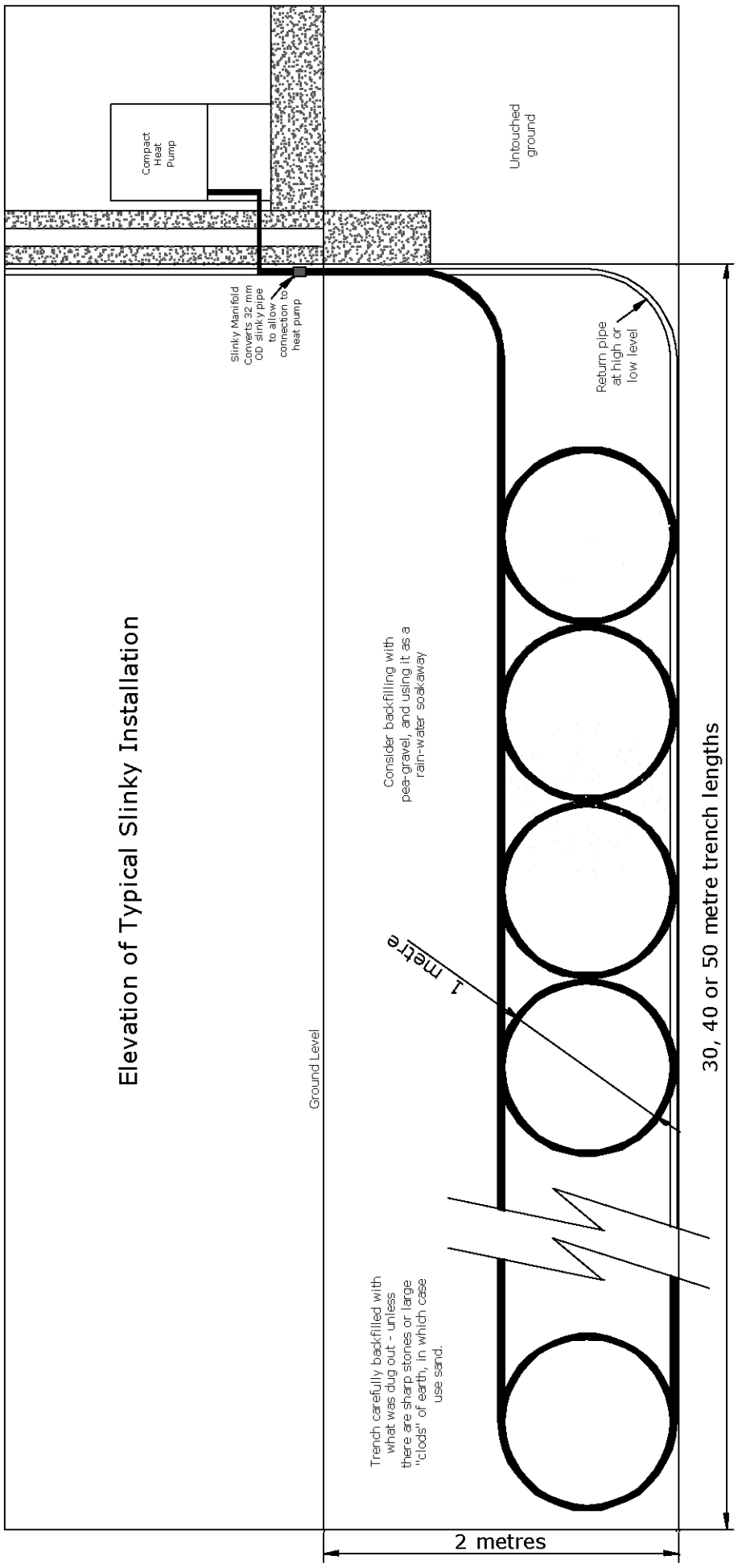


Cross Section Of Typical Slinky Installation

32 mm od plastic "slinky" pipe. Must be MDPE or HDPE, PE80 or PE100, black in colour

Return pipe to slinky manifold at high or low level

Slinky, and its return pipe, is placed in trench and carefully backfilled with the excavated material, graded to remove any large or sharp stones. Where the excavated material consists of large clods (which might leave air gaps around the pipes which result in poor heat conduction) or sharp flints (which could damage the slinky pipe) then sand should be used to backfill until the slinky is covered, after which the excavated material can be used.



Introduction

The invention of the slinky® in 1985 is credited to Oklahoma University in the USA, which could be considered the heart of ground source heat pump technology. Slinkies® are considered by many ground array design experts to be the best method of "horizontal ground coupling" for heat pumps. They are particularly well suited to the UK, and require less digging per kW of heat delivered than any other method - and therefore offer the most economic installation costs.

Why slinkies® ?

Ground source heat pumps do not generally use deep geothermal heat energy from the core of the earth to heat buildings. From several metres down to 100 metres or so, the ground temperature is more or less uniform in the UK, often between 8°C and 11°C; there are obvious local exceptions, including Bath and Southampton. Even "drilled" closed loop vertical ground arrays placed in a borehole only absorb perhaps 5% of their output from "deep geothermal" energy. Instead, ground source heat pumps absorb low-grade solar energy during the winter, which must be gradually re-charged by the sun, and also every time it rains. The ground acts as a battery, which means that incorrectly designed or sized closed loop ground arrays can over-cool the ground surrounding the pipe, leading to much lower outputs and efficiencies from the heat pump. The slinkies® should be a clear 1 metre below ground level; there is little or no temperature advantage achieved by digging much deeper. There is no evidence that vertical ground arrays are any warmer than slinkies®, mostly because the high cost of drilling means that usually only the "bare minimum" of vertical arrays are fitted, whereas slinkies® have a much larger margin of duty. slinkies® have a distinct thermodynamic advantage over drilled systems because the two pipes in a vertical borehole are right next to each other and connected by a porous grout, which ensures that there can never be much temperature difference between the feed and return pipes. In slinky® installations there is no such limitation and the pipes are widely spaced to prevent the very cold water leaving the heat pump from cooling down the warmer water returning from the ground.

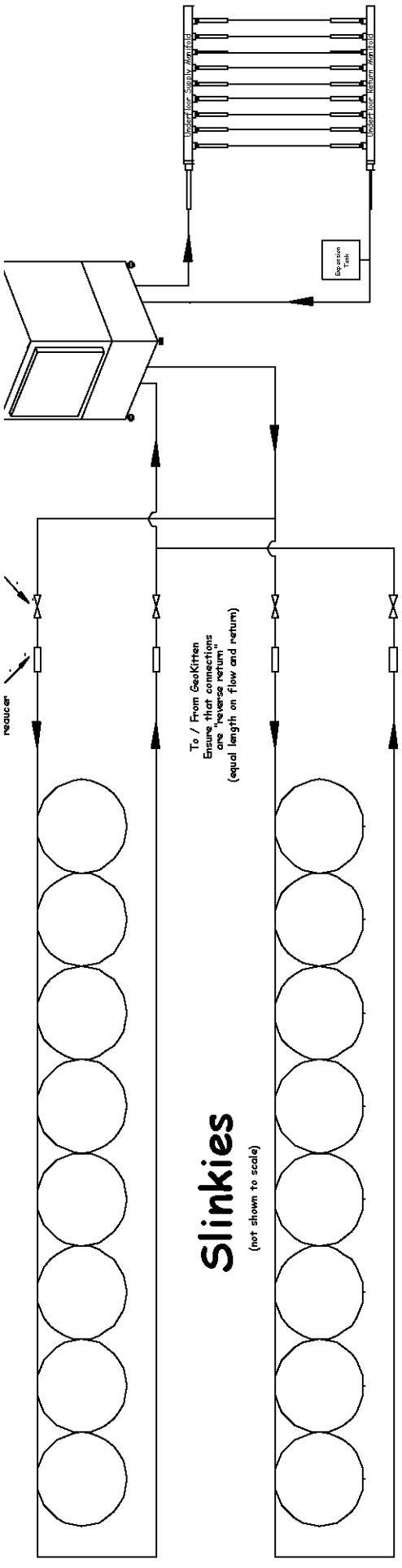
How do slinkies® work ?

The heat pump pumps a cold (typically between 0 and 10°C) mixture of water and "glycol" antifreeze out into the slinkies®. As this mixture passes around the slinkies®, it absorbs low-grade heat energy from the ground before returning warmer to the heat pump. The heat pump uses this low-grade heat to warm a refrigerant, which then transfers it to the water in the building's heating distribution system (usually underfloor heating), in the process "upgrading" the heat into usable energy to heat buildings. A useful analogy is with a domestic fridge, where the inside of the fridge (5°C) is the ground, and the back of the fridge (35°C) is the underfloor system in the building.

What's the difference between "closed" and "open" loop

Closed loop ground arrays circulate the same fluid around them all the time, usually a mixture of antifreeze and water. Open loop system pump water from a source (river/borehole/sea etc) through the heat pump and then dispose of the water. If a closed loop ground array such as a slinky® is placed in a large lake, river or the sea, it behaves like and open loop system, in that the "battery" effect does not apply.

General arrangement of heat pump



Watch out for sites of archaeological importance when digging !

Sizing

The amount of solar energy that lands per square metre is more or less the same anywhere in the UK. It follows that the amount of energy available for heat energy absorption by ground arrays is therefore not affected greatly by different soil types. As a rule, "wetter" soil is slightly better than well-drained soil. The sizing of slinkies® takes little account of soil types - although the type of soil does slightly affect heat transfer rates, other factors such the moisture content (which is not always easy to determine until digging has started) will make much more of a difference. However, the formulae of 10 metres of trench to provide 1 kW of delivered heat from the heat pump can be more or less uniformly applied across most of the UK.

There is a difference between using the "peak" heating requirement of a building to size a ground array, and using the "total annual heat demand". However, providing that the building is insulated at least to the requirements of Part L (J in Scotland) of the building regulations (and, preferably, far exceed this) then the "peak" heating requirement alone can usually be used to size the slinkies®. Provided that the recommended number and lengths of slinkies® are installed correctly, and the slinkies® are sized to meet the full peak heating requirement of the building (ie. as the sole source of heat - without supplementary electrical backup, for example), then they will absorb sufficient energy from the ground to heat the building year-around. If too little pipe is buried then the temperature of the slinky® will fall too much over the course of the winter, to below 0°C, and the heat pump will no longer give its rated output, and exceed its operating envelope. This will cause the heat pump to operate continuously, eventually potentially freezing the slinkies®. If too much pipe is buried then it will take a disproportionate amount of water circulating pump energy to move the fluid around the slinky® at a high enough speed to absorb the energy.

Installation Orientation

slinky® coils should be installed vertically in a narrow (300 mm) trench, dug with the narrowest digger bucket. A minimum distance of 5 metres between adjacent trenches should be maintained. Keep the edge of any trench at least 1.5 metres inside any property line and away from any buildings. The trenches do not have to be straight. If rock or large boulders are found before the trench gets to 2 metres deep, it is possible to turn the slinkies® on their side, for some or all of this part of the trench, and dig the trench 1.2 metres deep by 1.2 metres wide.

The pipe

Only MDPE or HDPE (Medium or High Density Polyethylene) pipe should be used, with at least the PE80 pressure rating. Beware of using blue pipe, which denotes that it contains only fresh water under Water Resources Council guidelines, which would be incorrect as ground arrays contain antifreeze.

Unrolling the coil

The slinkies® are formed and held together using black plastic "zip" ties. When formed into a coil for transport, the slinkies® are held together with white cable ties. When the slinkies® arrive on site, the white cable ties should be cut, which will allow the coil to be unwound. The slinky® can then be laid out and placed in the trench.

Headers

The slinkies® are supplied with a "header", which is usually about 10 metres or more. This allows the 2 m deep slinky® trench to be terminated a little way from the building, and for these header pipes from all the slinkies® to join together into a single "header trench", which is often only 1.2 m deep, and allows the header pipes to exit the soil vertically, directly under the "Slinky® Manifold", which is always fixed to the outside of the building.

Cutting the pipe

The pipe can be cut with a hacksaw, but it is recommended that a proper plastic pipe cutter is used. These are available from plumbers merchants. Do not reduce the total length of one slinky® without reducing the length of all of them by the same amount. This is because the lengths of the slinky® must be equal to ensure that there is equal flow through all the slinkies® .

Digging The Trenches

Any size of digger can usually be used, although a full-sized machine may be required to dig through shale, and to move large boulders or other obstructions. The best way is usually to lay out the slinkies® alongside the proposed route for the trench, and to start digging at the point furthest from the building.

Placing the slinky® in the trench

There are two ways of placing the coils in the trench:-

i) Dig the entire trench, unroll the slinky® from its coil and place it in the trench complete.

ii) Unroll the slinky® from its coil, dig part of the trench and place the slinky® in the trench as you progress.

The first method is preferable where only one or two people are working and where there are no health and safety implications for leaving a long trench open, and the soil is compacted sufficiently for there to be no risk of collapse.

The Return

The return pipe should go in the same trench as the slinky®, and run up the side of the building and into the slinky® manifold.

Unused or excess pipe

Allowing enough pipe above ground (usually 1.5 metres) to cut down and connect into the slinky® manifold, any excess "header" pipe can be coiled back into the trench. Alternatively, it can be cut off, as long as the same amount is cut off all the slinkies®

Tips on manipulating the pipe

There is a tremendous difference between the flexibility of the pipe at 5 deg C (an average winters day) and 20 deg C (an average summers day). However, even on the coldest days, the pipe can still be formed into a 1 metre diameter circle, but this is will be much more difficult.

Testing

The slinky® coils are supplied pre-tested and certified by Baxi. It is recommended that the slinkies® are re-tested with either air or water before the trenches are backfilled. It is possible to pressure test using an air compressor, but great care must be taken in case of a sudden release of air. Using water is a safest method, but it is necessary to "purge" the air from each slinky® using a plastic container full of clean water and a powerful pump. The connection of a garden hose will not produce sufficient volume of water to move the air from the tops of the loops. There are further instructions on the purging of slinkies® ® in our heat pump Operation, Installation & Maintenance Instructions.

Repairing Leaks - Cutting & Joining Pipe

The recommended method of joining buried plastic pipe is to use an "electrofusion" machine, which will produce a suitably robust joint. Alternatively, "Plasson" type "O" seal connectors or brass compression fittings can be used but this is not recommended.

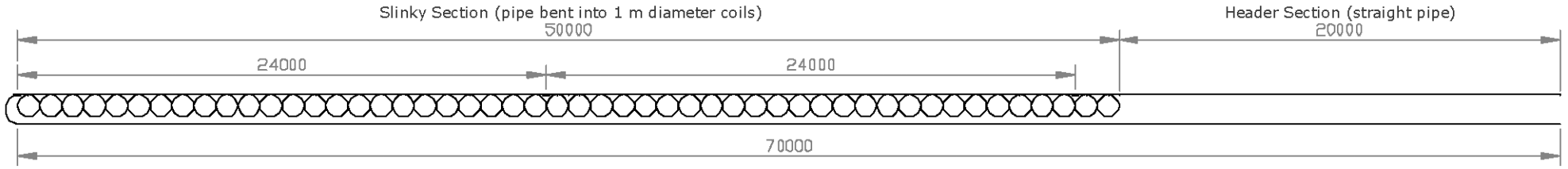
Kinked Pipes

If the plastic pipe is formed in too tight a radius it can possibly kink which must be avoided. If this does happen, it is may be possible to simply straighten out the pipe. If the kink has permanently deformed the pipe, then the damaged section will have to be removed and the pipe rejoined.

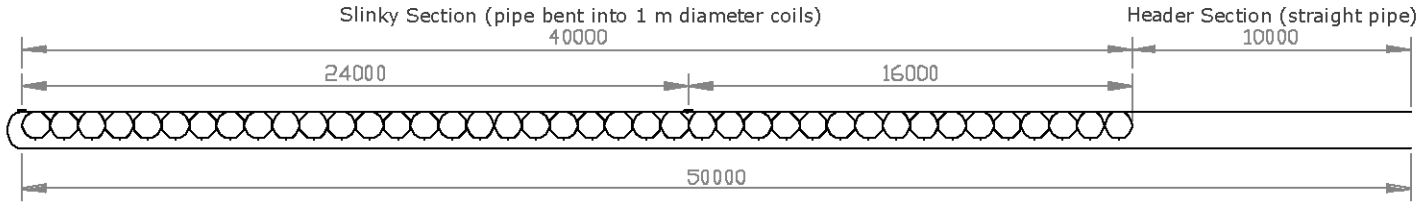
Backfilling

Care must be taken during the backfilling procedure as damage to the slinkies® can easily occur. Heat transfer depends on good contact between the pipe loop and the ground. Clay soils must be carefully prepared before returning the material to the trench, since much larger 'clods' can be present that could leave large air pockets around the slinky®. If the clay is unmanageable and cannot be broken down, a well-graded sand or pea gravel should be used as the backfill. Soils containing sharp flints and rocks should not be used as backfill. A digger bucket dropping stones from a height of 3 metres onto plastic pipe will easily damage the pipe. Since slinkies® are a "closed loop" system any leaks will allow the water pressure to fall below that at which the circulating pump can operate. The earth pile should be shoveled sideways so that it falls gradually into the trench. Break up or discard any 'clods' or lumps of earth. Shoring is required under health & safety legislation if a trench is more than 1.2 metres deep.

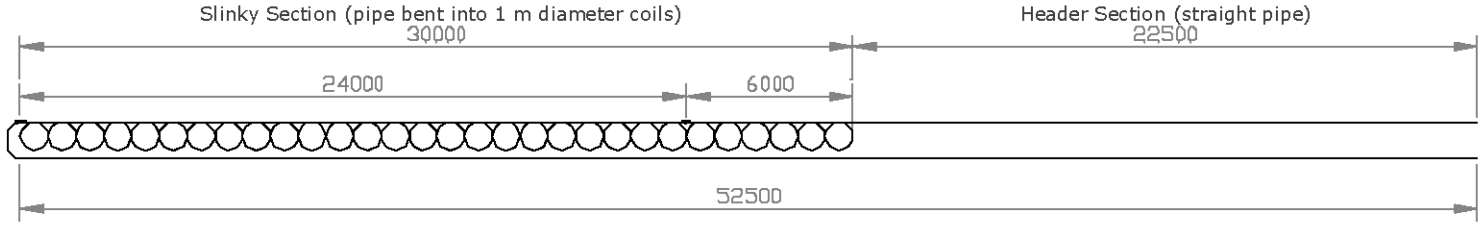
A 50 metre slinky - made from 3 x 100 m lengths of 32 mm OD HDPE Pipe Joined with 3 electrofusion couplers



A 40 metre slinky - made from 2.5 x 100 m lengths of 32 mm OD HDPE Pipe Joined with 2 electrofusion couplers. 20 metres of scrap pipe



A 30 metre slinky - made from 2 x 100 m lengths of 32 mm OD HDPE Pipe Joined with 2 electrofusion couplers



Manifolds

The manifold for the slinkies® should be placed on the outside wall of the building, with the heat pump on the other side of the wall. It is strongly recommended that the manifolds are NOT situated inside a building, as this would require insulation. On the slinky® manifold, each end of each slinky® is terminated in a 32 mm to 28 mm reducer which is connected to a 28 mm compression valve. Each of these valves is connected to either a "feed header" or "return header". It is important that the effective length of each slinky® is the same, to ensure even flow across them all; plumbers call this principle "reverse return".

Connecting pipe to the manifold

The pipe must be cut squarely, and neatly, and any burrs inside or outside removed. A proper plastic pipe cutter should be used. Each slinky® manifold is supplied with copper ferules, one of which must be inserted into the end of each pipe. These ferules act as support sleeves so that the plastic pipe is not crushed by the olive in the 32 to 28 mm reducers. It is essential that the slinkies® must be the same length to ensure even water flow. The slinkies® are all supplied in identical lengths - they must not be cut to different lengths.

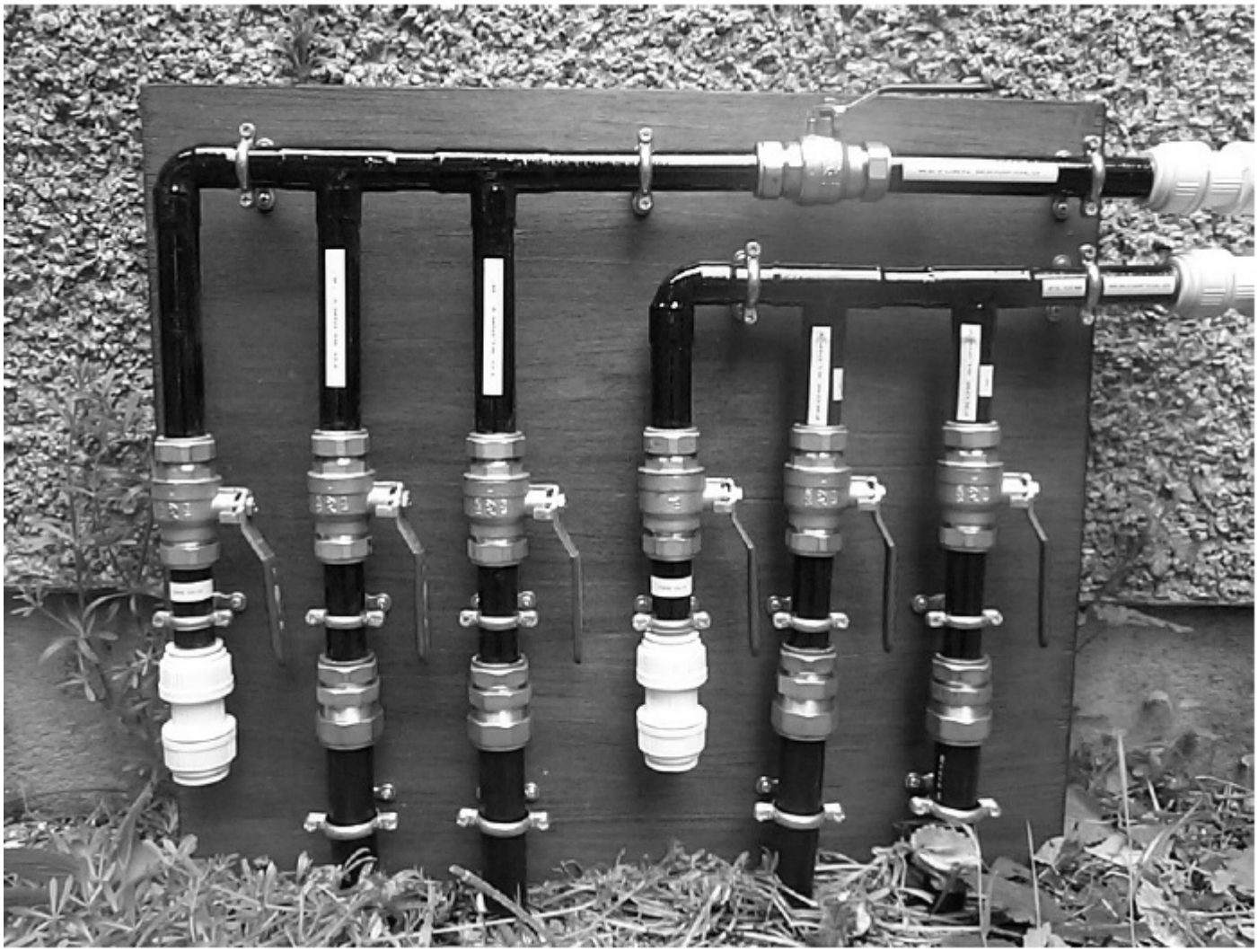
The pipe must be pushed all the way into the reducers, before the nut is tightened. Two spanners must be used to tighten the reducers - one to hold the body of the reducer, and one to turn the nut. As the nut is tightened, the copper or brass olive is compressed onto the plastic pipe, sealing the joint. A jointing compound such as Stag® may be used on the joints. For it to be effective it must be applied to the pipe before it is inserted into the reducer to achieve maximum coverage.

Connecting the manifold to the heat pump

All standard twin slinky® manifolds are supplied with 28 mm Speedfit® push-fit connectors for connection via 28 mm Hep_2O® or similar plastic pipe systems to the heat pump. This pipe can be purchased from any plumbers merchants. The pipes should be insulated using "vapour barrier" (such as Armaflex®) insulation once inside the building to prevent dripping. Any pipe outside the building need not be insulated since the circulating fluid contains anti-freeze.

Typical Manifold Arrangement

Typical manifold arrangement for a pair of slinkies®. Ensure that the slinkies® are connected "reverse return" to ensure even flow through both slinkies®.



Orientation of connections

It is immaterial which direction the fluid is pumped around the ground arrays - the connections to the heat pump are generic. It is essential that the slinkies® are connected so that one end of each slinky® is connected to the "feed" manifold, and the other end is connected to the "return" manifold"; the effective length of each of the slinkies® must be the same.

Using ground arrays in lakes, ponds, rivers etc

Since plastic pipe is buoyant even when filled, the arrays and their headers must be kept in place using weights. The arrays should be assembled on a stainless steel mesh and held down using plastic zip ties. The arrays should be filled with air, not water, and floated into place with any weights attached. When in the proper location, the arrays can be filled with water using a hose (providing that there is sufficient main water pressure) and sunk into position. Additional weights may then also need to be carefully placed on the arrays.

After commissioning

The "disturbed" ground surrounding the newly installed slinky® will not make perfect contact with the pipe initially. After several years of constant rain, and the compression effect of the ground, conduction with the soil will improve. Essentially, if the building is heated successfully over the first winter, performance in later winters will generally improve.

What will the water temperature coming from the ground into the heat pump ?

This will be anywhere between 2 and 5°C below "static" ground temperature—in simple terms, between 3 and 7°C

slinkies®, installed in a lake

Slinkies® being installed in a lake. Note the headers from the other slinkies® on the left hand side that are already floated out.

Adding antifreeze to an 8 slinky® system.

Notes

Baxi Heating UK Ltd
Brooks House, Coventry Road, Warwick. CV34 4LL
After Sales Service and Technical Enquiries 08700 603 261
Website www.baxi.co.uk
e&oe

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