



The Certification Mark for Onsite
Sustainable Energy Technologies

For MIS 3005

Guidance on designing heat pumps to MIS 3005 v3.1a

TABLE OF CONTENTS

1.	INTRODUCTION	3
2.	POWER HEAT LOSS CALCULATION	4
	2.1 INTERNAL DESIGN TEMPERATURES	4
	2.2 EXTERNAL DESIGN TEMPERATURES	5
	2.3 VENTILATION HEAT LOSS	6
	2.4 BUILDING DIMENSIONS AND ROOM SHAPE	6
	2.5 U-VALUES	7
	2.6 POWER HEAT LOSS CALCULATION	7
	2.7 GROSS & NET AREA IN THE DHDG & SIMPLIFIED METHOD	9
	2.8 SPECIFYING THE GROUND, PARTY WALLS & INTERNAL WALLS FOR THE DHDG METHOD	9
	2.9 f_k , TEMPERATURE CORRECTION FACTOR FOR THE SIMPLIFIED METHOD	9
	2.10 EXPOSED LOCATION	9
	2.11 INTERMITTENT HEATING	10
	2.12 SUMMATION OF THE POWER HEAT LOSSES	10
3.	SPACE HEATING ENERGY CONSUMPTION	10
4.	HOT WATER CALCULATION	11
5.	HEAT PUMP MODEL SELECTION	12
6.	RUNNING COSTS	14
7.	CUSTOMER COMMUNICATION	14
8.	SIZING THE GROUND COLLECTOR	14
9.	CONCLUSIONS AND DISCLAIMER	15
	APPENDIX A : TYPICAL SPACE HEATING ENERGY CONSUMPTION FOR A HOME BASED IN SHEFFIELD	17
	APPENDIX B : REFERENCE DOCUMENTS	18

1. INTRODUCTION

To design a heat pump system to MIS 3005 version 3.1a, various actions need to be taken. This can be summarised as:

1. Calculating the power heat loss of the property using BS EN 12831 and the internal and external design temperatures in MIS 3005.
2. Calculating the space heating energy consumption of the property. This allows the designer to calculate the space heating running costs and size a ground loop collector.
3. Calculating the hot water requirements using either BS 6700 or BS EN 806.
4. Selecting the heat pump model.
5. Calculating the various running costs of the heat pump heating system and its individual parts.
6. Communicating to the customer the power, energy, running costs and factors such as energy efficiency requirements and how anti bacterial measures will be implemented.
7. If designing a ground source heat pump (GSHP) system, size the ground loop collector and make sure that the Reynold's Number <2500 & ground loop pumping power $>2.5\%$.

There are 2 suggested methods for specifying a heat pump system for the property:

- a method based on the CIBSE Domestic Heating Design Guide (DHDG method);
or
- a method based on the Simplified Method in BS EN 12831 (Simplified Method).

The recommendation is to use the DHDG method for properties built prior to year 2000 and the Simplified Method for properties built after 2000. This will be discussed further in the ventilation section below.

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 3 of 19

It is worth noting that when designing power and energy losses from a property, it is always better to err on the side of caution and to design conservatively. There are frequent requests to use U-values and ventilation rates other than those indicated in this guidance. All design decisions have to be made by the specifier. They must be justifiable both to the customer and to an MCS Certification Body. Whilst it is not good practice to significantly oversize a heat pump, it is definitely poor practice to undersize a heat pump. Therefore, if in doubt, it is better to choose the greater value.

2. POWER HEAT LOSS CALCULATION

This figure is obtained by calculating the total of all the heat losses through the fabric of the building and from the ventilation of the building. It must be obtained by calculating for each room the fabric losses from:

- the 4 walls;
- the ceiling;
- the floor;
- the windows;
- the doors; and
- all the thermal bridges where the walls, floors, ceilings, windows and doors intersect.

Fortunately, the thermal bridges can be estimated by using “factors” for newly-built properties. For pre-2000 properties, the spreadsheet model has sufficient latitude to take thermal bridging into account as part of the calculation process.

The space heating has to be made to the internal and external temperatures as laid out in MIS 3005 v3.1a. These are shown below.

2.1 INTERNAL DESIGN TEMPERATURES

Room	Internal design temperatures (°C) from the UK national annex to BS EN 12831
Living room	21
Dining room	21
Bedsitting room	21

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	Page 4 of 19
Date: 17/07/2012		

Bedroom	18
Hall and landing	18
Kitchen	18
Bathroom	22
Toilet	18

2.2 EXTERNAL DESIGN TEMPERATURES

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

For the external design temperature, in the absence of more localised information, data from the closest location may be used, and 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.

For the internal design temperature, it simplifies the calculation method if one internal design temperature is used. Otherwise, low levels of heat flow between different rooms occur within the property. Therefore, the example spreadsheets have used 21°C throughout the property.

Potentially this causes issues for the bathroom which should use an internal temperature of 22°C. You can either size the bathroom to this temperature or declare the bathroom as a toilet and use the lower internal temperature.

2.3 VENTILATION HEAT LOSS

The following table sets out the various ventilation rates for different ages of property. DHDG ventilation rates are used on houses built before year 2000:

Room	DHDG VCR	2000-06 VCR	2006 on VCR
Living room	1.5	1.0	0.5
Dining room	1.5	1.0	0.5
Bedsitting room	1.5	0.75	0.5
Bedroom	1.0	1.0	0.5
Hall and landing	1.5	1.0	0.5
Kitchen	2.0	1.5	1.5
Toilet/Bathroom	2.0	1.5	1.5
Office Room	not specified	1.0	1.0
Meeting Room	not specified	2.0	2.0

The higher ventilation rates on earlier properties are used to represent the greater heat loss from these buildings. If you are aware that considerable steps including excellent draught-proofing and careful sealing around all building penetrations, such as well installed replacement windows, have been taken within the property to address the ventilation rates, then it is feasible to use lower ventilation rates in an existing property. However, this option should only be taken with caution as field trials indicate these ventilation rates tend to provide good in-use estimates of power and energy consumption.

2.4 BUILDING DIMENSIONS AND ROOM SHAPE

Care must be taken when measuring internal room dimensions. There is reported evidence showing a 30% to 40% variation in internal measurement recording. Inaccuracies lead to poor design. To improve calculation accuracy, it is best to measure to the middle of the wall for internal walls and to the far end of the wall for external walls. Wall thickness can be checked at the windows to add to the internal dimensions. Floor height should be taken from the top of the floor to the top of the floor above. See diagram on “scope” worksheet of all the spreadsheet models for further clarification.

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 6 of 19

For each room, the external wall length must be carefully specified in the relevant cell. The specifier must evaluate how many walls are externally facing.

Most rooms are rectangular and so easy to enter into the spreadsheet. Rooms such as L-shapes or circular are not so simple. For L-shapes, divide the room with imaginary dividers to make the room into a series of rectangular rooms. For shapes such as round or oval, the area of the individual elements should be entered into the area section of the spreadsheet. Basic maths such as πr^2 or πD can assist here.

2.5 U-VALUES

These can be taken either from the DHDG tables as available on the MCS website or calculated from the U-value calculation worksheet in all the spreadsheet models. If the λ -value of the material is unknown, this can either be checked with the supplier or by running a web search for the materials.

2.6 POWER HEAT LOSS CALCULATION

This ventilation power heat loss is calculated for by multiplying the volumetric hourly air change rate (VCR) by the air change factor and design temperature difference. For fabric heat losses, for each different element, multiply the relevant area by the U-value and the design temperature difference. All the various separate power heat losses are then summed to provide the power heat loss for the room.

The DHDG spreadsheet uses an air change factor of 0.33 W/m³K whilst the Simplified Model spreadsheet uses an air change factor of 0.34 W/m³K. This is because these two slightly different constants are used in either model respectively. Please refer to the DHDG book and BS EN 12831 standard for further clarification.

Within the factors of the New Build and 2000 to 2006 spreadsheets, there are effectively 4 grades of neighbouring space that can be unheated and so contribute to the heat loss as follows:

to an adjacent building entity	0.3	if thermal bridges are insulated
	0.42	if thermal bridges are not insulated

to an adjacent building	0.5	if thermal bridges are insulated
	0.7	if thermal bridges are not insulated
through unheated space	0.8	if thermal bridges are insulated
	1.12	if thermal bridges are not insulated
through the roof space	0.9	if thermal bridges are insulated
	1.26	if thermal bridges are not insulated

These 4 options offer the engineer plenty of options to make the right choice for the property in question. For example, if the engineer knew the adjacent building entity was a well insulated garage or double glazed conservatory, they would use the “adjacent building entity”. However, if the garage was not draught proofed and had a very thin metal door, then they would use the “unheated space” option as the right choice for this property. We are aware that this is asking for value calls in assessing the property. As engineers we should have the ability to make reasonable value calls on the building in question and be prepared to include our assumptions in the output so that everyone is satisfied with the final outcome. The engineer would use the “adjacent building” as it says here and use these figures for a terraced or semi-detached house.

We note that heat loss calculations require judgement to model the expected behaviour of the property and its typical occupants. To confirm again what was shared in the introduction to this document, this is a design procedure, not an assessment procedure. Good design will tend to err on the side of caution and model higher power loss so that the heating system has the capacity to supply enough power for any instantaneous heat load occurrence and enough energy available to cover the requirements of the whole year.

2.7 GROSS & NET AREA IN THE DHDG & SIMPLIFIED METHOD

The spreadsheets automatically subtract the window and door areas from the wall and ceiling areas respectively.

2.8 SPECIFYING THE GROUND, PARTY WALLS & INTERNAL WALLS FOR THE DHDG METHOD

When designing for a suspended floor, the external design temperature should be used for the design temperature difference. In the following cases you should use:

- For Solid Ground Floor: Design Temperature Difference = Internal Temp. – Mean Air Temp.
- For Party Walls: Design Temperature Difference = Internal Temp. - 10 °C
- For Internal Walls: Design Temperature Difference = Internal Temp – Internal Temp Adjacent Room

2.9 f_k , TEMPERATURE CORRECTION FACTOR FOR THE SIMPLIFIED METHOD

For the Simplified Method, the Design Temperature Difference should not be altered. It remains as Internal Temperature minus External Temperature throughout. To accommodate both the variation in design temperature differences and thermal bridging, different temperature factors (f_k), are specified for the different scenarios. These are shown on the factors worksheet. It is important to use “not insulated” thermal bridging factors unless it is known that real care has been taken to insulate thermal bridges. This is only normally addressed in very recently constructed new build properties.

If the Party Wall is ventilated, the Adjacent Building temperature correction factors should be used unless care has been taken to minimise or seal the party wall heat losses. If this is the case then the Adjacent Building Element temperature correction factors can be used. This is because losses through ventilated party walls have been found to be higher than initially anticipated.

2.10 EXPOSED LOCATION

If the property is located in an exposed location such as a rural hilly location in Scotland or a flat wind-swept location in East Anglia where the wind chill factor adds

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 9 of 19

to the heat loss from the property, it is important to add an extra 10% to the overall Power Heat Loss Calculation.

2.11 INTERMITTENT HEATING

In the DHDG method, if an allowance needs to be made for heating up the building from a cold situation, an extra 15% should be added to the Design Heat Loss for the room to allow some extra heat pump power to facilitate the reheat process. Any heating control strategy based on heating cycles rather than continuous heating should add this 15%.

For the Simplified Method the reheat factor (f_{rh}) should be used. As the temperature setback is only a few degrees in a newly-built property, a low reheat factor should typically be employed. A low to medium factor of 6 has been used in the sample spreadsheets.

2.12 SUMMATION OF THE POWER HEAT LOSSES

Depending on the heat pump system in question, all the Power Heat Losses are summed in either the air source heat pump (ASHP) or ground source heat pump (GSHP) worksheets.

A W/m^2 figure for each room is provided in cell L24. This is not the Power Heat Loss for the room. It is the Power Heat Loss per square metre and is to be used in conjunction with the Heat Emitter Guide.

The Heat Emitter Guide is a guidance tool and not a design tool. Manufacturers' and specifiers' information must be used for design purposes.

3. SPACE HEATING ENERGY CONSUMPTION

Either binned data or degree day data can be used to calculate the space heating energy consumption of the property. Binned data is typically used in dynamic space heating energy consumption methods. The spreadsheet model is a static model and so a degree data method has been employed. To understand degree day methods, search the internet for "heating degree days".

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 10 of 19

The degree day data for 18 different UK locations is provided in the Tables worksheet. This data should be used on every Room Worksheet page. Losses to Party Walls, Internal Walls or Intermittent Heating energy heat losses should not typically be included in the Space Heating Energy Consumption as in these situations typically:

- the room on the other side of the party wall will be heated;
- the internal energy flows balance out; and
- the intermittent heating is an exceptional rather than a typical occurrence.

The exception to this rule is when the adjacent building is unheated or the party wall is ventilated then the Space Heating Energy Consumption should be included.

Depending on the heat pump system in question, all the Space Heating Energy Consumptions for the different rooms are summed in either the ASHP or GSHP worksheet.

The degree day data in the spreadsheet is taken from CIBSE Guide A and is based on a 20 year period from 1976 to 1995. A 15.5 °C base temperature is represented in all the models. This temperature has been used because in most British homes, the space heating is switched on when the external temperature drops below 15.5 °C. However, it is noted that heat pump system designers might want to use different degree day data if:

- more recent, local and so potentially more accurate UK Met Office data is sourced; or
- a higher or lower base temperature is required depending on fabric & ventilation levels.

As ever in specifying the system, as long as the change can be recorded, explained and verified, then it is possible to improve the methodology with better practice.

4. HOT WATER CALCULATION

In MIS 3005 v3.1a there is no recommended method for specifying the hot water calculation. In the absence of a specified method, the spreadsheet calculation

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 11 of 19

methodology has been based on an occupancy rate for the building which is the total number of bedrooms plus one person.

The hot water consumption rate is taken from BS 6700 which says that unless steps such as low flow rate points of use have been implemented, the property will typically use 45 litres of hot water per person per day. This can be dropped to 40 or 35 litres hot water per person per day if steps to minimise hot water consumption have been taken within the property.

An efficiency has been allowed for the heat losses between the heat pump and the cylinder. The default value for this heat loss is 70%. For a tank-in-tank heat pump, this could be increased to 85%. However, in most cases, without further field trial data, 70% is a reasonable allowance.

The Hot Water Calculation has been left on a daily bacteria (Legionella) cycle. However, if a 4 or 7 day bacteria cycle is specified by the supplier or system designer, then the immersion heater energy consumption can be divided by this cycle length.

In the cell 'Power Required for Hot Water', an allowance of 0.2 kW of heat pump power has been employed. This is because many suppliers suggest adding 0.2 kW of power for each building occupant for hot water. However, other suppliers do not suggest allowing extra heat pump power capacity for hot water and others specify other power allowances such as 0.25 kW per person. There is no reason why the heat pump suppliers' recommendations should not be followed as long as design responsibility is taken for any decisions made.

5. HEAT PUMP MODEL SELECTION

Manufacturers should provide heat pump power data in either tabular or graphical form at varying temperature flow rates for every heat pump model they offer.

For hot water provision, it is typically better to use the heat pump rather than an immersion heater. Therefore the maximum flow temperature (up to 65 °C) for the heat pump in question should be entered in the Flow Temperature in 'HW Mode' cell. The spreadsheet then automates the hot water calculation including an allowance for the heat emitter guide Seasonal Performance Factor (SPF) and a temperature

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 12 of 19

difference of 5 °C (K) between the primary central heating water and the secondary potable hot water.

For space heating provision, the flow temperature to the heat emitters must be known. The Heat Emitter Guide discusses this further. This space heating flow temperature is entered into the 'Flow Temp in Space Heat Mode' cell and the relevant 'HP capacity in Space Heat Mode' is entered into this cell based on the Manufacturer's tabular or graphical data.

Finally, to complete the data entry, the 'Marginal Electricity Cost', 'Running Mode for CH Power' and 'Power Consumption of CH Pump' should all be entered. The default values in the spreadsheets are:

- 12 p/kWh for electricity cost;
- Full Load Equivalent run hours (FLEQ) for Running Mode ;
- 105 Watts for CH pump power; and
- Power Ground HX Pump (for GSHP worksheet only).

12 p/kWh is a typical cost for each kWh of electricity purchased after standing charges. If the electricity price is known to differ from this 12 p/kWh, then this new price should be used. For example, in Northern Ireland electricity typically costs 17 p/kWh so this price should be used.

FLEQ is specified as the default if the central heating pump is automatically switched on by the heat pump control system. However, if a different control strategy is used such as leaving the Central Heating (CH) pump permanently on, the total hours of CH pump operation should be specified in this cell. The spreadsheet will use either the hours information or total HP operational hours, depending on which control strategy is employed.

105 Watts for the CH pump is the typical power consumption for a 5 m head CH pump on setting 3. Modern energy efficient CH pumps often use much less energy than this. However, the value has been left on a high default setting with allowance for reductions based on the CH pump selection and its final in use setting.

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 13 of 19

For GSHP specification only, the Power Ground HX Pump calculation is discussed further in the Hydraulics Design Guide. The value should be entered after the pump has been specified. It has been left on 2.5% of GSHP power which is a default setting as the pump must be 2.5% or less than the GSHP space heating power output.

6. RUNNING COSTS

The spreadsheet automates the calculation of the various running costs that need to be communicated to the customer, and sets out these values in the Information for Householder section. It is noted that that the pump running costs are included in the Heat Emitter Guide SPF and so for the latest versions of the spreadsheet, this has been allowed for in the overall running cost where these costs are not added to the Total Estimated CH Running Cost.

7. CUSTOMER COMMUNICATION

MIS 3005 v3.1a specifies a series of parameters that should be explained in the customer quote. These parameters are included in the 'Information for Householder' section of the ASHP and GSHP worksheets respectively.

These parameters include making sure that:

- the cylinder and pipework will be specified to the relevant national Building Regulations or Standards (Scotland);
- best practice for hot water has been implemented. For example, if a HW cylinder is used, electric showers should ideally be replaced with showers provided from the HW cylinder;
- a bacteria (Legionella) pasteurisation strategy has been implemented and explained to the end user; and
- for GSHPs, the antifreeze is set to at least -10 °C, biocide has been used and 2 samples of antifreeze have been checked.

8. SIZING THE GROUND COLLECTOR

Table 3 in MIS 3005 v3.1a sets out how to size a ground loop collector for an MCS installation. It uses the look-up tables to obtain the maximum power to be extracted

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 14 of 19

per unit length of collector via the ground thermal conductivity and mean air temperature. Further advice on ground thermal conductivity is provided in Section 3.2 of MGD 002.

Box [1] in Table 3 should be taken from the 'Total Energy Consumption HP' cell and Box [2] in table 3 should be taken from the Mean Power Output HP cell.

The Hydraulics Design Guide available on the MCS website sets out how to design for Reynold's Number >2500 and ground collector pumping power <2.5% heat pump power.

9. CONCLUSIONS AND DISCLAIMER

This guidance and the associated spreadsheets (and any associated software) are provided to assist you in sizing heat pump systems for domestic heat pump applications. The spreadsheets are based on 2 recognised methods, the Domestic Heating Design Guide for pre-2000 properties and the Simplified Method in the main body of BS EN 12831 for post-2000 properties.

If used judiciously these spreadsheets should provide an output that models the heat energy consumption of a typical group of occupants of the building. It is the responsibility of the building specifier to check that the final output corresponds to the heat energy consumption of similar properties. Always follow the motto of check, check and check again. The attached table (see Appendix A) provides typical heat energy consumption rates for British properties based in Sheffield. They are taken from the CERT documentation. They can assist in checking your work. However, it is worth noting that your results might differ significantly from the results in this table if the house has different construction methods and insulation levels.

It is important to check the accuracy of measurements, U-Values and any other data changed, entered or computed. The final result is a model. The actual performance of the property will depend on the number of occupants, how long they stay in the property during the day, the thermostat and timer settings and how they ventilate the building amongst other variables. A bachelor who takes short showers and works long hours will probably use much less energy than a young family or an old couple. In most circumstances, the heat pump system should be designed irrespective of the occupants, as the typical British home changes hands every 7 years. Exceptions to

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 15 of 19

this advice should be made if the customer requests property design to their own requirements and specifications.

The advice, information and support tools provided here are given in good faith. Please email or contact MCS to highlight any omissions or misstatements and they will be addressed accordingly. As stated above, the user is responsible for both the inputs and outputs from the spreadsheets (and any associated software) and MCS and its partners take no responsibility for the output from the incorrect use of these spreadsheets and guidance.

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 16 of 19

APPENDIX A : TYPICAL SPACE HEATING ENERGY CONSUMPTION FOR A HOME BASED IN SHEFFIELD

The following is taken from the Carbon Emissions Reduction Target and is an estimate of a typical house's space heating energy consumption if the house is located in Sheffield. This information is provided for your reference. It is not for design purposes. It can act as a check to see if the BS EN 12831 calculation covered as part of an MIS 3005 v3.1a installation is somewhat similar to an expected result from a similar property. Typically, it is expected that a BS EN 12831 calculation would produce higher results than the figures provided below as these figures are based on assessment rather than design methods.

	Bedrooms Units	Floor Area m2	Cavity Wall Construction kWh/yr	Solid Wall Construction kWh/yr
Flats	1	42	3,685	6,244
	2	61	4,441	7,525
	3	89	5,365	9,089
Mid terrace House	2	63	4,699	7,961
	3	79	5,262	8,914
End Terrace House	2	63	8,248	13,974
	3	79	9,236	15,648
Detached bungalow	2	67	7,786	13,192
	3	78	8,401	14,234
	4	90	9,024	15,289
Semi- detached house	2	77	8,998	15,245
	3	89	9,674	16,390
	4	102	10,356	17,546
Detached house	2	90	14,674	24,861
	3	104	15,774	26,724
	4	120	16,994	28,707

APPENDIX B : REFERENCE DOCUMENTS

- BS EN 12831 - Heating systems in buildings. Method for calculation of the design heat load. Available from : <http://shop.bsigroup.com>
- CIBSE Guide A : Environmental Design. Available from : <https://www.cibseknowledgeportal.co.uk/cibse-guides>
- DHDG Sizing Spreadsheet. Available from ; <http://www.microgenerationcertification.org/installers/installers/decc-heat-pump-training-road-show>
- Domestic Heating Design Guide : <http://www.centralheating.co.uk/Domestic-Heating-Design-Guide>
- Heat Emitter Guide. Available from : <http://www.microgenerationcertification.org/installers/installers/decc-heat-pump-training-road-show>
- New Build house using BS EN 12831 simplified method : <http://www.microgenerationcertification.org/installers/installers/decc-heat-pump-training-road-show>

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 18 of 19

AMENDMENTS ISSUED SINCE PUBLICATION

Document Number:	Amendment Details:	Date:
1.0	First Issue	20/07/2012

Issue 1.0	Guidance on designing a heat pump system to MIS 3005 v3.1a	
Date: 17/07/2012		Page 19 of 19