Microgeneration Installation Standard: MIS 3005

REQUIREMENTS FOR CONTRACTORS UNDERTAKING THE SUPPLY, DESIGN, INSTALLATION, SET TO WORK, COMMISSIONING AND HANDOVER OF MICROGENERATION HEAT PUMP SYSTEMS

Issue 4.0

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This Standard has been approved by the Steering Group of the MCS.

This Standard was prepared by the MCS Working Group 6 ‘Heat Pumps’.

REVISION OF MICROGENERATION INSTALLATION STANDARDS

Microgeneration Installation Standards will be revised by issue of revised editions or amendments. Details will be posted on the website at www.microgenerationcertification.org

Technical or other changes which affect the requirements for the approval or certification of the product or service will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments.

The issue number will be given in decimal format with the integer part giving the issue number and the fractional part giving the number of amendments (e.g. Issue 3.2 indicates that the document is at Issue 3 with 2 amendments).

Users of this Standard should ensure that they possess the latest issue and all amendments.

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FOREWORD

The following document contains provisions, which, through reference in this text, constitute normative or informative provisions of this document MIS 3005. At the time of publication, the editions indicated were valid. All documents are subject to revision, and parties applying this document (MIS 3005) are encouraged to investigate the possibility of applying the most recent editions of the documents referenced.

The following document, MIS 3005 Issue 4.0, is a substantive update to MIS 3005 Issue 3.2. It is available for reference from the date of publication [16/12/2013]. Installers of microgeneration systems who are certificated in accordance with MIS 3005 may commence working in accordance with this update from [16/12/2013]. Installers of microgeneration systems who are certificated in accordance with MIS 3005 shall commence working in accordance with this update from [16/03/2014].

This Standard identifies the evaluation and assessment practices undertaken by Certification Bodies of the MCS for the purposes of approval and listing of Contractors undertaking the supply, design installation, set to work, commissioning and handover of heat pump systems. The listing and approval is based on evidence acceptable to the certification body:

- that the system or service meets the standard;
- that the contractor has staff, processes and systems in place to ensure that the system or service delivered meets the standard;

And on:

- periodic audits of the Contractor including testing as appropriate ;
- compliance with the contract for the MCS listing and approval including agreement to rectify faults as appropriate.

This Standard shall be used in conjunction with document MCS 001, and any other guidance and / or supplementary material available on the MCS website specifically referring to this Microgeneration Certification Standard (MIS 3005). A catalogue of guidance and supplementary material to be read in conjunction with MIS 3005 can be found on the MCS website www.microgenerationcertification.org.

Government defines microgeneration as the production of heat and/or electricity on a small-scale from a low carbon source. The various technologies have the potential to help achieve the objectives of tackling climate change, ensuring reliable energy and tackling fuel poverty.

The objective of Government's Microgeneration Strategy is to create conditions under which microgeneration becomes a realistic alternative or supplementary energy generation source for the householder, for the community, and for small businesses.

NOTES:-
Compliance with this Microgeneration Installation Standard does not of itself confer immunity from legal obligations.

Users of Microgeneration Installation Standards should ensure that they possess the latest issue and all amendments.

The Steering Group welcomes comments of a technical or editorial nature and these should be addressed to "The Secretary" at mcs@gemserv.com

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1 SCOPE

1.1 This Standard specifies the requirements of the MCS for the approval and listing of Contractors undertaking the supply, design, installation, set to work, commissioning and handover of microgeneration heat pump systems supplying permanent buildings and either linked to the building's space heating and/or hot water system.

1.2 Microgeneration heat pump systems utilise different primary heat sources (ground, air, and water sources), each of which requires different design and installation considerations. This MCS Installation Standard includes the requirements for both compression and thermally activated heat pumps, as well as heat pump systems for heating or for heating and cooling. Cooling only systems and direct expansion (DX) ground-loop systems are excluded from this Standard.

1.3 For the purposes of this MCS Installation Standard, microgeneration heat pump systems are defined as those having a design output that does not exceed 45 kW thermal.

1.4 Multiple MCS certified heat pumps may be used in a single installation, but the individual output for a single heat pump shall not exceed 45 kWth, as defined by the MCS Product Certification scheme document MCS 007.

1.5 The scope of this MCS Installation Standard is limited to installations with a design heat load requirement of up to 70 kWth, as determined in accordance with BS EN 12831

1.6 The Contractor shall be assessed under one or more of the following four categories of heat pump installation work:

- Ground source heat pump (GSHP) systems;
- Air source heat pump (ASHP) systems;
- Exhaust air heat pump systems;
- Gas absorption and adsorption heat pump systems.

1.7 The Certification Body must identify the scope of works that the Contractor wishes to be registered for and undertake the assessment in accordance with this Standard using the clauses relevant to the category of heat pump installation work.

NOTE: It can be deemed that installers successfully assessed on GSHP systems can also undertake work on ASHP systems.

2 DEFINITIONS

2.1 This Microgeneration Installation Standard makes use of the terms ‘must’, ‘shall’ and ‘should’ when prescribing certain requirements and procedures. In the context of this document:

- The term ‘must’ identifies a requirement by law at the time of publication;
- The term ‘shall’ prescribes a requirement or procedure that is intended to be complied with in full and without deviation;
- The term ‘should’ prescribes a requirement or procedure that is intended to be complied with unless reasonable justification can be given.

Contractor	An individual, body corporate or body incorporate, applying for or holding certification for the services detailed in Scope, Clause 1 above.
Contract	A written undertaking for the design, supply, installation, set to work and commissioning of Microgeneration systems and technologies
Design	The formulation of a written plan including a specific list of products and fixings to form a completed system for a defined Microgeneration technology. Including extensions and alterations to existing Microgeneration systems.
Installation	The activities associated with placement and fixing of a Microgeneration system
Set to work	The activities necessary to make the Microgeneration system function as a completed system.
Commissioning	The activities to ensure that the installed system operates within the boundaries and conditions of the design and the product manufacturers' claims.

Subcontract	A written Contract between a certificated Contractor and another firm for supply of products and services in connection with the fulfilment of a Contract.
Handover	The point in a Contract where Commissioning and certification of the system have been satisfactorily completed to the Contract specification so enabling the installation to be formally handed over to the client.
Heat Pump	A device which takes heat energy from a low temperature source and upgrades it to a higher temperature at which it can be usefully employed for heating and/or hot water. Heat pumps may utilise different heat sources: • Ground Source, where heat energy is extracted from the ground (e.g. from boreholes, horizontal trenches or aquifers) • Water Source, in which heat energy is extracted from water (e.g. lakes, ponds or rivers) • Air Source, where heat energy is directly extracted from ambient air.
Closed-Loop Heat Exchanger	A sealed loop of pipe containing a circulating fluid used to extract heat from ground- or water- sources.
Ground Heat Exchanger	The arrangement of horizontally or vertically installed pipes through which the thermal transfer fluid circulates and collects low grade heat from the ground. Can be either closed or open loop.
Thermal Transfer Fluid	Generally comprises components of anti-freeze, biocide, corrosion and scale inhibitors that circulate through the closed loop heat exchanger.

3 REQUIREMENTS FOR THE CERTIFICATED CONTRACTOR

3.1 Capability

3.1.1 Certificated Contractors shall have the capability to undertake the supply, design, installation, set to work, commissioning and handover of Microgeneration Heat Pump systems.

3.1.2 Where Contractors do not engage in the design or supply of heat pump systems, but work solely as an installer for a client who has already commissioned a system design; then the Contractor shall be competent to review and verify that the design would meet the design requirements set out in this Standard and this should be recorded.

3.2 Quality Management System (QMS)

3.2.1 Contractors shall operate a satisfactory Quality Management System which meets the additional requirements set out in the Scheme document MCS 001.

3.3 Subcontracting

3.3.1 In installations for private customers, any work within the scope of the Scheme not undertaken by employees of the Contractor shall be managed through a formal subcontract agreement between the two parties in accordance with the policies and procedures employed by the certificated Contractor. These procedures shall ensure that the subcontractor undertakes the work in accordance with the requirements of this Standard.

3.3.2 In other situations (for example new build, or for commercial customers), it is permissible for the physical installation, set to work, and commissioning to be undertaken by others (i.e. not subcontracted to the Contractor) provided that:

3.3.2a A contract between the Contractor and the commercial client details obligations on the client to include that evidence of skills and training of those employed by the client to do elements of work not undertaken by the Contractor. These are to be made available to the Contractor to ensure that the competence requirements of this Standard are met, and that access to the site for training and supervision in accordance with the following sections is agreed in advance.

3.3.4 The certificated Contractor provides additional product specific training for those undertaking the work not undertaken by the certificated Contractor.

3.3.5 The certificated Contractor assesses a sample number of installations under the contract, which is not less than the square root of the number of installations rounded up to the nearest whole number (e.g. a new build site of 50 installations, then a minimum of eight are assessed).

3.3.6 The certificated Contractor assumes responsibility at handover that the installation is in full compliance with the Standard.

3.4 Consumer Code of Practice

3.4.1 The Contractor shall be a member of and, when dealing with domestic consumers, comply with a Code of Practice (Consumer Code) which is relevant to the scope of their business in the microgeneration sector and which is approved by the Trading Standards Institute (or formally approved under the Office of Fair Trading (OFT) prior to April 1st 2013).

4 DESIGN AND INSTALLATION REQUIREMENTS

4.1 Regulations

4.1.1 All applicable regulations and directives must be met in full. It should be noted that regulations that must be applied may be different in England, Scotland, Northern Ireland and Wales. Certificated Contractors shall ensure they are working to the most recent documents and have a system to identify all applicable regulations and changes to them.

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

4.1.3 All Contractors shall make their customers aware of all permissions and approvals required for the installation. The Contractor shall assess the building using a competent professional experienced in heat pump systems to ensure that the site is suitable for the installation, and that the building will meet the requirements of the building regulations (in particular those relating to energy efficiency) and other regulations applicable to their work during and following installation. Where required, planning permission shall be obtained before work is commenced. Where work is undertaken that is notifiable under the building regulations, it shall be made clear to the customer who shall be responsible for this notification. The MCS Contractor shall ensure that this notification has been completed prior to handing over the installation. Self-certification, in lieu of building control approval is only permitted where installation and commissioning is undertaken by a person deemed competent and registered with a Competent Persons Scheme (CPS) approved by Department for Communities and Local Government (DCLG) for the scope of work being undertaken. Further details can be found at http://www.competentperson.co.uk.

4.2 Design and Installation

The areas of competence relevant to the design and installation of heat pump systems are included in Clause 5. The following principles shall be met when designing, specifying and installing heat pump systems.

Note: Appendix E provides a summary of heat pump design definitions and calculations.

Heat Pump Sizing

4.2.1 The following procedure shall be followed for the correct sizing and selection of a heat pump and related components for each installation:

a) A heat loss calculation should be performed on the building using a method that complies with BS EN 12831, taking into account any requirements for an uplift factor or allowance for intermittent heating in accordance with the heating system control strategy.

b) Heat loss calculations shall be based on the internal and external temperatures specified in BS EN 12831 UK National Annex adjusted for height and local conditions. Any supplementary in-built electric heater shall be designed to not operate above the external temperatures in Table 2 at the internal temperatures specified in Table 1.

When calculating the heat loss through a solid floor in contact with the ground, the temperature difference to be used is the internal design room temperature (Table 1) minus the local annual average external air temperature (Appendix B).

When calculating the heat loss through a suspended floor, the temperature difference to be used is the internal design room temperature (Table 1) minus the design external air temperature (Table 2).

c) Table 1 is reproduced from the UK National Annex to BS EN 12831. Clients should be consulted to establish whether they have any special requirements and the internal design temperatures increased if required.

Room	Internal design temperatures (/°C) from the UK national annex to BS EN 12831
Living room	21
Dining room	21
Bedsitting room	21
Bedroom	18
Hall and landing	18
Kitchen	18
Bathroom	22
Toilet	18

Table 1: Internal design temperatures from the UK annex to BS EN 12831. CIBSE Guide A should be consulted for data for other applications. CIBSE Guide A also contains information on how to adapt this data for non-typical levels of clothing and activity.

Table 2 is reproduced using selected data from Table 2.4 in CIBSE Guide A. These values are the hourly dry-bulb temperatures equal to or exceeded for 99% of the hours in a year. In the absence of more localised information, data from the closest location may be used, decreased by 0.6°C for every 100m by which the height above sea level of the site exceeds that of the location in the table.

Location	Altitude (/m)	Hourly dry-bulb temperature (/°C) equal to or exceeded for 99% of the hours in a year
Belfast	68	-1.2
Birmingham	96	-3.4
Cardiff	67	-1.6
Edinburgh	35	-3.4
Glasgow	5	-3.9
London	25	-1.8
Manchester	75	-2.2
Plymouth	27	-0.2

Table 2: Outside design temperatures for different locations in the UK taken from National Annex to BS EN 12831 table 1c column B. Corrections can be applied to account for altitude and heat island effects. Further information on how to adapt and use this data is available in CIBSE Guide A: Environmental Design.

Monthly and annual average air temperatures for various UK regions are provided by the MET office in Appendix B.

d) A heat pump shall be selected that will provide at least 100% of the calculated design space heating power requirement at the selected internal and external temperatures in Tables 1 and 2, the selection being made after taking into consideration the flow temperature at the heat pump when it is doing space heating. Performance data from both the heat pump manufacturer and the emitter system designer should be provided to support the heat pump selection. Heat pump thermal power output for the purposes of this selection shall not include any heat supplied by a supplementary electric heater. Where clauses 4.2.1d and/or 4.2.1e cannot be met, then clause 4.2.1f shall apply.

e) When selecting an air source heat pump, the heat pump shall provide 100% of the calculated design space heating power requirement at the selected ambient temperature and emitter temperature, after the inclusion of any energy required for defrost cycles. Where clause 4.2.1d and/or 4.2.1e cannot be met, then clause 4.2.1f shall apply.

f) For installations where other heat sources are available to the same building, the heat sources shall be fully and correctly integrated into a single control system. A heat pump shall be selected such that the combined system will provide at least 100% of the calculated design space heating requirement at the selected internal and external temperatures, the selection being made after taking into consideration the space heating flow temperature assumed in the heat emitter circuit and any variation in heat pump performance that may result. Heat pump thermal power output for the purposes of this section shall not include any heat supplied by a supplementary electric heater within the design temperature range.

4.2.2 For installations where other heat sources are available to the same building, it shall be clearly stated by the Contractor what proportion of the building's space heating and domestic hot water has been designed to be provided by the heat pump.

The figures stated (i.e. the proportion of the annual energy provided by the heat pump) shall be based only on the energy supplied by the heat pump and shall not include any heat supplied by a supplementary electric heater.

Notes on Section 4.2.1- Part (d)

Sizing a system to precisely 100% as defined in section 4.2.1 Part (d) will require supplementary space heating for the coldest 1% of the hours in a year. The system owner will need to be informed that the system may require the use of short term supplementary heating if:

- The building is being heated from a cold state;
- The desired heating mode is not continuous, such as bi-modal heating or heating using a split-rate tariff;
- Large quantities of domestic hot water are required frequently during cold weather.

Installers trying to design a system capable of achieving these requirements without supplementary heat should consider increasing the heating capacity of the heat pump. Further information is available in BS EN 12831.

Where an Installer considers that there may be lower than average ambient temperatures they may opt to use the latest national annex to BS EN 12831.

The clause in Section 4.2.1 (d) requires the CIBSE external design temperature to be the temperature at which the heat pump heating capacity at least matches the building design load.

First example of an installation that fulfils Clause 4.2.1- Part (d)

An average-size, three-bedroom, semi-detached, well-insulated property is calculated to have a 6.2 kW heat loss using BS EN 12831 and the internal, external and ground temperatures provided in this standard. The property is connected to a single-phase electricity supply.

Two heat pumps are available; one has an 8.4 kW heat output at the local design external temperature (from CIBSE Guide A) and the calculated emitter temperature; and the other has a 4.1 kW heat output, with a 3 kW supplementary electric heater.

Under the rule in Clause 4.2.1 (d) (i.e. the 100% sizing rule), the heat pump should provide at least 100% of the design load at the design temperatures in Section 4.2.1 (c) without the inclusion of any supplementary electric heater.

The second heat pump, whose total heat output is sufficient to meet the building heat loss but includes a 3kW supplementary electric heater, does not meet this rule; therefore, the 8.4 kW heat pump is selected for this job, even though it delivers more than the calculated heat loss at design conditions.

Notes on section 4.2.1- Part (d) (continued...)

Second example of an installation that fulfils Clause 4.2.1- Part (d)

A small, well-insulated, 2-bedroom flat is being designed to have a 3.4 kW heat loss at the design internal temperatures and local external temperature. The property is connected to a single-phase electricity supply.

After selecting a 3.5 kW heat pump to meet the calculated load, the heat loss calculations are updated because the designer changes the specification of the building fabric (insulation) and windows. The new heat loss for the property is 3.9 kW.

The heat pump originally chosen does have a 3 kW supplementary electric heater, giving it a total heat output of 6.5 kW. However, under the rule in Clause 4.2.1 (d), the heat pump should meet at least 100% of the design load at the design temperatures in Section 4.2.1 (c) without the inclusion of any supplementary electric heater.

For this reason, a new selection is made for a larger heat pump that has an output of 5.0 kW at the local external temperature without use of any supplementary heater.

Third example of an installation that fulfils Clause 4.2.1- Part (d)

A poorly-insulated, terraced house is calculated to have a 6.1 kW heat loss using BS EN 12831 at the design internal temperatures and local design external temperature in this document. The property is connected to a single-phase electricity supply.

A 5.4 kW heat pump would not meet 100% of the space heating power requirement at the design external temperature and calculated emitter conditions as required by Clause 4.2.1 (d), so the ventilation and fabric heat loss have been reduced by upgrading several of the windows and insulating the walls. A number of radiators were also replaced with larger, deeper units to enable the emitter circuit to operate at lower temperatures. With the improvements, the heat loss of the property is reduced to 5.5 kW. The lower emitter temperature has also increased the heat pump thermal capacity to 5.7 kW (without the use of a supplementary electric heater).

The design now meets the rule is Clause 4.2.1 (d) at the design temperatures in Section 4.2.1 (c).

Notes on section 4.2.1- Part (f)

An example of an installation that fulfils Clause 4.2.1- Part (f)

A very large, well-insulated, domestic property is calculated to have a 23 kW heat loss at the local CIBSE design temperatures. The property is connected to a single-phase electricity supply.

A heat pump is available that has a 24 kW heat output at the local CIBSE external temperature and calculated emitter temperature. However, the Distribution Network Operator (DNO) has said that the existing power supply will not support a further electrical load of this size. The DNO provided a quotation to upgrade their network, but this was excessively expensive in this case.

Instead, a heat pump with a 10.5 kW heat output at the local CIBSE external design temperature and calculated emitter temperature has therefore been selected for use with a 24 kW oil-fired boiler. In this system, the control system consists of an external thermostat that automatically changes the heat source from the heat pump to the boiler below a certain quoted external ambient temperature.

The heat pump has a 6 kW supplementary electric heater but no consideration of this is taken when sizing the system. The heat pump ground collector has been carefully sized to allow for the increased energy extraction associated with this type of heat pump operation, which reflects that the running hours of the 10.5 kW heat pump will be significantly greater than if it had met 100% of the space heating load.

Domestic Hot Water Services Design Considerations

4.2.3 Domestic hot water services design should be based on an accurate assessment of the number and types of points of use and anticipated consumption within the property, making appropriate adjustments for the intended domestic hot water storage temperature and domestic hot water cylinder recovery rate. The reheat time shall be estimated, and then discussed and agreed with the customer. Additional information for assessing hot water use is available: in EN 8558 Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to EN 806; EN 806 Specifications for installations inside buildings conveying water for human consumption; and studies conducted by the Energy Saving Trust (EST) and Department of Energy and Climate Change (DECC), for example "Measurement of domestic hot water consumption in dwellings (Energy Monitoring Company) March 2008".

4.2.4 For domestic hot water cylinder heat exchanger specification, installers shall follow the heat pump manufacturers' and/or cylinder manufacturers'/suppliers' recommendations. Domestic hot water heat exchangers for heat pump systems tend to require a much greater heat exchanger performance as compared to traditional combustion-based heat sources (i.e. boilers). For coil-type heat exchangers, this usually requires a significantly greater heat exchanger area.

4.2.5 Domestic hot water systems shall incorporate a means to prevent bacterial growth (including Legionella bacteria).

NOTE: Further guidance can be found within the Health and Safety Executive Approved Code of Practice L8 document (HSE ACoP L8).

General Design Considerations

4.2.6 The contractor shall communicate and explain in writing to the customer the implications of the space heating and domestic hot water system design on the costs associated with providing space heating and domestic hot water to the building, including but not limited to the following considerations:

The estimated annual cost of electricity and/or gas associated with operating the heat pump (this is provided in the estimate of annual energy performance calculated in Section 4.3.1).

Where the number of collectors or emitter circulation pumps exceeds two, or the run hours of the circulation pump exceeds the run hours of the heat pump, the electricity costs associated with the operation of the collector and emitter pumps shall be calculated.

Heat losses associated with storage vessels.

The electricity costs associated with domestic hot water that may have been produced with an immersion element or supplementary electric heater.

4.2.7 All space heating and domestic hot water installations must comply with local building regulations and standards, e.g. Part L in England & Wales, and Section 6 in Scotland. The Domestic Building Services Compliance Guide, where applicable, provides further advice on compliance including cylinder and pipe insulation sizing.

4.2.8 Where the system is intended to be eligible for domestic RHI payments, or where metering/monitoring equipment is to be fitted to an existing installation, the contractor shall:

Make the client aware of any metering that is required in order for the system to comply with requirements in the MCS Domestic RHI Metering Guidance, and ensure this is detailed in the quotation before the contract is awarded; and

Ensure the system conforms to the MCS Domestic RHI Metering Guidance in full.

4.2.9 The Contractor shall ensure that supply is adequate and ensure that the necessary permissions to connect to the electricity grid are obtained by the client.

NOTE: Where relevant heat pump connection forms are available from the MCS website www.microgenerationcertification.org.

Design of the Heat Emitter System

4.2.10 The Heat Emitter Guide (MCS 021), available from www.microgenerationcertification.org, is a tool to aid installers and customers to understand the relevance of building heat loss, heat emitter selection and heat emitter temperature on heat pump performance. It has been created by the MCS Heat Emitter Working Group for use with this document.

4.2.11 Installers should make sure they are using the most recent version of the Heat Emitter Guide. If existing emitters are to be re-used they should consult the “Tables of Heat Emitter Outputs” available on the MCS website at this link: http://www.microgenerationcertification.org/mcs-standards/installer-standards

4.2.12 The heat loss power per square metre (in W/m^2) used to select a table in the Heat Emitter Guide is the *room* heat loss averaged over the *room* floor area, also known as the ‘specific room heat loss’. This may be greater than the heat loss of the building determined in Section 4.2.1 Part (d) averaged over the total building floor area.

4.2.13 The temperature star rating shall be determined by the temperature of the water leaving the heat pump when supplying space heating at the external design temperature. This is the water temperature achieved prior to any blending valves installed to reduce the flow temperature through the heat emitters.

4.2.14 At, or before, the point at which the contract for the works is entered into with the customer, the installer shall in writing:

a) make the customer aware of all specific room heat losses (in W/m^2).
b) identify the type of emitter(s) to be used in the system.
c) make the customer aware of the design emitter temperature based on the worst performing room.
d) agree with the customer the “Temperature Star Rating” determined by the temperature of the water leaving the heat pump when supplying space heating at the external design temperature.
e) make clear the maximum achievable “Temperature Star Rating” for the flow temperature from the heat pump and the emitter system.

4.2.15 At, or before, the point at which the contract for the works is entered into with the customer, the Installer should:

a) Show the customer a relevant extract of the Heat Emitter Guide;

b) Explain the Heat Emitter Guide, including how it is possible to achieve a higher system SPF or SPER;
c) Explain how the design emitter temperature will be achieved using the type of emitter selected.

Design of closed-loop horizontal and vertical ground heat exchangers

4.2.16 Designing ground heat exchangers is a complex engineering problem. If insufficient information is available to accurately design a ground heat exchanger, the Installer shall adopt a conservative approach.

For systems which require the heating capacity found in Section 4.2.1 (d) to be ≥30 kW or incorporate ground loop replenishment through cooling or otherwise, the Installer should undertake the design process making use of specialist recognised design tools and/or seek advice from an expert.

4.2.17 Manufacturers’ in-house software or other commercial software packages may be used to design the ground heat exchanger provided that the software is location specific to take into account UK average ground temperatures and the following parameters are used for each installation:

a) Site average ground temperatures (or annual average air temperatures). For horizontal ground loops, calculations shall incorporate the swing of ground temperatures through the year at the ground loop design depth;
b) Site ground thermal conductivity values (in W/mK), including consideration of the depth of the water table;
c) An accurate assessment of heating energy demand over a year (in kWh) for space heating and domestic hot water for the dwelling as built;
d) An accurate assessment of the maximum power extracted from the ground (in kW) (i.e. the heat pump evaporator capacity);
e) An accurate assessment of the temperature of the thermal transfer fluid entering the heat pump.

4.2.18 The temperature of the thermal transfer fluid entering the heat pump shall be designed to be >0^{o}C at all times for 20 years in normal operating conditions.

NOTE: Designing the ground loops in accordance with the ground loop lookup tables (MCS 022 Supplementary Information 1) should satisfy Clause 4.2.18.

4.2.19 Simplified design methods, including look-up tables and nomograms, should only be used where these are location specific and have been designed to take into account UK average ground temperatures conditions, installation practices and comply with Clauses 4.2.17 and 4.2.18 in this Standard.

4.2.20 If proprietary software is not being used, systems with a heating capacity ≤30 kW that do not incorporate ground loop replenishment through cooling or otherwise shall use the following procedure for each installation for designing the ground heat exchanger[1]:

a) The total heating energy demand over a year (in kWh) for space heating and domestic hot water shall be estimated using a suitable method. The calculation shall include appropriate consideration of internal heat gains, heat gains from solar insolation, local external air temperature and the heating pattern used in the building (e.g. continuous, bi-modal, with an Economy10 tariff or otherwise).

[1] This method has been designed to produce a conservative ground array design that should result in the temperature of the thermal transfer fluid entering the heat pump being >0^{o}C in normal operating conditions in the vast majority of circumstances. Use of improved design input parameters and more sophisticated design techniques may result in a superior outcome.

Notes on determining the total heating energy consumption

The Government's Standard Assessment Procedure for Energy Rating of Dwellings (SAP) calculates the annual heating and hot water energy requirements from measurements and other data, using reasonable assumptions where actual measurement would be too laborious. Space heating includes fabric losses and ventilation losses, offset by adventitious heat gains from water heating, cooking, lighting, household appliances, solar radiation and metabolic sources. Water heating includes energy content of the water, storage losses, primary circuit losses, distribution losses, rejected water losses, and solar contribution. SAP is a heat loss model for the dwelling taken as a whole, and does not calculate losses from individual rooms. To allow a fair comparison of one building with another, standard occupancy conditions are assumed, meaning standard assumptions about heating hours and internal temperatures and the number of occupants for the size of building. For compliance with building regulations, the location of the dwelling is fixed, but meteorological data from any of the 21 regions covering the UK can be selected. SAP is compliant with BS EN ISO 13790 and refers to many other Standards including BS EN ISO 6946, 13789, 10077, 13370, 13203, etc. From SAP 2009 onwards the calculations are monthly instead of annual, the performance of heat pumps can be based on authenticated test data instead of default values, and the thermal mass of construction elements has been made explicit.

Reduced data SAP (RdSAP) was developed to allow a SAP calculation to be carried out without collecting as many measurements. For example, it uses a set of inference rules to estimate window area as a proportion of wall area. The underlying SAP calculation is not changed, and RdSAP can be thought of simply as a front-end extension to SAP. RdSAP is used to produce Energy Performance Certificates (EPCs) for existing dwellings. It has been extensively field tested for dwellings of standard construction, but is unsuited to those of unusual construction or type beyond what is considered "normal" unless additional data is collected.

The Green Deal Occupancy Assessment (GDA) is used by GD Assessors in conjunction with RdSAP to allow for occupancy factors that affect the annual heating and hot water demand. For example, the exact number of residents in the building, the normal heating times, and the internal temperature. Whereas SAP and RdSAP produce results on standard occupancy assumptions, the GDA produces results tailored for the present occupants.

The same methods and Standards can of course be used by other models. For calculation of the annual energy for heating and hot water it should be clear which standards they adhere to, and it is important to ensure assumptions are consistent and relevant to UK conditions.

BS EN ISO 13790: Energy performance of buildings - Calculation of energy use for space heating and cooling gives a method for the assessment of the annual energy use for spacing heating and cooling of a residential or non-residential building.

CIBSE Guide A contains comprehensive degree day information for different locations around the UK. Heating degree days can be used in conjunction with EN 12831 and an assessment of the appropriate base temperature to determine a building's heating energy requirement. Selection of the base temperature is critical and must take into account factors such as the internal heat gains.

The International Ground Source Heat Pump Association (IGSHPA) provides guidance on determining heating and domestic hot water energy production, electrical energy consumption and running hours using a temperature bin method.

b) The total heating energy consumption calculated in Section 4.2.20 Part (a) shall be divided by the heat pump capacity selected in Section 4.2.1 Part (d) to create a parameter called the "Full Load Equivalent Run Hours" (in hours).

$$\text{FLEQ run hours} = \frac{\text{Total heating energy consumption}}{\text{Heat pump capacity}}$$

c) The amount of power extracted from the ground is to be limited by the average ground temperature. If a full assessment of the average ground temperature is not being conducted, the annual mean air temperature for the appropriate UK region is provided in the tables and charts and shall be used as the estimate of average ground temperature. The data in the tables and charts is compiled by the MET Office; it is the annual average air temperature measured in a Stephenson Screen at 1.25m. The averaging period is nominally 1981 - 2010 (see Appendix B).

d) The local ground thermal conductivity (in W/mK) shall be estimated. The British Geological Survey keep logs from hundreds of thousands of boreholes from all forms of drilling and site investigation work; these can be used to estimate the depth and thermal conductivity of solid geology for closed-loop borehole systems. The British Geological Survey also compiles reports with information on the estimated thermal conductivity of superficial deposits for horizontal loop systems. Experienced geologists and hydro-geologists will also be able to estimate the local ground thermal conductivity. For larger systems, it may be beneficial to conduct a thermal response test. The Ground Source Heat Pump Association publication "Closed-loop vertical borehole design, installation and materials Standard" contains guidance on thermal response testing. See Appendix C for ranges of thermal conductivity for different rock types.

e) Using the information established in 4.2.20 Parts (b) – (d), the look-up tables and charts provided for vertical and horizontal systems shall be used to establish the maximum power to be extracted per unit length of borehole, horizontal or slinky ground heat exchanger. Online versions of these tables are kept on the MCS website www.microgenerationcertification.org. Installers should check for the latest release of these design aids. The ground heat exchanger design shall be compatible with the notes accompanying the tables, for instance concerning the minimum horizontal ground loop or slinky spacing and minimum borehole spacing.

For horizontal ground loops, calculations performed to determine the maximum power extracted per unit length have incorporated the swing of ground temperatures through the year.

f) The Seasonal Performance Factor (SPF) (or the Seasonal Primary Energy Ratio (SPER) for thermally activated heat pumps), given in the Heat Emitter Guide at the design emitter temperature should be used to determine the length of ground loop from the specific heat power extraction information found in the look-up tables and charts. The following formula shall be used to estimate the maximum power extracted from the ground (i.e. the heat pump evaporator capacity)*:*

$$G = H\left(1 - \frac{1}{SPForSPER}\right)$$

where ***H*** is the heat pump heating capacity determined in the Section 4.2.1 (d).

g) The length of the ground heat exchanger active elements, L_b (in metres (m)), is determined according to the formula:

$$L_b = \frac{G}{g}$$

where g is the specific heat power extraction from the ground (in W/m) found in the look-up tables. ***L_b*** is the length of the borehole heat exchanger; the length of pipe for the horizontal ground heat exchanger; and the length of trench required for the slinky ground heat exchanger.

h) For horizontal and slinky ground heat exchangers, the total ground heat exchanger area, ***A*** (in m^2), is determined according the formula:

$$A = L_b d$$

where ***d*** is the minimum centre-to-centre spacing of the horizontal or slinky ground heat exchanger specified in the look-up tables and charts.

i) The minimum length of ground heat exchanger pipe in the active elements, ***L_p*** (in m), is determined according to the formula:

$$L_p = L_b R_{pt}$$

where ***R_{pt}*** is a non-dimensional ratio. ***R_{pt}*** = 2 for boreholes; ***R_{pt}*** = 1 for horizontal ground heat exchangers; and ***R_{pt}*** is the minimum pipe length to trench length ratio specified in the look-up tables and charts for slinky ground heat exchangers.

j) The Installer shall ensure that the flow of thermal transfer fluid is turbulent in the ground heat exchanger active elements. The viscosity of the thermal transfer fluid and therefore Reynolds number, which governs the development of turbulence, changes according to temperature. The Reynolds number of the thermal transfer fluid in the ground heat exchanger active elements should be ≥ 2500 at all times.

4.2.21 For all installations, should the geological situation on drilling or digging show substantial deviation from the conditions used in design or should drilling conditions become unstable or for some other reason the target depth or area not be achieved, the design of the ground heat exchanger shall be recalculated and the installation revised or adjusted if necessary.

4.2.22 For all installations, the Installer shall complete and provide the customer with Table 3 on the following page.

NOTE: Where manufacturer's software is used to complete Table 3, boxes [4] through to [12] may not need to be manually filled in / calculated as they may be integral to the software. Where this is the case the installer / designer shall ensure a copy of the software calculation is given to the customer, where it is not the case the boxes must be completed.

4.2.23 For all installations, the hydraulic layout of the ground loop system shall be such that the overall closed-loop ground collector system pumping power at the lowest operating temperature is less than 3% of the heat pump heating capacity.

Table 3 - Details of ground heat exchanger design to be provided to the customer

Parameter	Value	Unit	Ref	Comments
Estimate of total heating energy demand over a year for space heating and domestic hot water		kWh	[1]	(state calculation method)
HP heating capacity at $0^{o}C$ ground return temperature and design emitter temperature, H		kW	[2]	
FLEQ run hours [1]/[2]		hrs	[3]	
Estimated average ground temperature		^{o}C	[4]	
Estimated ground thermal conductivity		W/mK	[5]	
Maximum power to be extracted per unit length of borehole, horizonal or slinky ground heat exchanger (from the charts and look-up tables), g		W/m	[6]	
Assumed heat pump SPF (from heat emitter guide)			[7]	
Maximum power extracted from the ground (i.e. the heat pump evaporator capacity) G = [2]*1000*(1 - (1/ [7]))		W	[8]	
Length of ground heat exchanger calculated using the look-up tables L_b = [8] / [6]		m	[9]	(i.e. 2 no. 50m slinkies)
Borehole, horizontal loop or slinky spacing, d		m	[10]	
Total length of ground heat exchanger active elements, L_p = [9]*R_{pt}		m	[11]	(NB: does not include header pipes)
Total length of the ground heat exchanger active elements installed in the ground, L_p'		m	[12]	(NB: state if proprietary software has been used to determine the design length)

Installation

4.2.24

Where manufacturer's instructions conflict with the requirements of this Standard, the MCS Contractor shall conform to this Standard unless it can be proven that conformance to the manufacturer's instructions will facilitate a system that is more efficient than if the requirements of this Standard had been met.

4.3 System Performance

4.3.1 An estimate of annual energy performance shall be calculated or obtained and shall be communicated in writing to the client at or before the point at which the contract is awarded. Separate calculations for space heating and for hot water shall be performed and subsequently added together to give a combined annual energy performance figure.

4.3.2 The means of estimating the annual energy performance is as follows:

a) Assess the annual heat load for the building (space heating or hot water) using any suitable performance calculation method. Such calculation method shall be clearly described and justified.
b) Multiply the result from a) by the proportion of the relevant heat load provided by the heat pump system as determined in accordance with Clause 4.2.2.
c) For space heating, divide the result from b) by the default efficiency (expressed as a Seasonal Performance Factor, SPF or SPER) for heat pumps contained in the Heat Emitter Guide. For water heating, divide the result from b) by the efficiency (expressed as a Seasonal Performance Factor, SPF or SPER) when the heat pump is operating at the flow temperature of the heat pump while providing water heating service.
d) Calculate the energy supplied by the auxiliary heater by multiplying the result from a) by the proportion of the relevant heat load not supplied by the Heat Pump.
e) Add the result from c) to the result from d) to give the total energy required for the relevant heat load.
f) The results from e) for space heating and hot water are added together to give an overall energy requirement for the building for these heat loads.

4.3.3 This estimate, when communicated to the client, shall be accompanied by the following disclaimer:

‘The performance of microgeneration heat pump systems is impossible to predict with certainty due to the variability of the climate and its subsequent effect on both heat supply and demand. This estimate is based upon the best available information but is given as guidance only and should not be considered as a guarantee.’

4.3.4 Additional estimates may be provided using an alternative methodology and/or alternative SPF (or SPER for thermally activated heat pumps), but any such estimates shall clearly describe and justify the approach taken and factors used, shall not be given greater prominence than the estimate obtained using the method described above and shall have an associated warning that it should be treated with caution if it is significantly greater than the result given by the method described above.

4.3.5 This Standard includes reversible systems, i.e. systems that may provide cooling in addition to heating. It is a requirement that such reversible systems be designed and optimised for heating.

4.3.6 The Contractor shall provide evidence of consultation and compliance with the requirements of the designers and installers of the building’s heat distribution system (and hot water system if applicable) regarding specification and performance to ensure the correct and efficient operation of the system as a whole. This shall cover the selection of a heat pump of appropriate output for the building, and the design of heat distribution systems and controls compatible with efficient operation.

4.4 Site Specific Issues

4.4.1 Heat pumps should be located according to the manufacturer’s instructions. For air source heat pumps, these will include consideration of factors that may detrimentally affect the performance of the heat pump system such as recirculation of chilled air.

4.4.2 The suitability of a proposed heat pump system installation site, including the location of ground loops or bore holes, where present, shall be assessed by a qualified professional experienced in heat pump systems. Contractors shall make their customers aware of all permissions, approvals and licences. For example, for the abstraction and discharge of ground water required for their installation. Where required the Contractor shall ensure that these permissions and approvals have been obtained before work is commenced.

4.4.3 Heat pumps should not be located adjacent to sleeping areas or on floors that can transmit vibration.

4.4.4 Anti-vibration pads/mats/mounts and flexible hose connections should be installed according to the manufacturer's instructions to reduce the effects of vibration on the building structure.

4.4.5 The location of external fans and heat pump compressors should be chosen to avoid nuisance to neighbours and comply with planning requirements.

4.4.6 Internal fans and ducts should be fitted with sound attenuation devices.

4.4.7 For air source heat pumps, consideration should be given to the removal of condensate water produced during a defrost cycle from the outdoor coil. The installation should make provision to deal with this water transferring it to a suitable drain or soak away thus preventing ice build-up within the unit or its location during extreme winter conditions.

4.4.8 Where installations wish to apply for Permitted Development Rights for air source heat pumps in England, MCS 020 Planning Standards must be complied with.

4.5 Commissioning

4.5.1 Heat pump systems shall be commissioned according to the manufacturer's instructions and the system design parameters.

4.5.2 A label indicating the flow temperature of the heat pump shall be fixed on the manufacturers equipment as specified in Appendix D.

4.5.3 The Installer shall complete the Compliance Certificate for heat pump systems.

4.5.4 In addition gas absorption heat pumps shall be physically inspected and commissioned by the product manufacturer or their authorised representative to ensure the gas supply has been fitted in accordance with the manufacturer's instruction, where statutory regulations apply, e.g. GSIU regulations; these shall also be adhered to.

Closed-loop ground heat exchangers

4.5.5 The following commissioning procedure shall be followed for each installation:

a) Ground arrays (including header pipes and manifolds) shall be flushed as one system to remove all debris and purged to remove all air. Installers shall flush vertical, horizontal, and slinky ground arrays in both directions. The heat pump (and its associated pipework) shall be isolated from the ground heat exchanger during this process to avoid damaging the heat exchanger inside the heat pump (e.g. by using 3-port valves).

b) The heat pump (and its associated pipework) shall be flushed and purged as another system, in isolation from the ground array system.

c) Once the ground array is free from debris and visible air bubbles/pockets, purging should continue on the entire system, including the heat exchanger inside the heat pump, for a at least 15 minutes with a minimum flow velocity of 0.6 m/s. This is to remove micro air bubbles formed on the inside of the ground array pipes. Achieving this velocity will require different flow rates dependent on pipe diameter and ground loop layout. Flow rates for standard pipe diameters are given in Table 4.

NOTE: Flushing and purging of debris and visible air bubbles may require a significantly greater flow rate than the values shown for purging micro-air bubbles. Recommended flow rates for flushing and purging horizontal ground arrays and slinky ground arrays of debris and visible air bubbles are also given in Table 4.

Pipe outer diameter /mm	Recommended flow rate for flushing and initial purging		Minimum flow rate for purging micro air bubbles after flushing and initial
	Horizontal ground arrays (1m/s) /litres/min	Slinky ground arrays (1.5m/s) /litres/min	All ground arrays (0.6m/s) /litres/min
25	20	30	12
32	32	48	20
40	50	76	31
50	79	118	48
65	133	200	81

Table 4: Flow rates required for different pipe diameters to achieve 0.6m/s flow velocity for purging micro air bubbles; 1m/s for flushing and purging horizontal ground arrays of debris and visible air bubbles; and 1.5m/s for slinky ground arrays. Parallel loops or layouts with variable pipe geometry may require higher flow rates to achieve these flow speeds.

d) Once purged of all micro-air bubbles, Installers shall conduct a pressure test on all closed-loop ground source heat pump installations in accordance with BS EN 805 section 11.3.3.4 to prove that they are watertight. The entire system, which usually comprises the heat pump, header pipes, manifold and all ground arrays shall be pressure tested.

e) The entire ground array system shall have antifreeze added to the thermal transfer fluid to give freeze protection down to at least -10^{o}C. The quantity and type of antifreeze used shall be appropriate for the system design, in particular with respect to the flow rate stipulated by the heat pump manufacturer; the viscosity of the finished thermal transfer fluid; and the choice of ground array circulation pump.

f) A quantity of biocide recommended by the manufacturer and/or supplier of the antifreeze shall be added to each ground heat exchanger.

g) Two separate, random samples of the commissioned thermal transfer fluid should be tested using a refractometer to confirm that freeze protection down to at least -10^{o}C has been achieved. Evidence should be provided to the customer that this has been achieved.

4.5.6 The Ground-Source Heat Pump Association's Closed-loop vertical borehole design, installation and materials Standard contains further guidance on commissioning vertical ground arrays.

4.6 Equipment

4.6.1 When making installations in accordance with this Standard, the heat pumps used in installations shall be listed under the MCS (http://www.microgenerationcertification.org) or equivalent.

4.6.2 Equipment shall be suitable for its application and have a manufacturer's declaration of conformity for the appropriate Standard.

4.6.3 All heat pumps that are installed within the European Union must be CE marked in compliance with the relevant European Directives.

5 ROLES AND COMPETENCY REQUIREMENTS

5.1 All personnel employed by, or subcontracted to, the Contractor shall be able to demonstrate that they are competent in the disciplines and skills, appropriate to the activities required for their role, in accordance with this Standard.

5.2 Complete records of training (where appropriate) and competence skills of personnel shall be maintained by the certificated Contractor, in particular:

- Design staff, carrying out full conceptual design, shall be able to demonstrate a thorough knowledge of the technologies involved and the interaction of associated technologies;
- All personnel engaged in the actual installation are expected to have technical knowledge and installation skills, to install components and equipment within the designed system, in accordance with all appropriate codes of practice, manufacturer's specifications and regulations. As a minimum Installers should have proven current training / experience with relevant heat pump systems as shown in Appendix A;
- All personnel engaged in the final inspection, commissioning, maintenance or repair, shall have a comprehensive technical knowledge of the products, interfacing services and structures to complete the specified processes.

Please see Appendix A below which contains the required Roles which will need to be fulfilled by the installation company for this MIS 3005 Standard.

The Competence Criteria to be demonstrated by the installation company can be found via the MCS website (www.microgenerationcertification.org). In addition to this, the installation company guidance on how to achieve compliance and the descriptions of the required Roles which will need to be fulfilled can also be found on the MCS website (www.microgenerationcertification.org).

6 HANDOVER REQUIREMENTS

6.1 At the point at which the heat pump system is handed over to the client, the Contractor shall explain and provide to the client the following:

- The maintenance requirements and maintenance services available;
- The duly completed Compliance Certificate available from the MCS website at this link.

6.2 All MCS Installations shall be registered to the MCS Licensee through the MCS Installation Database (MID). A certificate shall be obtained from the MCS Installation Database for each installation showing that the installation has been registered with the scheme and shall be provided to the customer no later than 10 working days after the date of commissioning the system; on provision of the certificate the customer shall be instructed to include it within the handover pack.

6.3 The generation of the certificate shall be undertaken in full compliance with the terms and conditions of use of the MCS Installation Database[2], and the registration of the system on the MCS Installation Database shall only be undertaken after the system has been fully installed and commissioned.

6.4 A “per installation” fee is levied on installers for each registration added to the database. Details of any such fee will be advised from time to time through MCS Certification Bodies.

[2] The terms and conditions of use can be found on the MCS Installation Database website.

7 REGIONAL OFFICES

7.1 Where the Contractor wishes to design, install and commission under the Scheme in regional offices, then these offices shall meet the requirements of this standard to be eligible for certification.

8 PUBLICATIONS REFERRED TO

8.1 In the following list reference to undated publications implies the latest edition and amendments:

- BS EN 12831: Heating systems in buildings
- CIBSE Domestic Heating Design Guide. A CIBSE publication
- Closed-loop Vertical Borehole – Design, Installation & Materials Standard Issue 1.0 2011 www.gshp.org.uk
- "Design of low-temperature domestic heating systems – a guide for system designers and installers", 2013, BRE Trust publication FB59, www.brebookshop.com
- EN 806: Specifications for installations inside buildings conveying water for human consumption
- EN ISO 13790: Energy performance of buildings- Calculation of energy use for space heating and cooling
- EN 8558: Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. Complementary guidance to BS EN 806"
- Environmental good practice guide for ground source heating and cooling. GEHO0311BTPA-E-E. Published by Environment Agency 2011 www.environment-agency.gov.uk
- Guide A: Environmental Design. A CIBSE publication
- HSE Approved code of practice (ACOP) L8 - The control of legionella bacteria in water systems approved code of practice and guidance
- MCS 001- MCS – Installer certification scheme document. Available from: www.microgenerationcertification.org
- MCS 022 – Ground heat exchanger look-up tables. Supplementary Material to MIS 3005. Available from: www.microgenerationcertification.org
- MCS 021 - Heat Emitter Guide. Available from: www.microgenerationcertification.org
- MCS 020 – Planning Standards. Available from: www.microgenerationcertification.org

- “Report for DECC: Measurement of domestic hot water consumption in dwellings”, Energy Monitoring Company, March 2008. Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48188/3147-measure-domestic-hot-water-consump.pdf
- The Compliance Certificate for heat pump systems. Available from: http://www.microgenerationcertification.org/mcs-standards/installer-standards

APPENDIX A: ROLES AND COMPETENCY REQUIREMENTS

	3001	3002	3003	3004	3005	3007	3007-2	300x
Roles	**ST**	**PV**	**Wind**	**Biomass**	**Heat Pumps**	**CHP (Heat)**	**CHP (Elec)**	**Innovative Technology**
Nominee	✓	✓	✓	✓	✓	✓	✓	**
Nominated Technical Person(s)	✓	✓	✓	✓	✓	✓	✓	**
Health and Safety co-ordinator	✓	✓	✓	✓	✓	✓	✓	**
Designer(s) Full scope	✓	✓	✓	✓	✓	✓	✓	**
Designer(s) Limited scope	✓	✓	✓	✓	✓	✓	✓	**
Electrical competencies	*	✓	✓	*	*	✓	✓	**
Plumbing competencies	✓	✗	✗	✓	✓	✓	✓	**
Heating competencies	*	✗	✗	✓	✓	✓	✓	**
Refrigeration competencies	✗	✗	✗	✗	*	✗	✗	**
Specialist competencies	*	*	*	*	*	*	*	**

✓ Required for the technology

✗ Not required for the technology

* If applicable to the technology

** For further details please see the MCS Change Process and the Competence Criteria on the MCS website: (www.microgenerationcertification.org).

☐ A change of staff fulfilling this role would require notification to the Certification Body.

APPENDIX B: MET office mean monthly & annual air temperatures (°C) for selected stations based on the Long Term Averaging period 1981-2010

Region	Mean monthly and annual air temperature /°C (1981-2010)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NE Scotland (Dyce)	3.5	3.8	5.3	7.2	9.6	12.4	14.6	14.4	12.2	9.1	5.9	3.6	8.5
NW Scotland (Stornoway)	4.8	4.7	5.6	7.1	9.3	11.5	13.4	13.5	11.8	9.3	6.8	5.1	8.6
E Scotland (Leuchars)	3.6	4.0	5.7	7.5	10.0	12.9	15.0	14.8	12.7	9.5	6.1	3.6	8.8
Borders (Boulmer)	4.4	4.5	5.9	7.4	9.8	12.6	14.7	14.8	12.9	10.1	6.9	4.6	9.0
W Scotland (Abbotsinch)	4.0	4.2	5.9	8.0	10.9	13.5	15.4	15.0	12.6	9.4	6.2	3.8	9.1
N Ireland (Aldergrove)	4.4	4.5	6.2	8.1	10.9	13.5	15.4	15.0	13.0	9.9	6.8	4.7	9.4
North-eastern (Leeming)	3.8	4.1	6.1	8.1	11.0	13.9	16.2	15.9	13.5	10.0	6.5	3.9	9.4
North-western (Carlisle)	4.3	4.5	6.2	8.2	11.1	13.7	15.7	15.4	13.2	10.1	6.8	4.2	9.4
Midlands (Elmdon)	4.1	4.1	6.4	8.4	11.5	14.5	16.8	16.5	13.9	10.3	6.7	4.2	9.8
Wales (Aberporth)	5.3	5.1	6.6	8.2	10.9	13.4	15.2	15.3	13.7	11.0	8.0	5.9	9.9
E Pennines (Finningley)	4.2	4.4	6.6	8.6	11.7	14.6	16.9	16.8	14.2	10.6	6.9	4.4	10.0
W Pennines (Ringway)	4.5	4.6	6.6	8.7	11.9	14.5	16.6	16.3	14.0	10.6	7.1	4.6	10.0
East Anglia (Honington)	4.1	4.1	6.5	8.6	11.9	14.8	17.3	17.2	14.6	11.0	7.0	4.4	10.1
South-eastern (Gatwick)	4.3	4.4	6.7	8.7	12.0	14.9	17.3	17.0	14.3	10.9	7.1	4.6	10.2
Southern (Hurn)	4.9	4.9	6.8	8.7	12.1	14.8	17.0	16.8	14.4	11.2	7.6	5.2	10.4
Severn Valley (Filton)	5.0	5.0	7.2	9.2	12.4	15.3	17.3	17.1	14.7	11.3	7.8	5.3	10.6
South-western (Plymouth)	6.4	6.2	7.7	9.3	12.2	14.6	16.6	16.7	14.8	12.1	9.0	7.0	11.0
Thames Valley (Heathrow)	5.2	5.2	7.6	9.9	13.3	16.4	18.7	18.4	15.6	12.0	8.0	5.5	11.3

Notes:

1) All values are provisional
2) Monthly station data are included where the number of missing days each month is 2 or fewer. For months with more than 2 missing days, estimated monthly values are taken from the monthly mean temperature grid for that particular month. The long-term average is therefore based on the combination of monthly station data where there are two or fewer missing days, and monthly grid estimates, for more than two missing days. The method used to produce the monthly gridded datasets is described in Perry MC and Hollis DM 2005, The generation of monthly gridded datasets for a range of climatic variables over the UK, Int. J. Climatology. 25: 1041-1054 and available here: http://www.metoffice.gov.uk/climate/uk/about/Monthly_gridded_datasets_UK.pdf

The Table B1 (below) lists the number of missing months for each station (with more than two missing days) where grid estimates are used.

Station	Comments
NE Scotland (Dyce)	Complete record
NW Scotland (Stornoway)	Complete record
E Scotland (Leuchars)	Complete record
Borders (Boulmer)	Complete record
W Scotland (Abbotsinch)	Missing from May 1999 to December 2010
N Ireland (Aldergrove)	Complete record
North-eastern (Leeming)	Complete record
North-western (Carlisle)	Several months missing between 1994 and 2001 inclusive
Midlands (Elmdon)	Missing from April 1999
Wales (Aberporth)	Complete record
E Pennines (Finningley)	Missing from October 1995 to December 2010
W Pennines (Ringway)	Missing from November 2004 to December 2010
East Anglia (Honington)	Missing from October 1992 to July 1997 and April 2003 to December 2010
South-eastern (Gatwick)	Missing from January 1981 to March 2003
Southern (Hurn)	Complete record
Severn Valley (Filton)	Missing from January 1981 to February 2001
South-western (Plymouth)	Several months missing between 1995 and 2000
Thames Valley (Heathrow)	Complete record

Table B1: The number of months missing in the long-term averaging period 1981-2010 for each

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APPENDIX C: Values for thermal conductivity

	Type of rock		Thermal conductivity (/W/mK)		
			Min	Max	Recommended
Unconsolidated rock	Sand, dry		0.3	0.8	0.4
	Gravel, dry		0.4	0.5	0.4
	Peat, soft lignite		0.2	0.7	0.4
	Clay/silt, dry		0.4	1.0	0.5
	Clay/silt, water saturated		0.9	2.3	1.7
	Gravel, water saturated		1.6	2.0	1.8
	Claystone, siltstone		1.1	3.5	2.2
	Sand, water saturated		1.5	4.0	2.4
Solid Sediments	Hard coal		0.3	0.6	0.4
	Gypsum		1.3	2.8	1.6
	Marl		1.5	3.5	2.1
	Sandstone		1.3	5.1	2.3
	Conglomerates		1.3	5.1	2.3
	Limestone		2.5	4.0	2.8
	Dolomite		2.8	4.3	3.2
	Anhydrite		1.5	7.7	4.1
	Salt		5.3	6.4	5.4
Magmatites	Tuff		1.1	1.1	1.1
	Vulcanite, alkaline to ultra-alkaline	e.g. andesite, basalt	1.3	2.3	1.7
	Plutonite, alkaline to ultra-alkaline	Gabbro	1.7	2.5	1.9
		Diorite	2.0	2.9	2.6
	Vulcanite, acid to intermediate	e.g. latite, dacite	2.0	2.9	2.6
		e.g. rhyolite, trachyte	3.1	3.4	3.3
	Plutonite, acid to intermediate	Syenite	1.7	3.5	2.6
		Granite	2.1	4.1	3.4
Metamorphic rock	Slightly metamorphic	Clay shale	1.5	2.6	2.1
		Chert	4.5	5.0	4.5
	Moderately to highly metamorphic	Mica schist	1.5	3.1	2.2
		Gneiss	1.5	3.1	2.2
		Marble	1.3	3.1	2.5
		Amphibolite	1.9	4.0	2.9
	Vulcanite, acid to intermediate	e.g. rhyolite, trachyte	2.1	3.6	2.9
		Quartzite	5.0	6.0	5.5

Table C1: Ranges of thermal conductivity for different rock types, indicating recommended values.

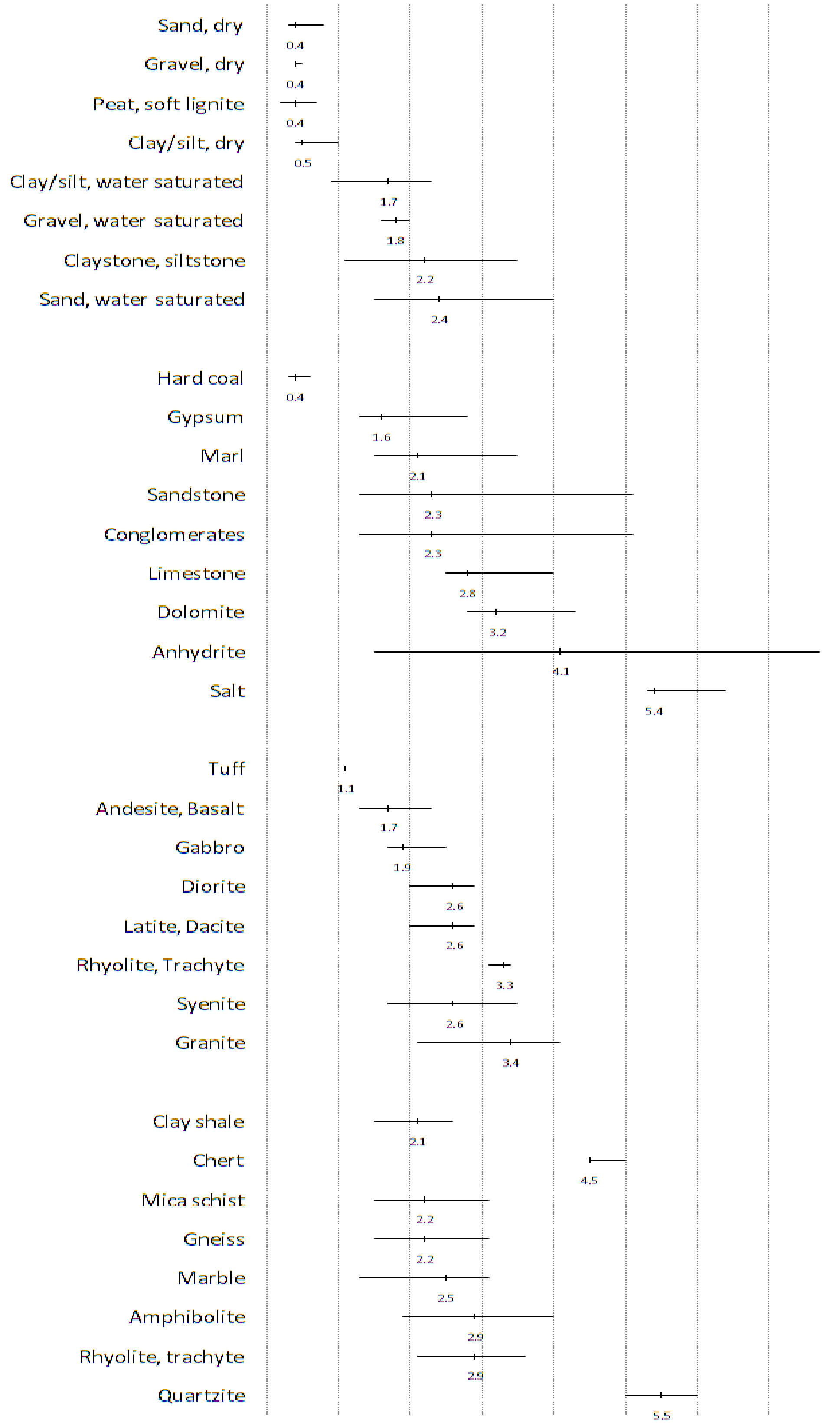

Figure C1: Ranges of thermal conductivity for different rock types, indicating recommended values. The data is the same as that in table B1. Horizontal lines represent the range of thermal conductivity for each rock type. Recommended values are written on the chart.

APPENDIX D: Label

A label shall be fixed, in a position that remains accessible and visible after the installation is completed.

This label shall be made from a durable material and so affixed as to ensure that it will remain in place for the expected lifetime of the system.

The label shall be a minimum size of 75mm X 100mm and contain the text as detailed below; it shall have a black border, black font and yellow background. It shall have a minimum font size of 20 for the first line and a minimum font size 9 for the remainder of the text.

Caution Before Altering Settings

This system has been commissioned to run efficiently using carefully considered setting(s)

Alterations to these settings could invalidate the system's certificate of compliance

Any alteration to these settings may have an adverse effect on the efficiency of the system resulting in increased running costs, and should only be undertaken in full knowledge of the overall system design

APPENDIX E: Heat pump design definitions and calculations.

NOTE: This is for information only and should be read in conjunction with the Compliance Certificate.

Data from design calculations

Annual energy calculations for MIS 3005 3.4, ¶4.2.1, ¶4.2.2, ¶4.3.1 (electric HPs only)

SPACE HEATING

Annual heat demand

Demand	kWh/yr	[101]	Obtain from installer calculations	4.3.2(a)
Heat supplied by HP, excluding auxiliary heaters	kWh/yr	[102]	Obtain from installer calculations	4.3.2(b), referring to 4.2.1
SPF(2)		[103]	Obtain from installer calculations	4.3.2(c), referring to HEG for "default efficiency".
Electricity consumed by HP, excluding auxiliary heaters	kWh/yr	[104]	= [102] ÷ [103]	4.3.2(c)
Renewable heat supplied by HP	kWh/yr	[105]	= [102] - [104]	
Remaining heat to be supplied by auxiliary heaters and other heat sources	kWh/yr	[106]	= [101] - [104] - [105]	4.3.2(d)
Remaining heat, supplied by other heat sources	kWh/yr	[107]	Obtain from installer calculations	4.2.2(e)
Remaining heat, supplied by auxiliary heaters	kWh/yr	[108]	= [106] - [107]	4.3.2(d)
Electricity consumed by HP, including auxiliary heaters	kWh/yr	[109]	= [104] + [108]	4.3.2(e)

Where other heat sources are used:

Fuel used		[110]	Electricity / gas / LPG / oil / solid fuel	
Efficiency of other heat sources		[111]	Obtain from relevant source; eg SAP or boiler database	

Consumed by other heat sources	kWh/yr	[112]	= [107] ÷ [111]	4.3.2(e)

WATER HEATING

Annual heat demand

Demand	kWh/yr	[201]	Obtain from installer calculations	4.3.2(a)
Heat supplied by HP, excluding immersion heater	kWh/yr	[202]	Obtain from installer calculations	4.3.2(b), referring to 4.2.1
SPF(2)		[203]	Obtain from installer calculations	4.3.2(c)
Electricity consumed by HP, excluding immersion heater	kWh/yr	[204]	= [202] ÷ [203]	4.3.2(c)
Renewable heat supplied by HP	kWh/yr	[205]	= [202] - [204]	
Remaining heat to be supplied by immersion heater and other heat sources	kWh/yr	[206]	= [201] - [204] - [205]	4.3.2(d)
Remaining heat, supplied by other heat sources	kWh/yr	[207]	Obtain from installer calculations	4.2.1(e)
Remaining heat, supplied by immersion heater	kWh/yr	[208]	= [206] - [207]	4.3.2(d)
Electricity consumed by HP, including immersion heater	kWh/yr	[209]	= [204] + [208]	4.3.2(e)

Where other heat sources are used:

Fuel used		[210]	Electricity / gas / LPG / oil / solid fuel	
Efficiency of other heat sources		[211]	Obtain from relevant source; eg SAP or boiler database	
Consumed by other heat sources	kWh/yr	[212]	= [207] ÷ [211]	4.3.2(e)

PROPORTIONS, ENERGY CONSUMPTION, AND PERFORMANCE

Proportion of space heating and water heating demand provided by heat pump (excluding auxiliary/immersion heaters)	%	[301]	= ([102] + [202]) ÷ ([101] + [201])	4.2.2
Renewable heat	kWh/yr	[302]	= [105] + [205]	
Electricity consumed by HP (excluding auxiliary/immersion heaters)	kWh/yr	[303]	= [104] + [204]	

Electricity consumed by auxiliary/immersion heaters (supplied as part of HP)	kWh/yr	[304]	= [108] + [208]
Fuel consumed by other heat sources	kWh/yr	[305]	= [112] + [212]
HP combined performance SPF(4)		[306]	= ([102] + [202] + [108] + [208]) ÷ ([109] + [209])

RUNNING COSTS

Cost per unit of electricity for HP	p/kWh	[401]	Obtain from consumer, or SAP Table 12
Cost per unit of fuel for other heat sources	p/kWh	[402]	Obtain from consumer, or SAP Table 12
Cost of electricity for HP (including auxiliary/immersion heaters)	£/yr	[403]	= ([303] + [304]) × [401] ÷ 100
Cost of fuel for other heat sources	£/yr	[404]	= [305] × [402] ÷ 100

RHI CALCULATIONS

Annual energy figures

Annual space heating demand	kWh/yr	[501]	Obtain from EPC
Annual water heating demand	kWh/yr	[502]	Obtain from EPC
Is space heating supplied by the HP?		[503]	0 = no, 1 = yes
Is water heating supplied by the HP?		[504]	0 = no, 1 = yes
Maximum qualifying heat supplied by the HP	kWh/yr	[505]	= [501] × [503] + [502] × [504])
SPF for RHI purposes		[506]	Obtain from HEG (= design calcs box [103])
Maximum qualifying renewable heat	kWh/yr	[507]	= [505] × (1 - 1 ÷ [506])

AMENDMENTS ISSUED SINCE PUBLICATION

Document Number:	Amendment Details:	Date:
1.2	Amended 3.4 Consumer Code of Practice wording. Updated e-mail and website addresses.	25/02/2008
1.3	Gemserv details added as Licensee. Document reformatted to reflect brand update. References to BERR updated to DECC, MCS logo updated accordingly. Website and email addresses updated to reflect new name.	01/12/2008
1.4	Quality review	10/01/2009
1.5	MCS Mark updated	25/02/09
1.6	Additional contacting options were added to Clause 3.3. As agreed in the MCS Steering on 27/10/2009. References to Clear Skies have been removed from Clause 4.7 and a link to the MCS website added.	28/01/2010

2.0	Addition of text under Section 6 – Handover incorporating the generation of MCS Certificates from the MID for each installation. Changes are as agreed at SG meeting of May 27th 2010.	26/08/2010
3.0	Significant updates full document. Readers are advised to read all sections.	05/09/2011
3.1	Update to figure for Plymouth in Table 2 from -1.2 to -0.2, as detailed in CIBSE Guide A. Updated clause 4.2.1c, d and e. Corrected clause 4.2.18. Updated 4.3 to refer to Heat Emitter Guide and SPFs instead of SAP. Addition of note to clause 4.2.17. Addition of CIBSE Domestic Heating and Design Guide to Publications referred to.	01/02/2012
3.1a	A note has been added below Clause 4.2.17, and update to Section 6 Handover Requirements.	20/02/2012
3.2	Requirements for installation of gas	22/07/2013

	absorption heat pumps added. Clause 4.2.18 changed to 3% from 2.5%. Clause 3.4 consumer code of practice updated.	
4.0	Significant update to all sections of the standard. Insertion of Appendix D	16/12/2013