Shallow Ground Source Standard

Issue 1.0

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Ground Source Heat Pump Association
23 York Road,
Stony Stratford,
Milton Keynes
MK11 1BJ

T: 01908 562600
E: info@gshp.org.uk
W: www.gshp.org.uk

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1.0 PREAMBLE

1.1 Introduction

The Ground Source Heat Pump Association (GSHPA) has recognised that the industry, including consumers and industry members, require "Best Practice" installation standards in order to maintain a high level of installation quality whilst protecting the environment.

The standards are aimed at the designers and installers of ground source systems, architects and engineers specifying ground source systems and main and sub-contractors involved with installer companies supplying ground source systems or designs.

The GSHPA Standards are intended to act as an all-round installation standard for ground source heat pump systems. Written in conjunction with the Microgeneration Certification Scheme (MCS) MIS Installation Standards[1], this document is not intended to be solely for use with systems aimed at RHI eligibility,

The standards should also prove to be a useful document for the general public and anybody else with an interest in the subject, when considering a ground source installation.

1.2 Definitions

BIN Analysis	Analysis of weather data consisting of dividing the heating season into a number of hours occurring at a given temperature for a specific location.
Closed loop	A sealed loop of pipe placed in the ground (or water and designed by specialist designers) and filled with thermal transfer fluid. Only closed loop shallow systems are considered in this document. Systems to be considered here are: • Straight horizontal collector pipe • Coiled horizontal collector pipe (e.g. Slinky™) • Spiral Probe • Thermal Screw Pile See section 1.3 for more detail on each of these.
Coefficient of Performance (COP)	This is the ratio of heating or cooling delivered by the heat pump, to the electrical energy supplied to power the heat pump at any given time during operation.

[1] DECC (2013) Microgeneration Certification Scheme Microgeneration Installation Standard 3005: Requirements for contractors undertaking the design, supply, installation, set to work commissioning and handover of microgeneration heat pump systems, Issue 4.

Ground (source) heat exchanger (GHE)	A ground heat exchanger comprises arrays of horizontally or vertically installed closed loops and a ground loop circulation pump. The ground heat exchanger can be installed using an array of boreholes, piles, pond loops, or horizontal collectors that are exchanging heat with the ground around them. This includes header pipes to the plant room, including manifolds and/or flushing valves/arrangement and excludes the heat pump and circulation pump.
Ground source heat pump (GSHP) system	A heating or cooling system that works by using the ground as a heat source or heat sink, including the heat pump.
Header pipes	Pipes connecting the ground-loop(s) to the plant room, normally via a ground source manifold.
Heat pump	A device which collects heat energy from a low temperature source and uses it for space and/or hot water heating by converting the heat energy into a higher temperature. Some heat pumps can also provide cooling to buildings if required.
Lake loop	A sealed loop of pipe placed in a body of water with sufficient surface area / volume to sustainably deliver the required heat load. This type of system is specialist, bespoke design and must be designed and installed by an adequately trained and experienced GSHP designer.
Seasonal Performance Factor (SPF)	This is the ratio of the heat delivered by the heat pump, to the energy supplied to power the heat pump, over a set time period (typically one year).
Soil conductivity test	A test carried out prior to shallow ground array installation to determine the thermal conductivity of the soil.
Thermal Response test	A test carried out on a ground heat exchanger (generally boreholes) to determine the thermal properties of the ground.
Thermal transfer fluid	Fluid that circulates through a closed loop system generally containing antifreeze, biocide, corrosion and scale inhibitor. Please note that Chapter 11 of this Standard “Thermal Transfer Fluid Requirements” is currently under review in line with international developments. The information provided is correct at time of publication, but will be reviewed accordingly as appropriate.

Detailed definitions of roles and responsibilities of the design and construction team members are given in Section 3 however brief definitions of the parties involved are given below.

Employer	The Employer or Client is the project funder in contract with the Engineer and Main Contractor.
Engineer	A term used for a qualified or suitably experienced engineer who is appointed by the Employer to act as their representative, and to provide specification and supervision of the project.
Groundworks Contractor	The groundworks contractor is responsible for civil works on site and for safeguarding the integrity of the ground loops during this operation.
GSHP Designer	Person or organisation responsible for the design and performance of a GSHP system which meets the energy requirements specified in the contract.
Heating Contractor	Person or organisation responsible for provision and installation of the GSHP system.
Main Contractor	The Main Contractor (or Principal Contractor in CDM regulations) is appointed by the Employer and has overall responsibility for the works.
M&E Designer	Person or organisation responsible for the integration of the ground source heat pump design solution into the mechanical and electrical system. The M&E Designer is also responsible for defining the building thermal loads and the performance requirements for the GSHP system.
Pile Designer	Person or organisation responsible for the design of structural piles to current codes and standards, which meet the building load requirements.
Structural Engineer	Person or organisation responsible for the design of structural elements to resist structural loads.

1.3 Scoping Statement

This GSHPA standard is designed to be a concise document providing information on the materials and general specification of closed-loop shallow ground source systems to a maximum depth of 10 metres. The standard also covers internal pipework up to and including manifolds and/or flushing valves/arrangements. It is not designed to be an installation or training manual and the standards must be referred to in conjunction with recognised design qualifications and training programmes.

The standard is designed so as to enable anybody reading it to quickly reference minimum materials specification, techniques and qualification requirements that are to be met and ensure that they either comply with the standard (or exceed it) or are employing companies and personnel who do comply with the standard (or exceed it).

It is vital that closed-loop shallow ground source heat pump systems are designed and installed with sustainable system longevity in mind to ensure that they do not have a negative impact on the ground conditions or environment around them.

1.4 Ground array descriptions

- **Straight pipe**

Straight pipe ground array systems consist of pipes recommended to be buried at a depth of between 0.8m to 1.5m below the surface with a thermal transfer fluid passing through them. Typically pipe spacing is 0.75m, but system design would determine this specifically. This fluid absorbs stored solar energy within the ground and returns it to the ground source heat pump where it is used to heat and/or cool buildings and/or produce hot water. The layout of the pipe can vary depending on the design of the array and installation, but generally consists of polymer pipe laid in shallow excavations.

- **Slinky™ pipe**

Another form of horizontal ground array is coiled polymer pipe, commonly referred to as slinkies™. These are generally laid in a trench approximately one metre below the surface and consisting of pipe arranged in loop or coils with a thermal transfer fluid passing through them absorbing stored solar energy from the ground.

- **Spiral Probe**

A spirally wound probe installed vertically to a typical depth of 4-5 metres, into a pre-augured hole of commonly 450mm diameter.
If spiral probes are being used in a thermal pile, please refer to the GSHPA's Thermal Pile Standard.

- **Thermal Screwpiles**

Screwpiles are a steel screw-in piling and ground anchoring system which may be used for building foundations.
A thermal screw pile is a modified screw pile that acts as a ground heat exchanger.
If these are to be used as a structural thermal screwpile, please refer to the GSHPA's Thermal Pile Standard.

1.5 Acknowledgements

The standards have been developed by the GSHPA Training & Standards Sub-Committee (T&SC) working party. Thanks from the association and members must go to the working party members for their efforts which have been provided at their own expense and time. Support has also been provided by the GSHPA secretariat.

The shallow ground source working party comprised:

John Barker-Brown	Kensa Heat Pumps Ltd (Chairman)
Bean Beanland	ISO Energy Ltd
Gareth Powell	GI Energy.
Jon Busby	British Geological Survey
John Findlay	Carbon Zero Consulting Ltd
Jake Salisbury	GSHPA
Nic Wincott	NeoEnergy (Sweden) Ltd
Robin Curtis	GeoScience Ltd
Steve Richmond	REHAU Ltd

The funding for the standards has come from the members of the association and the association acknowledges this fact and continues to use funds in order to improve the standards within our industry.

Edited by: John Barker-Brown; Chairman GSHPA Shallow Ground Source Standard Working Group.

2.0 REGULATORY & GOVERNMENT AGENCY REQUIREMENTS

2.1 Health & Safety at Work Act '74, Management of Health & Safety at Work Act '99

The Health and Safety at Work Act 1974 and The Management of Health and Safety at Work Act 1999 shall be adhered to at all times. Both acts apply to every work activity.

2.2 The Construction (Design & Management) Regulations (CDM)

The current CDM Regulations apply to all construction work in Great Britain and, by virtue of the Health and Safety at Work Act 1974 (Application outside Great Britain) Order 2001, its territorial sea, and apply to both employers and the self-employed without distinction. Reference shall be made to the Health & Safety Executive (HSE) Approved Code of Practice[1] with respect to implementation of and adherence to the CDM Regulations.

2.3 Groundwater Protection – Policy & Practice

No specific requirements regarding the control of heat in the environment are currently detailed in legislation or statutory guidance. Groundwater Protection; Policy and Practice[2] (GP3) provides guidance on the Environment Agency's position with regard to the regulatory constraints which they may impose on Ground Source Heat Pump Systems (GSHPS) and provides guidance on the preferred planning and risk assessment procedures which shall be referenced and should be employed. The Environment Agency's 'Good Practice Guide'[3] explains how the environmental risks of a ground source heating and cooling scheme can be reduced. For clarification, these documents, along with the Environment Agency itself if necessary, shall be consulted early on in the planning process. In Northern Ireland (Northern Ireland Environment Agency), Scotland (SEPA: Scottish Environmental Protection Agency) and Wales (Natural Resources Wales), the equivalent agencies shall be consulted if necessary.

2.4 Building Regulations & Other Certification Material

Relevant local, regional and national building & water regulations still apply and many of these documents are referenced in Microgeneration Installation Standard: MIS3005, the heat pump installation standard.[4]

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[1] HSE, 2007. Managing Health and Safety in Construction. Construction (Design and Management) Regulations 2007 Approved Code of Practice. HSE Books.

[2] Environment Agency, 2007. Groundwater Protection: Policy and Practice.

[3] Environment Agency, 2011. Environmental good practice guide for ground source heating and cooling schemes

[4] DECC (2013) Microgeneration Certification Scheme Microgeneration Installation Standard 3005: Requirements for contractors undertaking the design, supply, installation, set to work commissioning and handover of microgeneration heat pump systems, Issue 4.

2.5 Planning Permission Requirements

Most ground source heat pump installations within the curtilage of the property in question are classed as permitted development. Please check the current amendment of the General Permitted Development Order in the Town & Country Planning Act[1] for full details.

2.6 Party Wall Issues

All systems shall be designed assuming that adjacent systems will be installed and will therefore have a right to the heat under their property. The minimum distance between the installation in question and any adjacent systems should be determined by the designer and/or manufacturer. There should be a minimum distance of 1.5m – for example, from property boundaries.

2.7 Other Codes of Practice and Guidance

A list of recommended reading guidance and policy documents from other agencies are included at the end of the document.

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[1] Town And Country Planning (Permitted Development) Order 2013

3.0 DESIGN & INSTALLATION – PERSONNEL & TRAINING REQUIREMENTS

3.1 Shallow Ground Source Loop Designers

This document makes a distinction between a simple and a complex system in order to ascertain the requirements of training and qualifications for the different applications and information requirements etc. Essentially a simple system is a system which is a monovalent or mono-energetic whose loads are driven by the weather and control is by a room / temperature sensor or weather compensation.

The level of required competence would be determined by the size and complexity of the project.

The shallow ground heat exchanger shall be designed by competent personnel. The level of required competence would be dictated by the complexity of the project as outlined above. The decision tree shown in Figure 1 below is to help identify a complex system and a simple system.

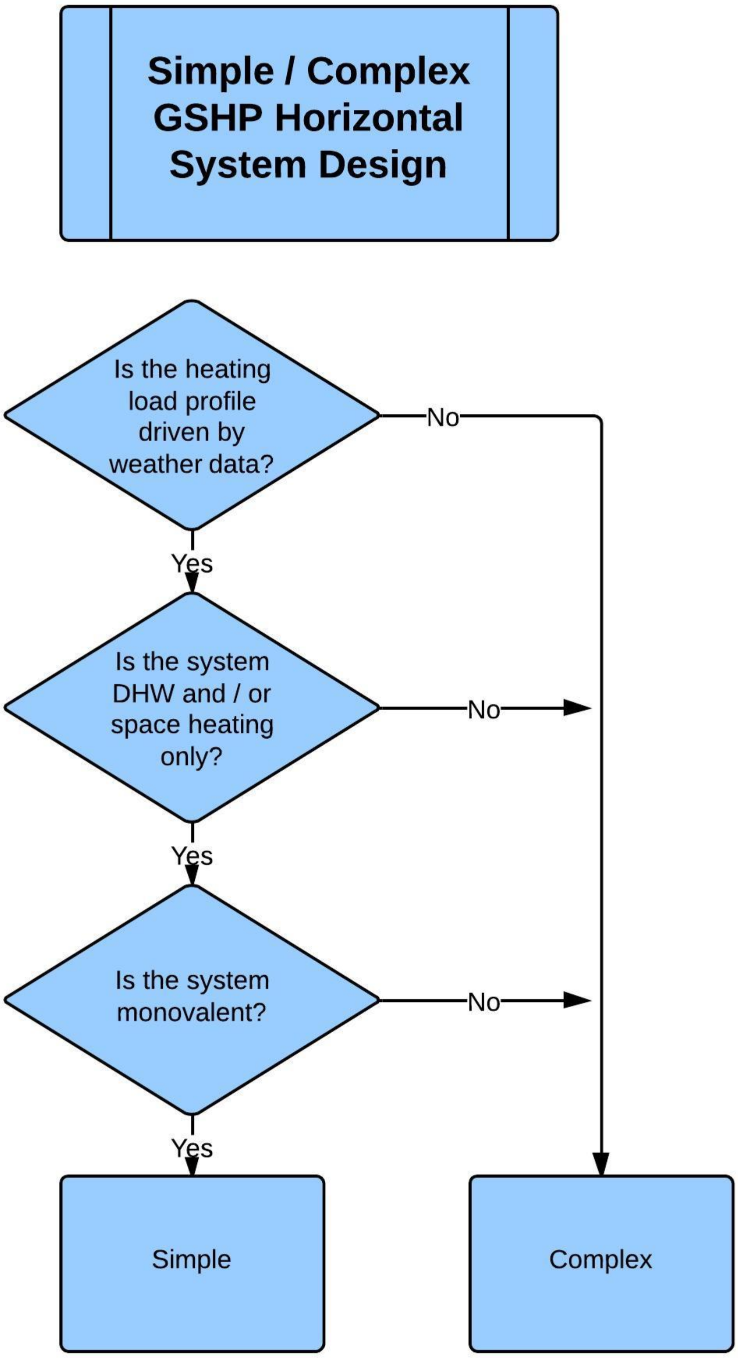

Figure 1: Simple or Complex System Decision Tree

3.2 Design of complex systems

Designers of complex systems as identified in Figure 1 shall have the following documented level of qualification/competence:

- A Chartered or experienced professional, in the field of engineering, geology, buildings services or physics, with demonstrable experience in the design of successful GSHP systems.

It is recognised that the design of a shallow ground heat exchanger will normally involve competent personnel with more than one specialism.

3.3 Design of simple systems

In the case of simple installations, as identified in Figure 1, the following are also deemed to be "Competent Personnel":

- MCS accredited installers for GSHP systems.
- Heat pump manufacturers with a competent and experienced ground source design staff.

Certified design personnel shall attain sufficient continuing education points in order to maintain their qualifications in accordance with the certifying body's requirements. Designers whose qualifications lapse for any reason shall regain the qualification in accordance with the certifying body's requirements before continuing with any design services.

3.4 Site qualifications

Employees must be trained and instructed in safe systems of work and safe work practices. Employers need to have an effective method in place to identify hazards and to determine whether there are significant hazards that require further action. A hazard is an existing, new or potential situation or event that could result in injury or harm to health.

Employers should ensure a competent person maintains supervision of employees when excavation work is being carried out.

All installers and workers employed on the contract shall be suitably experienced and competent in the installation of shallow ground source systems. If required, this will include holding a valid and current Construction Skills Certification Scheme (CSCS) card as issued by Construction Skills Certification Scheme Limited or an equivalent body in a state of the European Union.

Site Supervisors/Managers shall be suitably experienced or knowledgeable in all aspects of the installation they are supervising which may include ground works, flow and pressure testing, electro-fusion techniques, flushing and purging, sterilisation and the addition of thermal transfer fluids. They must also be aware of their statutory responsibilities and the environmental risks of their operations, with emergency planning if necessary.[1]

[1] Environment Agency, 2011. Environmental good practice guide for ground source heating and cooling schemes

4.0 DESIGN METHODS & COMPLIANCE

4.1 General Design Approach

Only suitably trained and/or competent persons shall carry out the design of a ground source heat pump system. Reference should be made to **Section 3**.

4.2 Building Load Data

An accurate assessment of the building's heating, cooling and hot water requirements shall be made based upon British European Standard (BS EN) 12831, current Chartered Institution of Building Services Engineers (CIBSE) guidelines as per the Domestic Heating Design Guide, and CIBSE Guide A.

MCS Microgeneration Installation Standard MIS 3005, contains heat loss calculation requirements for applications of 70 kW_{th} and under and shall be consulted. It refers to monthly and annual average air temperatures for various UK regions as provided by the MET Office and lists these in an appendix.

Large installations (complex systems) should be modelled by development of a Dynamic Simulation Model (DSM). The DSM shall provide peak and annual load data in the required time period resolution as indicated in Figure 2 below.

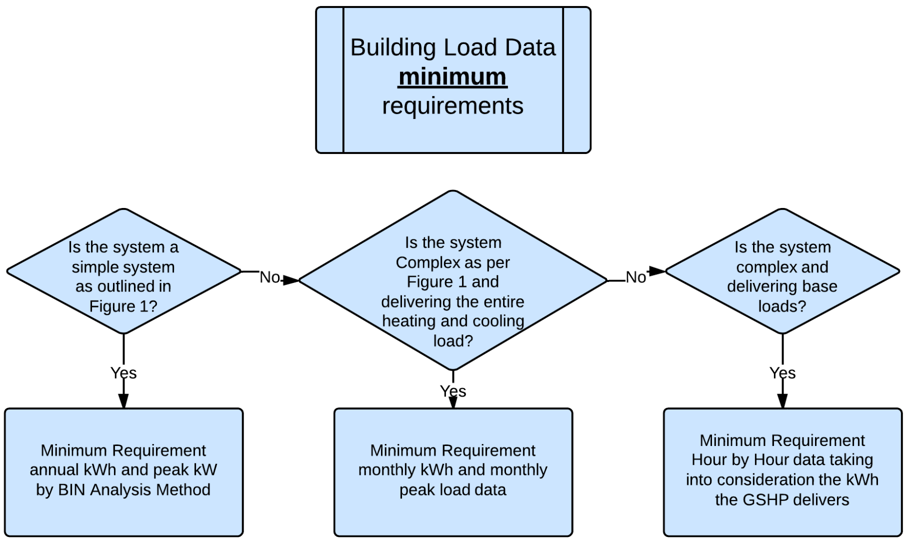

Figure 2: Minimum Building Load Data Requirements Decision Tree

Building heating, cooling and hot water loads shall be appropriate to building type, use and occupancy, e.g. *modern school, closed in August*.

The proportion of the building's design space heating/cooling or hot water that is expected to be provided by the heat pump system annually shall be stated by the designer. An understanding of the proportion of the heating, cooling & hot water peak demand which will be met by the heat pump system shall be demonstrated.

For applications of 70kW$_{th}$ and under, MCS Microgeneration Installation Standard MIS 3005, , requires that the heat pump will provide 100% of the calculated design space heating power requirement for monoenergetic systems. MIS3005 shall be consulted for the details of this.

4.3 Ground Heat Exchanger Desk Study

A desk study shall be carried out which shall be appropriate for the scale of the shallow ground source system to be designed and installed.

The desk study suitable for a simple shallow installation shall cover as a minimum:

- Regulatory requirements
- Previous site use and potential for presence of contaminated soils
- Soil characteristics and seasonal ground moisture conditions
- Assessment of the sustainability of the scheme based on annual kWh and peak loads for heating and cooling and the amount of energy to be extracted from the ground
- Potential for unexploded ordnance
- Impact on sites of special scientific interest where other parties may need to be informed
- Ground conditions, available space and ease of access for excavation equipment
- Underground and overhead services identification and location (including any private water supply or sewerage system)
- Measurement or assessment of thermal properties of the soil
- Estimated average undisturbed ground temperature
- Average ambient air temperatures
- Barriers to construction i.e. voids, buried services for example
- Party wall issues
- Whether a Coal Authority permit to excavate is required
- A desk study for complex systems shall contain the above as a minimum, plus: Assessment of soil thermal properties by in-situ measurement or consultation with a Chartered or experienced GSHP professional
- Impact assessments on the ground e.g. alteration of undisturbed ground temperature.
- Records of design calculations and or design model outputs

Where the desk study includes any outline design works the study shall clearly state what assumptions have been made and which particular elements of the design have been covered. Further guidance for content and format of desk studies is found within BS5930:

4.4 Shallow Ground Source Heat Exchanger Design

The design of the shallow source ground heat exchanger shall be in compliance with the heat pump manufacturer's specification and operating parameters of the heat pump and shall be clearly documented so that such compliance may be demonstrated.

The design of a simple shallow ground source heat exchanger system for small applications shall be undertaken in accordance with MCS Microgeneration Installation Standard MIS 3005, which defines a minimum water entry temperature of the thermal transfer fluid into the heat pump.

Detailed shallow ground source heat exchanger design incorporates:

- building heating, cooling and domestic hot water loads
- heat pump coefficient of performance (COP) and estimated seasonal performance (SPF)
- ground loop and header pipe configuration and its hydraulic implications, including ground loop pump sizing
- pipe material selection, dimensions and layout
- thermal transfer fluid characteristics and temperature constraints
- trench or excavation design
- average soil and air temperature
- assessment or measurement of soil thermal conductivity
- trench spacing and trench backfill
- manifold chambers or manifolds.

The scope can be further extended to include the building penetration, internal piping, pressurisation requirements, monitoring and Building Management Systems (BMS), monitoring requirements and load-side circulation pump sizing. The specific standards relating to such an extension of the scope of design are not covered by this document and further guidance as required, shall be sought.

It is important that turbulent flow is maintained in the individual ground loops; while pumping losses are kept to a minimum (MCS requires this to be less than 3% of the thermal output of the heat pump).

If a design specialist is involved, they shall clearly identify which elements of the design are covered and any assumptions that have been made by the specialist regarding other elements of the overall design.

Data obtained during the desk study and/or in-situ soil testing shall be used in accordance with MCS Microgeneration Installation Standard MIS 3005, or with appropriate design software for shallow ground source sizing. For larger and more complex heating and cooling systems, more sophisticated ground models shall be used to demonstrate the heat exchanger system design is viable for the requirements of the building in the longer term.

Whilst estimates of thermal conductivity are available from BGS please note these are for bedrock (bedrock is consolidated rock underlying the soil).

Building load information including annual kWh_{th} and peak load (kW) shall be used for simple ground heat exchanger design as outlined in Figure 1. For complex systems, the minimum requirements are for a monthly profile of kWh_{th} of heating and cooling along with peak load for each month and the maximum duration of the peak load per month. Where possible however, hourly kW_{th} and peak load information should be used.

5.0 SOIL THERMAL CONDUCTIVITY TESTING

For all projects an assessment of the soil properties and ground temperatures shall be undertaken. Where uncertainties exist, the following methodology is recommended and a conservative approach should be adopted and/or advice sought from an appropriate specialist.

5.1 In Situ measurement of soil thermal conductivity

Soil properties are highly variable and form an important element in shallow ground source array design. BGS provide data and reports, although quoted thermal conductivities are for bedrock – not soil. Generally there is very little information currently available on shallow thermal properties. The thermal conductivity of soil, one of the important input parameters in the design of a shallow ground source system, can be measured by means of a portable ‘thermal needle probe’ survey.

5.2 Aim of the Test

Short-duration in-situ soil thermal response tests can be carried out at various locations within a land area designated for the shallow ground source array. The survey should be performed with equipment complying with IEEE 442-1981 ‘Guide for soil thermal resistivity measurement’.

A thermal needle probe mounted on a long handle is inserted into the soil at the target depth. A rest period (typically 5 min) ensues, during which the system detects when the probe temperature has equilibrated with the ambient soil temperature. This temperature is recorded. A voltage is applied to an electrical resistance heater in the probe, generating a constant heat output. The increase in probe temperature is monitored with time after heater switch-on. The increase in temperature with time is analysed by standard line-source theory to yield a value of soil thermal conductivity.

It is recommended that the measurement depth should correspond as closely as possible to the proposed depth of burial of the ground loop, and that measurement points should be equally spaced along the line(s) of the proposed horizontal heat exchanger trench.

The geometric mean of measurements is considered the most representative best estimate of ‘bulk’ conductivity of an average site. Some 12–16 measurements are required to yield an estimate of the geometric mean soil thermal conductivity. Given a total test time of around 20 min per location, such a programme can be accomplished in the course of a day.

Thermal conductivity, as measured by the in situ techniques described here, will depend on the soil moisture content at the time of the survey. Careful consideration should be given to the timing of the survey to ensure that it is adequately representative of soil conditions at the depth of the ground loop during normal periods of operation.

6.0 GROUND HEAT EXCHANGER PIPE MATERIALS & JOINTING

Due to the nature of a shallow ground source installation e.g. lack of access and long design life, a very high level of quality and durability of all ground heat exchanger components shall be required. Section 6 is purely related to the material specification and manufacturer testing requirements and does not relate to the testing requirements for the materials once installed in the ground.

6.1 Pipe Materials

The acceptable pipe materials for ground source heat exchangers are: PE 100, PE 100-RC (Resistant to Crack) and PE-Xa, or recognised equivalent. The manufacturer shall warrant that the pipe is extruded from verifiable virgin grade raw materials which meet the relevant British / European standards listed below.

PE 100: BS EN 12201 or DIN 8074/8075. In addition, a slow crack growth resistance of greater than 500 hours measured at a pressure of 9.2 bar and temperature of 80°C.

PE 100-RC: PAS 1075 In addition, a slow crack growth resistance of greater than 8760 hours measured at a pressure of 9.2 bar and temperature of 80°C.

PE-Xa: DIN 16892/16893 or BS EN ISO 15875

Each pipe shall have sufficient markings on the pipe to identify the material, SDR rating, manufacturer's name and production period codes.

All pipe used for ground heat exchangers must either be black PE 100 (/ PE 100-RC) or grey/white (PE-Xa) to avoid confusion with other services.

6.2 Fusion Welding for PE 100 / PE 100-RC

For PE 100 and PE 100-RC, electro-fusion, butt-fusion or socket-fusion welding shall be used for connecting pipes underground. Fusion processes shall be carried out strictly in accordance with the manufacturer's instructions. Personnel must be fully accredited with Butt Fusion Jointing and/or Electro Fusion of Mains and Services Certificate F/500/6500 (City & Guilds of London) and/or Socket Fusion Jointing or suitable manufacturer's training certification.

Contractors must also be aware of the leak risk and that they could be liable if pollution occurs from their defective work (refer to MIS 3005).

The acceptable material for the fusion fittings is black PE100. The manufacturer shall warrant that the fittings are made from verifiable virgin grade raw material. Fittings shall be manufactured to dimensional tolerances as specified in BS EN 12201.

6.3 Permanent Mechanical Fittings for PE-Xa

For PE-Xa pipes, permanent mechanical fittings (without O-rings) shall be used for pipe connections. When installed underground, self-amalgamating tape shall enclose the fittings.

All other types of mechanical and compression connections shall be accessible for future maintenance, removal and replacement.

6.4 Transition Fittings

Transition fittings shall be used to adapt to copper or threaded pipe work above ground or in easily accessible locations only. Acceptable transition fittings include flange; threaded; Victaulic; barbed and clamped.

6.5 Specific Pipe Application & Dimensional Specification

All fittings and pipe shall have specified pressure ratings including any assembly of individual components used to manufacture a sub-assembly for a ground heat exchanger.

External pipe diameters between 20mm and up to 75mm and any pipe diameter utilised as a ground heat exchanger shall be manufactured with minimum pressure rating of 15 bar with SDR of 11.

External Pipe diameters larger than 75mm can be manufactured with minimum pressure rating of 10 bar (SDR 17).

6.6 Off Site Factory Manufacture

Off-site fabrication can be used to reduce installation times on site and ensure joints are made under factory conditions. The GSHPA therefore encourages off-site fabrication for any pipe work.

The manufacturer/supplier shall warrant that all ground loops are manufactured in compliance with the above standards.

Components pre-assembled by a third party prior to delivery to site should be leak tested accordingly.

6.7 Leak Free Installation

The system shall be installed as leak-free for the design life of the installation, which would generally be a minimum of 50 years.

7.0 GROUNDWORKS

7.1 General

In all cases, ground heat exchanger manufacturer's installation guidelines shall be adhered to.

Ground heat exchangers are commonly laid in trenches and/or excavations, however trenchless techniques may also be considered at the design stage as they replace the need for major excavations. **Excavations are recognised within the construction industry as one of the most hazardous operations, with risk always present.**

Installers shall ascertain relevant information before excavation work begins. This should include relevant information on:

- Ground conditions
- Underground structures or water courses
- Location of buried services.

This information should be used during the planning and preparation for excavation work.

As part of the excavation works it may become necessary for workers to venture near to or enter the trench. Legislation says you must prevent danger to workers in or near excavations. To maintain the required precautions, a competent person, with relevant training and experience, must inspect excavation supports or battering at the start of the working shift and at other specified times (section 7.4). No work should take place until the excavation is safe.

<u>All work, and working practices, must be in compliance with all relevant health and safety regulations and a risk assessment shall be conducted before any work on site is commenced.</u>

7.2 Preplanning

Preplanning and co-ordination between those involved in excavation operations is essential to ensure the safety of employees and protect members of the public.
Safety in and around excavations should be considered as part of job planning from the commencement of a project. Identification of hazards should be part of the planning, design and estimating process.

Particular hazards should be identified by those people involved in excavation projects before work commences and during the life of the project as site conditions change.

7.3 Excavation

Before excavation commences, all available information should be collected about the exact location and details of the excavation, and disposal areas for excavated material, so that suitable methods of working can be planned and the most appropriate plant for the job can be mobilised.

7.4 Site Inspections

All trenches and or excavations should be inspected by a competent person, with relevant training and experience.

The frequency of these inspections will vary depending on the ground and weather conditions but as a minimum MUST be

- at the start of every shift,
- if stability of the sides is in doubt
- after inclement weather or after any fall of material..

7.5 Trench Supports

Trenches or excavations shall always be made safe. Where there is a risk of trench collapse the trench or excavation side should be sloped, stepped or battered or supported by using trench support systems. Trench supports shall be inspected by a trained and competent person.

Where larger excavations are required a specialist engineer should be consulted and the supports erected, altered or dismantled by competent workers.

7.6 Access

Safe access to the trench and excavation shall be provided. This can be by the use of ladders which shall be well maintained and securely fixed.

Walling struts and props shall not be used as a means of access.

7.7 Guarding, Ventilation and Warning Signs

All trenches should be guarded and signed if there is a risk of injury from a fall. The guarding shall be sufficient to keep people, materials, plant and equipment back from the excavation.

Stop blocks shall be used to prevent vehicles tipping into the excavation and shall be placed far enough from the edge to prevent collapse.

Trenches shall be well ventilated to avoid the build-up of naturally occurring gases, exhaust gases, leaks from pipes and LPG.

Deep excavations and in some cases manifold chambers may be considered as Confined Spaces[1] and appropriate measures shall be taken accordingly. Consideration should be given to using air movers to force ventilation if required.

Excavations on or near highways require Local Authority and relevant transport authority approval.

7.8 Excavation maintenance

All persons inspecting or entering excavations should be aware of physical indications of an imminent trench collapse. These may include but not be limited to the following:

- Small earth movements

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[1] Health & Safety Executive, 1997: The Confined Spaces Regulations

- Timber distortion
- Timber shrinkage or rotting
- Dried out ground
- Water ingress
- Damage to the excavation from skips or buckets
- Slumping spoil heaps due to bad weather

8.0 PIPE PLACEMENT & BACKFILLING

8.1 Piping Material Delivery to Site and Storage

All pipes shall be delivered suitably wrapped from the manufacturer and fitted with protective caps to prevent debris from entering the pipe work on site. The caps shall only be removed when the pipe is to be connected to the system.

Pipes shall be brought to site and unloaded and stored using correct handling equipment. Pipes shall not be dropped, dragged or mishandled on site and accidental damage during delivery and handling shall be avoided.

Pipes shall be stored in dry areas of the site that are not subject to build up of rain water in puddles or creation of muddy surfaces. The pipe work shall be stored in a manner so as not to damage the ends of the pipe or the main body of the pipe. They shall be stored in areas that are not prone to other heavy site traffic etc that may cause accidental damage to the pipes. Ground loops shall be stored on pallets to ensure they are not directly in contact with the ground and the possible sharp stones that may exist at the surface. Straight pipes shall be supported sufficiently based on their diameter to ensure that no part of the pipe comes into contact with the ground where sharp stones or objects may be lying. The number of supports will depend on the diameter and SDR of the pipe in question.

Pipes should also be stored in a manner that prevents contamination with substances at the surface; e.g. oils etc, which could cause environmental risks to groundwater and the integrity of the piping product.

8.2 Pipe Installation

Where pipes are laid into a trench and bends are formed, pipe manufacturer's guidelines for bending radii shall be consulted. Care must be taken to ensure that pipes do not 'kink' around corners and, where required, elbow fittings will be used to prevent kinking.

Prior to installation of the pipe, the trench bottom shall be inspected to ensure that no sharp objects, liable to damage the pipe are present.

Backfill material shall also be inspected prior to re-installation to ensure the suitability of the backfill and ensure that no sharp objects or rocks exist in the backfill.

Where excavated material is not suitable for backfilling, a sufficient blinding layer (refer to pipe manufacturer's guidelines) shall be placed in the trench bottom and surrounding the pipe work.

Any pipe in proximity to a wall, structure, or wet services shall be insulated with non-compressive insulation suitable for operation at all temperatures and conditions experienced by the ground heat exchanger system.

Warning tape shall be laid above all header pipes at half the trench depth. The warning tape shall clearly identify that they protect for example "Geothermal Pipes Below". Ideally, this tape should be detectable to prevent pipework being damaged by any future works.

Collector pipe is recommended to be buried at a depth of between 0.8m - 1.5m with a typical pipe spacing of 0.75m between the flow and return pipe. The layout of the pipe can vary depending on the design of the array and installation. Where the minimum distance cannot be maintained over long pipe runs, pipe shall be insulated sufficiently.

Where header flow and return pipe work is within the same trench, a minimum of 0.5m between flow and return pipe shall be maintained, either vertically or laterally. Where the minimum distance cannot be maintained over long pipe runs, pipe shall be insulated sufficiently.

8.3 Ground Array Installation

The design of the ground array system should follow manufacturers and MCS guidelines/or recognised design standards and should be designed by a competent person (See Section 3).

Trenches or alternative excavations shall be sized to accommodate the ground loop array.

Each loop should be installed as a single length of pipe. Where this is not practical, only welded and permanent mechanical fittings/joints shall be used in inaccessible locations. These should be pressure tested prior to backfilling, see below (Section 9).

Pipe depth and spacing shall be arranged to eliminate the possibility of frost heave and should not deviate from the designer's specification.

Multiple pipe runs should be balanced to maintain uniform hydraulic resistance by means of an appropriate and accessible Ground Source Manifold or the use of a properly designed reverse-return (Tichelmann) arrangement.

Once installed at the desired depth the loop pipe shall be gently but securely held in place to prevent pipe movement during backfill.

The backfilling procedure is critical because it is the time when damage to the collector is most likely to occur. Care should be taken to avoid damaging or creasing the collector.

Heat transfer depends on good contact between the pipe loop and the ground e.g. Clay soils must be carefully prepared before returning the material to the trench, since larger clods of clay will leave sizeable air pockets around the collector.

Pea gravel or similar material should not be used as a backfill material.

The ground array shall be purged of air on completion of the installation and again during commissioning as per section 9.2.

Once loops are installed into the trenches, temporary caps shall be securely fitted again and the trench protected in order to maintain the integrity of the loop until such time as the loop has been flow and pressure tested. On completion of the flow and pressure test, if there is to be any break in the installation process, appropriate protection shall be used for the ground arrays.

Multiple collector pipe runs should be terminated in a readily accessible appropriate Ground Source Manifold with the ability to isolate / adjust flow on each pipe loop.

9.0 FLUSH, PURGE & PRESSURE TEST OF GROUND HEAT EXCHANGER

9.1 Quality Control

Where completed sub-assemblies, such as manifold chambers and manifolds, are delivered to site, these shall be accompanied with a pressure test certificate from the manufacturer.

During installation of the loop, a visual inspection of the pipe shall be made as the loop is inserted into the trench (or alternative excavation) for visible signs of pipe wall damage. A maximum indentation or scratch of 10% of the pipe wall thickness shall be allowable and any indentation or scratch in excess of 10% of the pipe wall thickness shall not be installed.

9.2 Purging the System

On completion of the ground heat exchanger or at stages throughout the installation of larger ground heat exchangers the system shall be flushed in order to remove debris and air. The flushing equipment shall be capable of delivering a sufficient flow rate and head pressure to achieve a minimum of 0.61 m/s (2ft/s) velocity in any pipe diameter in the system.

The flushing pump system shall be capable of reversing the flow without removal of hoses, monitoring the delivery and return pressure, monitoring the flow rate being delivered, have means of inspecting the fluid and shall be capable of filtering debris from the system. All values shall be recorded for the system Operations & Maintenance (O & M) Manual.

Visual inspections of the return flow shall be carried out. Once the return is free from visible air bubbles, the flushing at the minimum of 0.61 m/sec shall be maintained for a minimum of 15 minutes, or longer for larger ground heat exchangers.

9.3 On-site Pressure Testing

Each loop shall be pressure tested following insertion into the trench (or alternative excavation) to ensure that no damage has occurred during the installation.

All horizontal header components of the ground heat exchanger shall be pressure tested prior to backfilling, where possible. As a minimum, all joints shall remain accessible until such time as a pressure test has been completed.

Due to health and safety reasons, under no circumstances must air be used to pressure test.

9.4 Pressure Test Procedure for In Situ Loops

The test procedure shall be in accordance with BS EN 805 section 11.3.3.4 which allows a modified test to be carried out for Polyethylene pipes. The modified test shall be in accordance with WRc “A Guide to the Testing of Water Supply Pipelines and Sewer Rising Mains” 1st Edition, June 1999, Section 5, available from:

http://www.wrcplc.co.uk/default.aspx?item=339

Or BS EN 805 Annex 27, available from: http://www.bsigroup.com/en/Standards-and-Publications

The ground array shall be fully purged of air prior to the test commencing. The ambient temperature shall also be monitored during the test and notes shall be taken as to whether the pipe line is exposed to direct sunlight or other conditions which may affect the results of the test.

For polyethylene (PE) tubes, the pressure testing has to be carried out as a ‘compression test’. An overpressure (inside-outside) is applied to the pipe over the whole length. This step inflates slightly the PE pipe over its whole length. Then a sudden pressure drop of around 10% of the testing pressure is applied. This pressure drop allows the pipe to compress again. If the pipe is tight, a pressure increase is measured. This test should only be carried out on the ground arrays with the heat pump isolated from the test.

To perform such a test, the following equipment is needed:

- A high-pressure pump or a manually operated pump
- 2 stop valves
- 1 manometer 0 -16 bar
- A de-aeration device (if any point of the ground array is at a high point where air can collect)

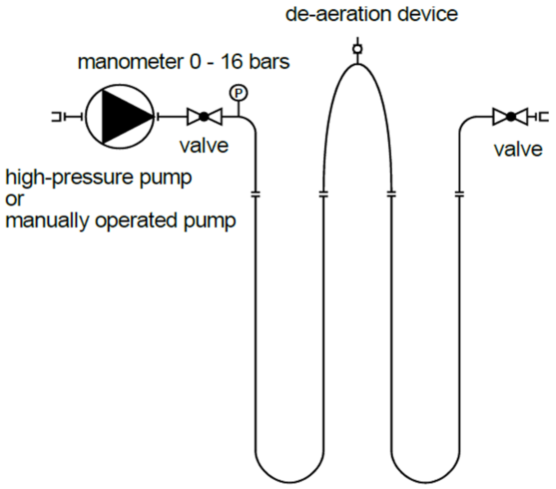

Figure 3: Basic pressure test procedure. Test procedure in detail (Fig.4 overleaf):

- 1 h Idle period. No overpressure is applied to the tube.
- Apply the test pressure. For PE100/PN16/SDR11 ground arrays this should be > 7.5 barg. If the heat pump is within the pressure test this should be less than 10 barg. For other materials follow the manufacturer's specification
- 10 min Keep up pressure test
- 1hr idle period. The tube is going to expand over the whole length
- Pressure measurement. The pressure drop may not exceed the manufacturer’s specifications

- Sudden pressure drop of at least 10% of the test pressure
- 10 mins. First pressure measurement 6 A
- 20 mins. Second pressure measurement 6 B
- 30 mins. Third and final pressure measurement 6 C

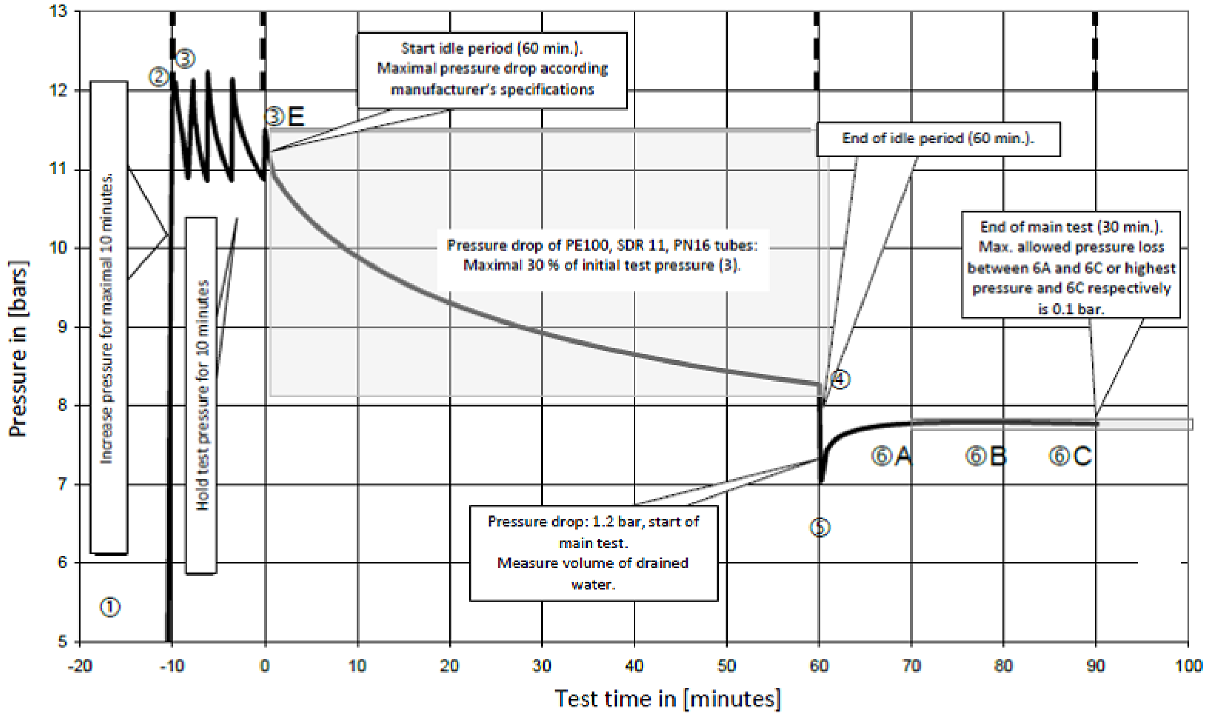

Figure 4: Detailed pressure test procedure

The ground array has passed the test if the pressure difference (pressure drop) between (6)C and (6)A does not exceed 0.1 bar.

The test should not be conducted in cold weather, when there is a risk of freezing.

9.5 Integrity of Fusion Joints & Pipe Wall

During the flushing or test periods, visual inspections of all joints shall be made. Where inclement wet weather may make it difficult to identify small leaks, the joints shall be wiped with a cloth to clear the rainwater and the visual inspection then made. Where weather conditions make it impossible to visually inspect the joints, on completion of the test, the system shall be left under pressure for a minimum of 24 hours.

10.0 PUMPS, MANIFOLDS & PRESSURISATION

10.1 Circulator Sizing and System Components

The circulating pump shall be selected such that it will be capable of delivering the heat pump manufacturer's minimum flow rate under all operating conditions.

Where heat pumps are installed with integral circulating pumps the ground heat exchanger shall be designed in order to be fully compatible with the flow rate and developed head of the integral circulating pump.

The circulating fluid properties such as addition of thermal transfer fluid and minimum operational temperatures shall be considered when sizing the circulating pump.

Debris and air shall have been removed by flushing prior to starting the circulating system.

Prior to start up, the loop shall be pressurised in accordance with manufacturer's recommendations:

- For example to 1.4 – 2.0 bar in summer cooling periods with circulating water between 20°C – 30°C, and;
- 2.75 – 3.5 bar in winter heating conditions where the water is circulated at 5°C or lower.

10.1.1 Expansion vessel

On the ground loop circuit it is possible that an expansion vessel should be fitted. The need for this arises from the requirement that there should always be sufficient pressure in the ground loop to maintain the minimum suction pressure specified for the ground loop circulation pump. (If the pressure falls below this, there is a possibility that cavitation will occur in the pump, and that air will be introduced into the system).

For shallow horizontal installations, some or all of this expansion capacity can be provided by the expansion of the plastic pipe used in the ground loop. This is particularly the case for heating only systems, where the installer can ensure that there is sufficient static pressure left in the ground loop at commissioning to provide the minimum pump suction pressure under all ground loop temperatures.

For larger systems and for heating and cooling systems, the potential variation in pressure can be larger, and a suitably sized expansion vessel is fitted on the ground loop, to provide the minimum pump suction pressure at all ground loop temperatures.

<u>Installers should be aware of the following</u>:

1) Plastic pipe, as used in ground loop installations, exhibits a perverse effect in terms of expansion and contraction compared to metal pipework as used in heating systems. When a GSHP is in heating mode, the ground loop temperature will drop, and the pressure in the ground loop will INCREASE. This is because the pipe will contract more than the thermal transfer fluid. (This is the opposite of what happens in a metal pipework heating system). Conversely, when a GSHP is in cooling mode, the ground loop temperature will increase, and the pressure will decrease. When commissioning a system, an installer should make allowance for this behaviour.

2) Installers should familiarise themselves with how to determine the appropriate size of expansion vessel for a ground loop system, and how the vessels themselves are to be pressurised on commissioning. Typically, these expansion vessels are fitted with a pressure gauge, a blow-off safety valve, and a non-return, valved, dis-connectable, cold fill point.

3) Expansion vessels are to be fitted to deal with the expected expansion and contraction of the sealed ground loop. This does not relieve the installer of the responsibility of ensuring that the entire ground loop needs to be 100% leak tight. Once commissioned, any cold fill pipework must be valved off and disconnected from the main water supply. A repeated use of the cold fill supply to top up the ground loop will be an indication of a leak in the system which must be rectified. An expansion vessel will only disguise any such leak for a short period of time.

Where pressurisation units are installed, the sizing of such units shall take into consideration the fluid thermal properties, the pipe component thermal properties, maximum and minimum pressure requirements for the pump and system.

10.1.2 Binder points

The circulation system shall have, within 500mm of the heat pump system, the ability to measure temperature and pressure in order to test the performance of the ground source side of the heat pump, e.g. Binder points. The capability may be integral to the heat pump and directly linked to the heat pump management system or through the incorporation of easily accessible manual binder points.

10.2 Indoor Piping Requirements

Flushing and charging valves shall be sufficiently plugged and/or be equipped with removable handles to ensure that no accidental leakage of fluid can occur.

Boiler-type service valves shall not be used.

Transition fittings between differing materials shall be easily accessible.

All indoor piping where condensation may form shall be fully insulated in accordance with chilled water pipework insulation requirements.

Any above ground exterior piping shall be fully insulated with exterior grade non-compressive insulation with suitable UV resistance.

Where pipes pass through walls or structures, they shall be sleeved and the annulus between the pipe and sleeve fully sealed with non-hardening sealing compound or components and/or insulation as required.

Where threaded connections are used, good quality clean threads shall be used with specific sealants taking into consideration the thermal transfer fluid being used.

10.3 Manifolds

Manifolds shall be designed so as to provide the minimum additional head loss and the mechanics to balance / isolate the system.

Manifolds should be installed with the option to include a pressure and/or temperature port on or adjacent to each manifold. Where required, a valve to allow flush and purge to be carried out should be incorporated in each manifold.

The manifold chambers shall be water tight. The structural stability of the chamber shall be considered when deciding the type of housing.

The specification of the chamber cover shall be assessed for suitability for purpose.

An appropriate ground source manifold and/or manifold chamber is the preferred option.

11.0 THERMAL TRANSFER FLUID REQUIREMENTS

11.1 Thermal Transfer Fluid Selection, Use & COSHH Requirements

Thermal transfer fluid refers to the fluid permanently installed in the ground array. The fluid will include components of antifreeze, biocide, corrosion and scale inhibitors.

The thermal transfer fluid material shall be compatible with all components within the closed-loop system including all pipework, valves, pumps, heat exchangers, expansion vessels and heat pumps. If in doubt, the installer/designer shall provide details of the fluid to be used to all component manufacturers whose products are intended for use in the system for verification of compatibility with their products. Compatibility data for system materials shall be made available on request.

The specifier/designer, supplier and installer shall all be aware of the Control of Substances Hazardous to Health (COSHH) regulations[1] and shall comply with these regulations where applicable. The designer and installer shall make their own selection of fluid and shall ensure that operatives are fully aware of all safety requirements for the use of the fluid and be familiar with the product. Reference shall be made to the product's Safety Data Sheet for information on its origin, composition, stability, hazard ratings, toxicity, handling, storage & disposal, regulatory information and fire/release/exposure response.

The thermal transfer fluid shall be biodegradable, non-toxic to the environment, should have a low acute oral toxicity as defined in 11.2 and be non-flammable. Preferably, it should also be non-hazardous (i.e. bear no standard hazard symbols or pictograms on its container or in the appropriate section of its safety data sheet).

Regular checks shall be made on the thermal transfer fluid to ensure that it continues to flow and transfer heat effectively.

JS to draft some comments here about regular checking of the TTFs etc… see comments sheet

11.2 Specific Thermal Transfer Fluid Requirements

The thermal transfer fluid shall be classified as inherently and ultimately biodegradable as measured under OECD Guideline No. 302B (1992) "Inherent Biodegradability: Modified Zahn-Wellens/EMPA Test" EEC Commission Directive 87/302/EEC and US EPA Fate, Transport and Transformation Test Guidelines OPPTS 835.3200.

The fluid shall not be harmful by ingestion (as originally classified by the EEC Dangerous Products Directive 1999/45/EC) and shall not have an acute oral toxicity of less than 2000 mg/kg as assessed under OECD Guidelines OECD 401, OECD 420 or OECD 423. The Thermal Transfer Fluid shall be classified as Category 5 for Acute Toxicity under the Globally Harmonised Classification System (GHS).

The fluid shall not be harmful to the environment as classified under EEC Dangerous Products Directive 1999/45/EC and or CLP legislation 1272/2008 (must not bear Risk Phrases R50 to R59 inclusive).

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[1] http://www.hse.gov.uk/coshh/

The fluid shall have suitable and appropriate levels of corrosion and scale inhibitors as outlined in ASTM D1384-05 and BS6580. The use of thermal transfer fluids that meet these standards offer an acceptable level of corrosion protection as proven by experimental evidence.

The thermal transfer fluid shall be non-flammable as determined by ISO 2719 for flash point and ISO 9038 for combustion.

Freezing point of the fluid as measured according to ASTM D1177 and setting point as measured according to DIN 51583 (DIN EN 23015) shall be sufficient to fully protect all components including the heat pump evaporator under static conditions following heating, taking into account the required freeze protection below the minimum fluid temperature.

The minimum concentration requirements of the fluid shall be in accordance with the heat pump manufacturer’s and/or system designer’s recommendations.

The make-up water used for the mixing of the thermal transfer fluid shall be, as a minimum, potable mains water supply quality.

Upon arrival to site, the fluid shall be homogenous without settlement, uniform in colour, and have no lumps, skin or foreign matter.

The fluid shall be supplied to the job site in suitable manufacturer’s containers with manufacturer supplier suitable labelling identifying the material, toxicity signage, concentration and emergency telephone numbers. Transport documentation and labels shall comply with current transport regulations.

If requested, the manufacturer shall provide an up to date Safety Data Sheet (compiled in accordance with European Regulation 1907/2006 (REACH) as amended by Regulation 453/2010) with each shipment.

11.3 Inhibitors & Biocides

Where the Thermal Transfer Fluid has corrosion inhibitors and/or biocides, the Thermal Transfer Fluid shall conform to the above safety, non-flammability, degradability and toxicity requirements. The addition of such chemicals shall not lower the levels outlined in section11.2 above which may then allow the Thermal Transfer Fluid to fall outside of the required standards.

11.4 Filling of Ground Loop with Thermal Transfer Fluid

The method for filling the system must ensure that the entire ground loop array contains antifreeze to the correct concentration – i.e. that sufficient mixing has occurred prior to heat pump operation, resulting in a homogenous fluid.

12.0 DESIGN DRAWINGS & AS BUILT RECORDS

12.1 Design Drawings

The designer/installer shall produce detailed, dimensioned design drawings of the location of the installed ground array noting the position of the client’s drainage, water and gas supplies and other utilities or underground hazards.

The client shall be provided with copies for future reference and all documentation required under MCS.

12.2 Installation Records

The design drawings, design information, pressure test certificates, flow testing and antifreeze concentrations (including brand and type) shall be provided to the client. The installer shall also keep a copy for their records. Operation and Maintenance manuals will also be left with the client.

12.3 Re-instatement

Prior to commencement of the works, the contractors and any of their sub-contractors shall agree in writing the level of re-instatement required for the works and clear lines of responsibility of part re-instatement required prior to landscaping works carried out by others.

The written agreement shall incorporate clear definition of the backfill materials, level of compaction of trenches and surface finish.

13.0 SUBMITTALS & ALTERATIONS TO STANDARDS

13.1 Requirement for a Change Process

From time to time, new products, testing requirements, health and safety legislation and environmental requirements may render items within the installation standards obsolete or in need of up-dating.

Under such circumstances the following procedure shall be followed.

13.2 Persons or Organisations Permitted to Submit Change information

Change information to the standards may be submitted by GSHPA members and non-members, including manufacturers, suppliers, installers, designers and specifiers. Change information may also be submitted by regulating bodies, other related trade organisations, Health & Safety Executive and the Environment Agency.

13.3 Standards Change Process

A proposal for the change of a particular standard or section of the standard shall be presented to the GSHPA Secretariat electronically with a copy to the current GSHPA Chair as well as to the current Chair of the GSHPA TSC.

Submissions for review shall be received four months prior to a GSHPA council meeting.

The submission shall clearly identify the section to be reviewed. It shall identify what the proposed revisions are with a single line through wording to be changed and where altered or additional wording is proposed this shall be underlined and in bold font.

The submission shall have a clear, concise reason for each change contained within the submission and the submission shall only enhance the standards to a higher level and shall not reduce the levels of any of the standards.

Where a specific EN/BS standard is referenced, clear details of the standard shall be included with the submission.

The GSHPA reserves the right to amend the above procedure should the need arise.

13.4 Standards Change Review and Outcome

The submissions shall be reviewed by TSC members individually and comments returned to the GSHPA TSC Chair with a copy to the GSHPA Chair & Secretariat one week prior to the TSC standards meeting.

TSC shall meet with a quorum of minimum 50% of the sub-committee and shall make a recommendation to GSHPA Council Meeting. The TSC meeting may from time to time be conducted by conference call.

Recommendations shall be one of the following:

- Approve the change submission and amend standards as required
- Approval of a revised change submission
- Disapproved

- Recommend further study and submission from proposer

13.5 Dispute of Outcome

Where a submission outcome is disputed, the person, organisation or body making the submission may make representations to the GSHPA Council.

The submission shall include all relevant information as to why the outcome is disputed. The information shall be provided one month prior to the following GSHPA Council Meeting for review. Failure to adhere to this requirement shall render the dispute resolved in favour of the GSHPA.

The proposer of the change can re-submit their proposal and the same procedure will apply as above.

A bona-fide dispute shall be discussed by the GSHPA Council and shall be decided upon by a vote of all council members and secretariat present at the meeting with GSHPA Chair having a casting vote if needed.

13.6 Records of Changes

The Secretariat shall maintain a record of all submissions, meeting dates, meeting attendees, meeting minutes, recommendations by individual TSC members, GSPHA Council recommendations, dispute resolutions and date of standards amendments.

The GSHPA publication “Shallow Ground Source Standards” may not be re-published each and every time there is an agreed amendment.

Amendments shall be published on the GSHPA member’s website in the member’s area. Addendums to the standards can be purchased by non-members.

The standards document shall be reviewed on a bi-annual basis by TSC and GSHPA Council and the amount of changes approved shall be assessed as to whether they constitute a material alteration in the inference of the standards document, at which point a further revision of the document shall be published.

The changes shall be highlighted in the revised publication with the date of the change approval in brackets next to the section that has been altered or added.

LIST OF REFERENCES AND RECOMMENDED READING MATERIALS

Organisation	Document Name	Document Ref. No.
ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)	Heating, ventilating and air-conditioning application. Chapter 32 - Geothermal Energy.	
British Drilling Association	Guidance For Safe Intrusive Activities On Contaminated Or Potentially Contaminated Land:2008	
	Guidance Notes For The Protection Of Persons From Rotating Parts And Ejected Or Falling Material: 2000	
British Standards Institution	Code of Practice for site investigations	BS 5930: 1999 + A2 :2010
	Geotechnical investigation and testing - Identification and classification of rock - Identification and description	BS EN ISO 14689-1:2003
	Geotechnical investigation and testing - Identification and classification of soil - Part 1: Identification and description	BS EN ISO 14688-1:2002
	Heating Systems in Buildings, design of heat pump heating systems	BS EN 15450:2007
	Investigation of potentially contaminated sites. Code of practice	BS10175:2001
	Quality management system. Requirements	BS EN ISO 9001:2008
	Technical drawings. Construction drawings. General principles of presentation for general arrangement and assembly drawings	BS EN ISO 7519:1997
Building & Engineering Services Association (B&ES)	Heat Pumps – Guide to Good Practice TR-30	
Chartered Institution of Building Services Engineers (CIBSE)	Ground Source Heat Pumps – TM51	
DCLG	Domestic Building Services Guide, 2010 edition	
	Non Domestic Building Services Guide, 2010 edition	
Environment Agency	Environmental good practice guide for ground source heating and cooling schemes: 2011	
	Ground Water Protection: Policy and Practice	GP3 2007
European Parliament	Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances	80/68/EEC
	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy	2000/60/EC
	Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration	2006/118/EC

Health and Safety Executive	Managing Health and Safety in Construction. Construction (Design and Management) Regulations 2007 Approved Code of Practice.	
	Protection of workers and the general public during development of contaminated land	HSG 66 (1991)
	The Confined Spaces Regulations	1997 1713
Institution of Civil Engineers (ICE)	The Specification for piling and embedded retaining walls, 2nd edition. (2007)	
MCS (Microgeneration Certification Scheme)	Requirements for contractors undertaking the supply, design, installation, set to work commissioning and handover of microgeneration heat pump systems	MIS 3005 Issue 4.0 (2013)
Northern Ireland Executive	Groundwater Regulations (Northern Ireland) 2009	
The Scottish Government	The Water Environment (Groundwater and Priority Substances) (Scotland) Regulations 2009	
UK Government	The Environmental Permitting (England and Wales) Regulations 2010	
	The Pressure Equipment Regulations 1999	
	Town And Country Planning (Permitted Development) Order	2013 1101