Department of Energy & Climate Change

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Partner for progress

Report on under-floor heating design

Prepared by: Kiwa GASTEC at CRE
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DECC
30035

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Commercial in Confidence

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1 Introduction

Kiwa GASTEC at CRE (Kiwa) have been contracted to carry out monitoring of the energy demand of under-floor heating and radiators in a social housing flat by the Department for Energy and Climate Change (DECC).

Kiwa are currently working with a housing provider on a Technology Strategy Board (TSB) Building Performance Evaluation (BPE) project which is now in the phase 2 stage. This work for DECC therefore runs concurrent to the work already underway. Phase 1 of the BPE project included a design and construction audit (including SAP review), co-heating tests, thermal imaging, and walkthroughs with the design team and new tenants.

The site is a mixed use development of office/retail and residential in London. There are a total of 23 flats in the development including 14 social rented and 9 shared ownership properties. Two flats are being monitored in detail for the BPE project; a second floor, 3 bedroom flat and a fourth floor, 1 bedroom flat, both in the social rented part of the development.

Each flat in the development contains an exhaust air heat pump (EAHP) which provides domestic hot water (DHW) and space heating by way of an under-floor heating system. The development is a Code for Sustainable Homes Level 3 development and was completed in January 2010. Energy monitoring equipment was installed by Kiwa in January 2010, when phase 1 of the BPE project was completed.

The follow-on project for DECC includes the following technical requirements:

1. Write a short report on the under-floor heating design in the flats
2. Install slab temperature sensors in both of the flats which are being monitored
3. Install electricity sub-metering on the fiscal meters for 10 of the social rented flats (in addition to the 2 being monitored currently)
4. Install radiators in the 3 bedroom flat in place of the under-floor heating system
5. Continue monitoring both flats for another year
6. To obtain feedback by way of a questionnaire from the residents in all 12 properties where monitoring is being carried out.

This project aims to determine the effect of radiators compared to under-floor heating on the performance of the EAHP.

This report aims to include on the following:

- Details of the design of the existing under-floor heating system
- Details of the designed floor construction and level of insulation
- Details of floor coverings which have been specified, with tog level, if information is available (e.g. details of any lining under the carpet including the potential insulating

effect)

- Details of the under-floor heating designer including whether they are a UHMA member
- Information on whether the design was copied from another design that may have been appropriate for a very well insulated building.

2 Heating system emitter design

The main contractor sub-contracted the plumbing work to a plumber. In turn, the plumber sub-contracted the design of the under-floor heating design to an under-floor heating specialist.

2.1 Under-floor heating system design

The decision to use EAHPs for primary heating systems in this development was made by the developer. The under-floor heating specialist was aware that the heating system which had been chosen for these flats was an EAHP. Based on the information provided, the under-floor heating specialist chose to design the under-floor heating system to operate with flow and return temperatures of 50°C and 40°C respectively. The under-floor heating specialist was briefed that the heat pump can operate on one of three different modes, of which some are more efficient than others. The under-floor heating specialist were not involved in the choice of heating system or the sizing of the heat pump – this is their normal procedure when they are commissioned to design and install an under-floor heating system.

The under-floor heating specialist provided detailed design drawings for the under-floor heating system on each floor of the development.

The design of the under-floor heating system was based on flow and return temperatures of 50/40°C. The external design temperature was -3°C. The under-floor heating specialist used the following U-values to calculate the heat loss for each room in the flats:

Element	**Construction**	**U value** W/(m^2K)
External wall	Insulated cavity	0.35*
Internal wall	Block/PB	1.8
Party wall	N/A	N/A
Garage wall	N/A	N/A
Ground floor	Insulated solid	0.01 UFH
Internal wall	Insulated solid	0.01 UFH
Roof	Insulated	0.25*
Windows	Double glazed	2.2*
Door		2.2*

Table 1: U-values used for heat loss calculations

* Indicates a value assumed by the under-floor heating specialist when the design was carried out

The under-floor heating specialist based their calculations on an external temperature of -3°C and internal temperature ranging from 18 - 22°C (depending on the room) i.e. an average ΔT of 20K.

The heat demand for flat 6 was calculated as 3106W and for flat 14 it was calculated as 3146W. The breakdown of this heat demand by room is shown below.

Room	**Floor area** m^2	**Ceiling area** m^2	**Temperature** °C	**Air changes/hour**	**Heat loss/m^2** W/m^2	**Heat loss** W

Hall	9.9	10	18	1.5	28	282
Living	19.7	20	21	1.0	46	903
Kitchen	7.8	8	18	1.5	28	221
Bed 1	11.9	12	18	1.0	33	397
Bed 2	14.2	14	18	1.0	32	449
Bed 3	9.4	9	18	1.0	36	337
Bathroom	5.0	5	22	2.0	73	367
WC	3.3	3	18	2.0	38	126
W1	1.2	1	18	1.0	19	24
Total	82.4	82	N/A	N/A	N/A	3106

Table 2: under-floor heating specialist heat loss calculations for flat 6

Room	**Floor area** m^2	**Ceiling area** m^2	**Temperature** °C	**Air changes/hour**	**Heat loss/m²** W/m^2	**Heat loss** W
Hall	6.5	6	18	1.5	35	223
Living	25.7	26	21	1.5	72	1850
Bed 1	10.7	11	18	1.0	58	618
Bathroom	4.5	5	22	2.0	100	455
Total	47.4	48	N/A	N/A	N/A	3146

Table 3: under-floor heating specialist heat loss calculations for flat 14

2.2 Heating system requirements calculated by Kiwa

The heat demand was calculated by Kiwa as part of the TSB BPE project. The demand figures were based on an external temperature of -5°C and internal temperature of 21°C i.e. a ΔT of 26K.

Room	**Floor area** m^2	**Temperature** °C	**Heat demand** W
Hall	9.13	21	329
Living	19.14	21	738
Kitchen	7.68	21	268
Bed 1	11.74	21	472
Bed 2	13.85	21	506
Bed 3	9.63	21	396
Bathroom	4.75	21	161
WC	3.54	21	125
Total	79.46	N/A	2995

Table 4: Kiwa heat loss calculations for flat 6

Room	**Floor area** m^2	**Temperature** °C	**Heat loss** W
Hall	6.63	21	267
Living	26.31	21	1317

Bed 1	10.64	21	547
Bathroom	4.33	21	200
Total	47.91	N/A	2331

Table 5: Kiwa heat loss calculations for flat 14

It should be noted that the floor areas calculated by Kiwa differ slightly from those calculated by the under-floor heating specialist because Kiwa excluded the unheated areas of the property for the purpose of these calculations i.e. he heat pump cupboard and storage cupboards.

2.3 Comparison of under-floor heating specialist and Kiwa heating system requirements

The heat loss calculations carried out by the under-floor heating specialist give higher values for the total heat demand than those calculated by Kiwa, therefore the emitter is sufficiently sized (if not oversized) to heat the property.

	Flat 6	**Flat 14**
Heat demand (calculated by the under-floor heating specialist), W	3106	3146
Heat demand (calculated for BPE), W	2995	2331

Table 6: Heat demands

With flow and return temperatures of 40°C and 45°C respectively, the radiator rating for the 3 bed flat was calculated to be 8810W i.e. the radiators needed to be oversized by a factor of 8810/2995 = 2.9. This was used as the basis for sizing the radiators which were installed in April 2012. The radiator rating was calculated using an external temperature of -5°C and an internal temperature of 21°C.

3 Floor construction

The floor construction is (from the top down) – 75mm k-screed (sub-floor screed), 50mm insulation, 6mm resilient layer sitting on concreted beams (200mm) spanning the steel beams. A more detailed description of the floor construction is shown in the box below.

It can be seen that the level of Celotex insulation is 100mm on the ground floor and 50mm on the upper floors. Celotex is a high performance polyisocyanurate (PIR) thermal insulation product which is more effective per mm than standard expanded polystyrene insulation.

Floating construction to ground floor
Insulation:
- Type: 100mm Celotex FF 3000 rigid PIR board insulation, with 35mm TB3000 rigid PIR board Insulation upstands to perimeter, or similar approved.
- Installation: Lay with tight butt joints. Continue up at perimeter abutments for full depth of screed.

Separating layer:
- Type: Polyethylene sheet.
- Installation: Lay over insulation and turn up at perimeter abutments. Lap 100mm at joints.

Under-floor heating to Mechanical Engineer's specification.

Floating construction to upper floors
Insulation:
- Type: 50mm Celotex FF3000 rigid PIR board insulation, with 35mm TB 3000 rigid PIR board Insulation upstands to perimeter abutments.
- Installation: Lay with tight butt joints. Continue up at perimeter abutments for full depth of screed.

Acoustic insulation:
- Type: 6mm Thermal Economics IsoRubber with IsoEdge flanking strip to all room perimeters.
- Installations: 50mm minimum overlaps. All joints taped. In accordance with manufacturer's instructions.

Separating layer:
- Type: Polyethylene sheet.
- Installation: Lay over Insulation and turn up at perimeter abutments. Lap 100mm at joints.

Under-floor heating to Mechanical Engineer's specification.

Note: If Robust Detail registration is sought, registration can only be accepted once the builder agrees to receive training from Thermal Economics on the installation of the screed and resilient layer.

4 Floor coverings

Kiwa had already been awarded a contract to carry out the BPE when the development was completed in January 2010 so were able to influence the floor coverings used in the 2 flats where detailed monitoring is being carried out.

Through conversations with floor covering manufacturers and a model created by Kiwa it was decided (with the support of the tenants) to apply different floor coverings in each flat.

In flat 14 (1 bed) the tenant was asked not to put down any wall-to-wall floor coverings but instead to use rugs only for at least the first year of the trial. The tenant was provided with an incentive for doing this.

In flat 6 (3 bed) the tenant was provided with laminate floor coverings throughout, except in the bathroom and WC. Laminate floor coverings typically have very low TOG values.

The under-floor heating specialist assumed a U-value of 0.08W/(m^2K) for floor coverings in their design for all the flats.

As part of this research, BUS surveys were recently carried out at all the flats in the development and it was noted by the research team that no tenants have installed carpets but that the majority of tenants have put down a few rugs with the remainder of the floor covered by the original vinyl floor tiles/covering.

5 Under-floor heating designer

The under-floor heating specialist was not a member of the Underfloor Heating Manufacturers Association (UHMA).

6 Relation of design to other properties

The design for the under-floor heating system at the development was not based on the design for another building. The under-floor heating specialist designs each system individually for each property they are working on.

7 Conclusions

The under-floor heating system at the development was installed after the under-floor heating specialist completed a design based on 50/40°C flow and return temperatures. These temperatures are high considering the type of heating system which was chosen for these flats (EAHP). Although the flats have a low overall heat demand, the heat pumps may not be operating at their optimum performance levels because the chosen flow and return temperatures are higher than would be expected for an EAHP. Under-floor heating systems to be used in conjunction with an EAHP (or any other type of heat pump) would generally be designed to operate at flow and return temperatures of 45°C and 40°C respectively.

The floor construction in the building includes a good level of insulation in all the floors, with additional insulation installed on the ground floor.

The level of floor coverings is currently low in both flats, with flat 14 having installed some rugs and laminate flooring having been installed in flat 6 throughout (apart from kitchens and bathrooms).

The under-floor heating specialist is not a UHMA member but the quality of the design and installation is good. The under-floor heating specialist individually designs each system which they work on so the design is tailored to the particular development and to some extent the choice of primary heating system.