PERFORMANCE SPECIFICATION FOR GROUND SOURCE HEAT PUMP SYSTEM

T40 HEAT PUMPS

CONTENTS

100 PERFORMANCE OBJECTIVES

To provide an energy efficient, low carbon means of generating heating and / or cooling 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.

In consideration of any potential congestion on the site, it is essential that the specialist sub-contractor liases closely with the Main Contractor to ensure that the installation of the ground heat exchanger is correctly programmed into the overall work plan, so that it does not interfere with or delay any other construction activity.

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 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 combined ground loop array and heat pump system shall be capable of delivering the specified peak output heating (and/or cooling) loads and the monthly energy quantities specified in the demand profile assessment of thermal energy.

The heat pump(s) shall be capable of delivering the specified output temperatures under all anticipated source side operating temperatures and able to achieve high average COPs (SPFs) commensurate with practical engineering constraints and cost effectiveness with a heating/chilled water distribution system designed for a

temperature drop/rise of 5-7℃ under source side EWT operating temperature limits of –5 to 15C in heating mode and 10C to 35℃ in cooling mode.

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.

The final number, 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.

Equal flow rates are to be achieved in each U-tube by the use of manifolds incorporating flow balancing valves.

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
- Supply and installation of flow and return pipework between manifolds and plant room
- Supply and installation of manifolds
- Initial filling of system
- Testing and commissioning

The ground loops shall be run back individually to manifolds which shall connect all loop pipes complete with isolating valves

The flow and return shall run underground and shall rise into the plant room where it shall be terminated with isolating valves.

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, with facility to output common fault alarm.
- Provision for remote heat pump enable and remote heating or cooling control inputs.
- Provision for controlling ground loop and primary circulating pumps
- Provision of all internal and / or external sensors, programmable weather compensated set points for heating and / or cooling.
- Provision for BMS communication via open protocol / modem

500 SCOPE OF WORKS

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

- Geological review of site conditions
- Ground loop thermal modelling and hydraulic design
- The drilling and grouting of boreholes (vertical system only)
- The provision and installation of all ground heat exchanger pipework, terminating in the plantroom.
- Selection and supply of heat pump(s), ground loop circulator(s) and buffer tank(s) (if required)
- The provision of relevant installation instructions, schematics and wiring diagrams.
- The testing, commissioning and setting to work of the ground loop and heat pump.
- The provision of test and commissioning data.
- The provision of Operation and Maintenance Manuals

Work “by others” is generally envisaged to comprise of the following;

- Main Contractor
    - Excavation and backfilling of trenches for horizontal pipework, supply and laying of sand / bedding material for horizontal pipework, excavation and construction of manifold / pipework enclosures for horizontal pipework.
    - Associated builder's work, including plant bases, making holes through walls or floors, provision of ducts for incoming ground loop pipework to plant room.
    - Removal of spoil from site

- Site storage for materials
- Provision of water supply on site for drilling and grouting activity.
- Off loading and dry storage of equipment, including heat pump.
- Provision of welfare facilities

- Mechanical Installer
  - All above ground pipe work, connection onto HDPE pipe work, all plant room fit-out including installation of heat pump units, circulation pumps and buffer vessels.
  - Placement of heat pumps, circulators and buffer tanks to assigned locations in plant room.
  - Heat pump, circulator and buffer tank installation.
  - Provision and pressure testing of pipework connections to heat pump within plant room.
  - Provision of facilities for thermal expansion, draining, venting, flow regulation, flow and temperature measuring.
  - Insulation of pipework to / from heat pump.
  - Plantroom as installed schematics, schedules and statutory notices
  - Energy metering and display (if required)
- Electrical Installer
  - Provision and testing of electrical power / earthing and control wiring to heat pump, sensors, M&E control panels and circulators.
- BMS Installer
  - All other control and power wiring.

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 PE 80 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 Specialist ground source heat pump contractor will provide manufacturer's technical data in the tender submission, detailing heating and/or cooling outputs (as appropriate) and COP's at quoted operating conditions. This should include conditions at or close to 0°C EWT in heating mode, and 35°C EWT in cooling mode, with stated output load side flow temperatures.

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 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 Health and Safety Plan provided by the Main Contractor on this site.

The ground source heat pump specialist will be required to produce drawings showing proposed borehole layout, associated horizontal pipework / manifold arrangements and flow /return pipework to plant room, together with plant room termination arrangements.

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 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 horizontal pipework to be marked using suitable detectable marker tape laid 200mm above buried pipework.

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 PAINTING

The following finishing paintwork shall be carried out by the specialist sub-contractor:

a) Bare steel tube and fittings Either exposed to atmosphere, or within plantrooms and service shafts	- 1 coat oil based undercoat - 2 coats oil based gloss paint
b) Internal bare Steel tube and fittings concealed from view within floor and ceiling voids	- left red oxide primer
c) Bare Copper tube and fittings	- cleaned of all flux and left unpainted. Tube to be polished where exposed to view internally.
d) Cast Iron, Valves, and other items of equipment.	- painted two coats oil based gloss paint.
e) Plant items provided with manufacturers own final paint finish necessary.	- paint finish to be "touched up" to maintain original finish as

900 FIXING TO BUILDING FABRIC

The specialist sub-contractor shall fix pipes and fittings securely with fixings and fastenings appropriate to the location.

All steel brackets and fixings shall be fabricated at works and painted one coat of zinc chromate before delivery to the site. All nuts and bolts shall be cadmium plated.

1000 IDENTIFICATION OF MECHANICAL SERVICES

The specialist sub-contractor shall identify the ground loop heat exchanger within the plant room in accordance with BS 1710 and the CIBSE Guide to current practice, each pipe shall be provided with flow direction arrows.

1100 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 headers have been connected to the borehole U tubes, the entire ground heat exchanger pipework is to be pressure tested as above prior to backfilling of any trenches for a test period of 2 hours.

Following connection to the heat pumps and ground circulating pump(s) 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 ground loop array and header pipework

O&M manual to be provided on completion of works and commissioning. All pressure testing records and commissioning performance records to be included.

Visually examine the installation including the following: -

- The piping is supported adequately
- Piping is arranged and painted correctly
- Hand wheels or levers are fitted to valves with clear indication of open/ closed position
- Electrical bonding is complete

1200 SCHEDULE OF INSTALLER'S SUBMISSIONS

Submit the following for the Design output : -

- Ground modelling output
- Hydraulics calculations
- Heat pump technical data
- Circulation pump technical data
- Buffer tanks and DHW cylinder technical data
- Schematic

- Borehole layout drawing
- Standard details drawing
- Designers risk assessment

Submit the following construction information

- Risk Assessments
- Method Statements
- Test and commissioning certificates
- operating and maintenance instructions

END OF SECTION T40

GROUND SOURCE HEAT PUMP SYSTEM SCHEDULE

For heating and cooling systems the heat pump arrangement will be required to operate as

- Changeover system (ie either heating or cooling)*
- Capable of delivering heating and cooling simultaneously using either*
    - Individual Heating and Cooling heat pumps*
    - Single mode Heat Pumps with external hot & cold buffer tanks*

(*delete as appropriate)

Design day heating/cooling loads

Design day heat loss: ……***kW***
Design day heat gain: ……***kW***

Heating secondary flow temperature **……ºC**
Cooling secondary flow temperature **……ºC**

Monthly Load profile

Month	**Heating kWh**	**Cooling kWh**
Jan	……	.....
Feb	.....	.....
March	.....	.....
April	.....	.....
May	.....	.....
June	.....	.....
July	.....	.....
Aug	.....	.....
Sept	.....	.....
Oct	.....	.....
Nov	.....	.....
Dec	.....	.....
Annual Totals:	***.....***	***.....***

Domestic Hot Water

Required quantity of DHW. …… litres/day