PERFORMANCE SPECIFICATION FOR GROUND SOURCE HEAT PUMP SYSTEM FOR SOCIAL HOUSING

T40 HEAT PUMPS

CONTENTS

100 PERFORMANCE OBJECTIVES

To provide an energy efficient, low carbon means of generating heating for the purposes of maintaining the building's internal temperature requirements and secondary hot water requirements (if required).

A specialist sub-contractor, EarthEnergy Limited or approved alternative with extensive experience of designing and installing closed loop ground source heat pumps of this size and nature is to undertake the design, the supply of the major components, the installation, testing, commissioning and setting to work of a closed loop, borehole based, ground source heat pump system.

Taking into consideration the required thermal energy demand of the building, the site geology, the thermal conductivity of the ground, and the characteristics of the heat pump, the system design shall enable year on year ground thermal equilibrium and achieve the performance objectives.

200 DESIGN PARAMETERS

This performance specification includes design parameters and standards for the ground loop heat exchanger, the heat pump(s) and associated equipment and controls. It does not include any heating/cooling distribution to the building.

The installation will comply fully with the edition (including amendments) of each of the following, current at the time of tender: -

- BS EN 15450 – Heating systems in buildings – Design of heat pump heating systems
- VDI4640 – Thermal use of the underground
- IGSHPA – Closed loop geothermal heat pump systems
- ARI330 – Standard for Ground source closed loop heat pumps
- BS EN 378 Specification for refrigerating systems and heat pumps. Safety and environmental requirements.
- BS EN 14511 Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling
- BSRIA TN18/ 99 Ground source heat pumps: a technology review.
- CIBSE Guide B4 Refrigeration and heat rejection
- HVCA TR30 Guide to good practice – heat pumps
- ISO 13256 International Organization for Standardization (ISO) - Water Source Heat Pumps
- BS 6880 Low temperature hot water heating systems of output greater than 45kW
- Building Regulations
- IEE 17th Edition
- Pressure Equipment Regulations 1999 (SI 1999/2001)
- BS EN 12201 Plastic Piping Systems for Water
- WIS 4-32-17 Polyethylene Pressure Pipes For Pressurised Water Supply And Sewerage Duties

The design day heat loss of the properties shall be calculated to achieve the following design temperatures for space heating:

Living rooms 21ºC
Bedrooms, kitchen, hallway 18ºC
Outdoor temperature – as CIBSE design guide

Hot water shall be heated to 60ºC + to avoid Legionella

The ground source heat pump system shall be sized to meet the design day heat loss with no direct electric supplementary heating.

The heat pump system shall be designed to avoid short cycling, the maximum number of start-up cycles per hour shall be limited to four.

Top up immersion heaters may be incorporated to achieve DHW temperatures in excess of 60ºC daily depending on the heat pump model selected:

Dimplex GSHP Model	SIH6ME	SI7ME	SI9ME
Maximum output temperature	70ºC	58ºC	58ºC

If required the ground source heat pump specialist will undertake an energy assessment of each property and advise energy saving measures to be undertaken. The heat loss coefficient used in determining the size of the GSHP system will be calculated on the basis that all recommended measures are completed prior to GSHP installation.

Controls shall have automatic weather compensation to minimise running costs during milder weather and maximise COP.

The ground loop should be designed using the appropriate ground thermal characteristics (conductivity and diffusivity) for the site. These parameters may be determined from existing information or an in-situ thermal test. The thermal modelling of the ground loop heat exchanger must take into consideration the borehole diameter, the type of grout and the u-tube pipe diameter.

The depth and layout of boreholes, U-tube pipework diameter, length and diameter of horizontal pipework to be arranged to meet the following hydraulic requirements:

- Turbulent flow (i.e. Reynolds Number > 2100) to be achieved under maximum demand conditions in the borehole U-tubes.
- Hydraulic pressure drop in total ground loop array (i.e. as seen by heat pump) to be <50kPa.

Ground loop design to take account of the effects of the antifreeze on viscosity and hence Reynolds number in the hydraulic and thermal design and sizing calculations.

300 SYSTEM DESCRIPTION

A ground source heat pump specialist shall be employed for the design, supply, delivery, installation, testing, commissioning and setting to work of a closed loop ground coupled, borehole based, heat exchanger, generally comprising of the following:

- Supply of heat pumps
- Supply of hot water cylinders (if required)
- Supply of buffer tanks (if required)
- Supply of ground loop circulation pumps
- Supply and installation of ground loop pipework including boreholes
- Initial filling of system
- Testing and commissioning

Warranty

The ground source heat pump specialist will remedy any defects within the above-defined scope of works arising within the first year after commissioning.

The heat pump shall carry a 3-year manufacturer's warranty.

Heating Distribution system (installed by others)

The ground source heat pump specialist shall advise on the heating distribution system within the property.

The requirement for high water content radiators shall be alleviated by installation of a buffer tank, and the system shall be capable of having thermostatic radiator valves fitted on the bedroom radiators.

Wherever possible the existing radiators and distribution pipe-work shall be re-used.

If the existing radiators are not considered to be of the correct size to give adequate heat output at the lower operating temperatures, then the preference is to add or upgrade existing radiators rather than wholesale replacement.

In properties with unsuitable or no existing radiator systems, the ground source heat pump specialist will provide guidance on correct radiator selection and sizing.

The ground source heat pump specialist shall supply an unvented hot water cylinder (minimum 180ltr) suitable for pressurised system and an appropriate buffer tank - these may be combined.

400 CONTROL REQUIREMENTS

Unless otherwise specified the heat pump shall be complete with microprocessor controller capable of the following:

- Complete autonomous operation, with all appropriate integral protection devices, fault indication and logging
- Provision for remote heat pump enable and remote heating or cooling control inputs.
- Provision for controlling ground loop circulating pump
- Provision of internal and/or external sensors, programmable weather compensated set points for heating.

If required, the ground source heat pump specialist shall provide a kWh meter for connection by others to allow monitoring of system consumption.

500 SCOPE OF WORKS

The ground source heat pump specialist shall include all elements considered necessary to affect a complete package, including the following:

Management / Supervision

Geological Assessment
Ground Loop Design
Supervision of drilling / groundworks / building entry / heat pump installation
Liaison with main contractor / plumbing contractor / electrical contractor

Work Undertaken

Supervisor
- Site survey
- Setting out
- Obtaining permissions for water use / disposal
- Provision of Safety / Welfare / Storage facilities

Drilling crew
- CAT scan
- Trial hole excavation
- Drilling of borehole(s) using appropriate technique
- Temporary / Permanent casing as required
- Control and disposal of water
- Collection and disposal of arisings
- U-tube installation, filling, pressure testing, capping
- Borehole Grouting
- Site clearance

Groundworks crew
- Trench excavation
- Pipe laying, including extension of u-tube by electrofusion welding
- Building entry and temporary pipe capping
- Sand bed and surround
- Insulation as necessary
- Backfill
- Clearance and disposal of surplus
- Making good building entry points

Engineers
- Heat Pump installation
- Ground loop pump box installation
- Ground loop connection pipework
- Flushing and purging of ground loop
- Filling with antifreeze
- Commissioning Heat Pump
- User Instruction / Training

Extent of Work by others

The client will arrange for the following works to be carried out by others:

- Electrical works
- Connection of heating distribution system to heat pump
- Alterations to radiator systems
- Supply and installation of new heating distribution systems where necessary
- Installation only of domestic hot water tank
- Connection of hot water tank to heat pump and to domestic hot water system
- Powerflush of existing heating distribution where this is being re-used
- Replacement fences where hedges removed
- Removal of redundant heating equipment within property
- Builder's work inside the house

600 SYSTEM COMPONENTS

Each system shall be a closed loop coupling to a brine/water heat pump unit

The ground loop shall consist of vertical boreholes incorporating specialist 'geothermal' u-tubes (also known as 'geothermal probes').

The U-tubes will be factory fabricated, HDPE, SDR-11, and PE100, the OD will be 32mm or 40mm – depending on the hydraulics of the system. U-tubes to be of continuous length (i.e. no joins/ welds) other than for U-bend. U-bend to be single moulded piece and to be factory welded to the pipe tails.

Horizontal connecting pipework shall be black Medium Density Polyethylene PE80 or PE100 SDR-11.

Borehole grout will be specified by the ground source heat pump specialist according to the ground loop heat exchanger design. Typically this will either be bentonite/water mixture achieving 20-30% solids content or a specialist thermal grout.

The grout is required to achieve the low permeability (i.e. $1x10^{-7}$ - $1x10^{-9}$ cm/sec) required to resist the through-flow of ground water and yet retain a pumpable consistency for an adequate period of time. [Note: This is not the same as the materials used in making bentonite / water drilling mud. This is a grout not an API drilling fluid.] Grout is to be injected over the full length of the boreholes, using tremmie pipes inserted to the bottom of the borehole, and withdrawn during grout injection.

Antifreeze protection to be monoethylene glycol treated with inhibitors and biocide to prevent corrosion and biological growth. Freeze protection to be to below the lowest temperature modelled by the specialist ground source heat pump company in the ground loop array and heat pump evaporator.

The heat pumps to be selected and supplied for this project are to be brine-to-water units suitable for closed loop application. NB many water-to-water heat pumps may be suitable for open loop operation, but are NOT suitable for closed loop operation.

The heat pump(s) is to use a zero ODP (Ozone Depletion Potential) and low GWP (Global Warming Potential) refrigerant that complies with all current UK legislation.

The heat pump cabinet is to provide acoustic protection and compressors are to be mounted on internal anti-vibration mounts. Heat pump to supplied with anti-vibration mounts.

'Buffer' tanks shall comply with BS EN 12897:2006 and shall be insulated with at least 50mm CFC/HCFC free spray foam insulation and with operating pressure range to 0.3MPa

Circulating pumps shall comply with BS EN 1151:1999 and shall be suitable for chilled water with ethylene glycol or other anti freeze as selected.

700 INSTALLATION

The project will be notifiable under CDM Regulations.

If required, the ground source heat pump specialist shall be principal contractor under CDM, and shall work with the CDM Coordinator to satisfy the CDM requirements.

The ground source heat pump specialist will be required to submit a Method Statement and Risk Assessment for the installation and will be required to meet all the requirements of the CDM regulations.

The ground source heat pump specialist will be required to produce drawings showing proposed borehole layout.

Borehole drilling will be undertaken by competent specialist drillers operating drill rigs in compliance with BS EN 791 – Drill Rigs Safety, BS EN 12100 – Safety of machinery, and including fixed or interlocked guarding where required.

The impact of the drilling operation on existing tenants and neighbours is a major concern. Every effort shall be made to minimise the nuisance from spoil, noise, access, water use etc. The site shall be left clean at the end of every working day, and paths on affected properties jet washed as necessary.

The vertical alignment of a borehole is never perfect, however each borehole shall be in alignment to such an extent that the closed-loop piping can be placed to the entire borehole depth and such that the borehole does not intersect another nearby borehole. Boreholes shall be spaced at a minimum of 5m centres to mitigate the risk of intersection.

Polyethylene pipework in horizontal trenches is to be laid at a nominal depth of 900mm below finished level with a 100mm thick bed and surround of course sand in order to avoid pipe abrasion. Remainder of trench to be backfilled with suitable excavated material or imported fill.

All sub-surface connections of the polyethylene (PE) pipework to be made using electrofusion welding, carried out to UK gas specification by competent operatives. All plastic welding to be carried out in suitable weather / environmental conditions. No mechanical jointing shall be used for buried pipework connections.

All ground loop heat exchanger pipework above ground will be insulated with flexible, closed cell, elastomeric, nitrile rubber insulation specified by the specialist sub-contractor. Insulation shall be fibre free and CFC free with an ODP of zero.

800 TESTING AND COMMISSIONING

The U-tubes for the boreholes are to be pressure tested, as a minimum, after installation in the boreholes and prior to grouting to maximum working pressure + 5 bar for a period of 0.5 hours, (refer to good practice guide HVCA TR6).

The U-tubes will be flow tested after installation in the boreholes and prior to grouting.

Once the flow and return have been connected to the borehole U tubes, the entire ground heat exchanger pipework is to be pressure tested as above for a test period of 2 hours.

Following connection to the heat pump and ground circulating pump the ground heat exchanger hydraulic circuit is to be flushed and purged of all air, charged with anti-freeze and left in a pressurised state (approx 1 bar). A typical flushing rate in excess of 0.6 m/s is required to remove entrapped air bubbles from the U-tubes and horizontal pipework.

Ground source heat pump specialist to allow for supply of as-installed drawings of the boreholes.

END OF SECTION T40

Schedule of Responsibilities

	New Build	Retrofit
Ground contamination assessment/investigation works if required (and necessary actions)		
Tracing and marking existing underground services.		**Y**
Production of property details sheet detailing borehole and heat pump locations		**Y**
Setting out of borehole positions.		**Y**
Protection to road surfaces, curbs, grass verges etc.		**Y**
Breaking out/Lifting and storage of block paving/tarmac		
Drilling of the geothermal boreholes.	**Y**	**Y**
Supply of Borehole U-tube (ordered separately)	**Y**	**Y**
Emplacement of single high density polyethylene borehole u-tubes.	**Y**	**Y**
Low permeability grout supply and grouting in place	**Y**	**Y**
Excavation of trench from the borehole to heat pump location (where necessary)	**Y**	**Y**
Protecting open trenches and existing underground services	**Y**	**Y**
Supply and lay connecting pipework and sand bed and surround in trenches.	**Y**	**Y**
Backfill and compaction of trenches.	**Y**	**Y**
Removal of drilling cuttings and trenching spoil	**Y**	**Y**
Obtaining permission to discharge de-silted water to foul drainage		**Y**
Reinstatement of block paving/tarmac		
Flushing, filling and pressure testing ground heat exchanger with water	**Y**	**Y**
Flush and purge the ground heat exchanger and charge with antifreeze	**Y**	**Y**
Supply of heat pump and hot water cylinder	**Y**	**Y**
Supply of flexible hoses to ground and load side of heat pump	**Y**	**Y**
Unloading and setting in place hot water cylinder		
Unloading and setting in place heat pump and ground loop pump	**Y**	**Y**
Installation of flexible hoses to ground and load side of heat pump	**Y**	**Y**
Connection of ground loop to circulation pump	**Y**	**Y**
Supply and installation of the building heating systems on the load side of the heat pump		
All load side plumbing works		
All electrical wiring		
Builders work in connection ground loop entry points into the building		**Y**
Builders work in connection load side pipework & electrical entry points into the building		
Filling and purging of air from the building heating systems		
Commissioning of ground loop circulation pump and heat pump	**Y**	**Y**
Optional		
Supply and installation of external enclosure for heat pump	**Y**	**Y**

Electricity Supply Specification

The following is an advisory document only and the responsibility for the installation remains with the electrician

The proposed ground source heat pumps incorporate an electrically driven refrigeration compressor powered by a 230 volt single phase motor incorporating a soft start facility.

The electrical specifications of these units are as follows:

Dimplex GSHP Model	SIH6ME	SI5ME	SI7ME
Nominal power consumption kW	1.47	1.30	1.70
Nominal running current Amps	9.3	7.1	9.3
Starting current with soft start	38	24	26
Power Supply Volts	230	230	230
Supply fuse rating Amps	20	16	16

A protected 230volt single phase supply will be required to be connected directly to the electricity distribution company's Customer Consumer Unit (fuse box). The supply should be rated at 30 Amps (similar to a cooker supply) and incorporate a motor rated fuse or Type C (motor rated) circuit breaker.

All cable and protective device sizes should be careful selected to provide the circuitry and associated equipment with adequate protection.

Where the heat pump is fitted in an external enclosure, it is recommended that consideration is given to the installation of a Residual Current Device (RCD) to ensure that the necessary tripping times are achieved. Also, the electrician should ensure that equipment with the appropriate weather-proof (IP rating) is fitted.

The supply should terminate in a double pole switched isolator mounted adjacent to the heat pump. This isolator should have a minimum 3mm air gap when turned off.

On completion of the work, the installation should be tested in accordance with the IEE Wiring Regulations prior to energising.

Mechanical Services Specification

The following is an advisory document only and the responsibility for the installation remains with the heating engineer.

1.0 Design Temperatures and Flow Rates.

Heat pumps do not produce water at the same temperature as fossil fuelled boilers. Typical maximum temperatures are 60ºC for heat pumps compared with 80ºC for boilers.

Flow and return temperature differences should not generally be designed to be greater than 5K.

2.0 Operating Efficiencies.

In general the lower the output temperatures of the heat pump the higher its overall efficiency.

Efficiencies (normally referred to as Coefficients of Performance or CoP s) can exceed 500% when supply temperatures are close to 35ºC, but will only be around 200% when temperatures are nearing 70ºC.

Overall seasonal efficiencies (known as Seasonal Performance Factors or SPFs) are lower than these, and could have typical values close to:

420% for under floor heating at 35ºC.
320% for radiator heating at 50ºC.
220% for domestic hot water heating at 60ºC.

3.0 Control Stability.

'Quick response' heating systems with low water content should be avoided to prevent short cycling of the heat pump, this can be achieved through the incorporation of a suitable buffer tank.

It is important that the heat pump 'sees' a substantial non-disconnectable thermal mass in the heat distribution system.

This should be achieved by restricting the number of thermostatically controlled zones in the house, allowing most of the system to be controlled as a single 'open' zone under the dictate of the main room thermostat (usually located in the living room or hall), which turns the heating circulation pump on and off in the normal way.

In general the kitchen and bedrooms are the only areas which should be control restricted (to give lower temperatures than those desired in the rest of the house).

4.0 Radiator Sizing.

Radiators should be sized assuming maximum flow/return water temperatures of 50/45ºC.

This will give a radiator surface to room air temperature difference of 25-30K, rather than the 'normal' difference of 50K which is the standard value used in the radiator sizing charts issued by the manufacturers.

The required heat output of each radiator in the house is calculated from the individual Design Day heat losses for each room plus 10% to allow for heat up. The sum total of all the room losses is then checked to ensure it does not exceed the rated output of the heat pump.

On a cautionary note, the radiators should not be oversized more than is necessary 'just to be safe'. Excessive radiator area will lead to the heat pump finding a balance point at lower than expected temperatures. On the plus side efficiency will be up, but occupants may feel that the radiators are not as hot as they expect and think that the heat pump is not working properly.

5.0 Under floor heating.

Under floor heating can be particularly suitable for connection to heat pumps because its ideal operating temperatures are low and the heat pump will be able to operate at its highest efficiency.

Floor surface temperatures should never be higher than 28ºC (other than in bathrooms where up to 32ºC may be permitted) and typical heating distribution temperatures would usually be no higher than 40ºC.

Care must be taken over the nature of the final finished floor covering since it is very easy to effectively insulate the heat distribution system from the room and reduce useful heat output.
In practice the heat pump will just keep running until the set room temperature is reached, but this will lead to the circulating water temperature being higher than necessary and the overall efficiency of the system will consequently be lower than expected. The manufacturers of under floor heating equipment should provide detailed information on suitable floor finishes that will match their system designs.