Passivhaus Designer Re-certification – Peter Ranken
(Renewal of Passivhaus Designer Certificate issued on 25 July 2012, expiring on 31 August 2017)

Gales Place, Three Bridges, Crawley UK Revision A 21 February 2019

Block 1 – three terraced houses

Block 3 – six apartments

Block 2 – four terraced houses

Gales Place is an affordable certified Passivhaus housing development by Crawley Borough Council that provides the following accommodation:

					U-values				
Total 7 houses and 6 flats in three blocks:	Treated Floor Area	Annual Heating Demand	Primary Energy Renewable	Heat Recovery	Wall	Roof	Ground Floor	Window	Air Tightness Result
		kWh/m².a	kWh/m².a	Efficiency	W/m²K	W/m²K	W/m²K	W/m²K	ach
▪ Three house terrace – 3 no. 2 bed houses	225.9m²	14.6	60	87.4%	0.101 0.098	0.068	0.122	0.95	0.583 0.623 0.606
▪ Four house terrace – 2 no. 2 bed houses, 2 no. 3 bed houses	330.2m²	14.2	60	88.9%	0.119 0.114	0.068	0.122	0.93	0.599 0.631 0.647 0.567
▪ Block of flats – 3 no. 1 bed, 3 no. 2 bed	255.6m²	14.3	6.8	88.6%	0.138 0.145	0.068	0.122	0.93	0.646

All three blocks are listed on the Passivhaus Database held by the International Passive House Association. These listings can be viewed from:

https://passivhausprojekte.de/index.php#k_Crawley
The PH database references are as follows:
Block 1 – three house terrace: ID 5406
Block 2 – four house terrace: ID 5414
Block 3 – block with six apartments: ID 5415

2. Abstract of Building Project

Gales Place is a social housing development in Crawley, West Sussex with thirteen dwellings in three separate blocks, all of which pass the Passivhaus standard. Seven of the dwellings are 2 or 3 bedroom houses, with one terrace of three houses and another of four houses. The third block comprises six 1 or 2 bedroom flats. The project provides high quality and low energy rented social housing for Crawley Borough Council.

All three blocks are built using cavity walls with a thin joint aircrete blockwork inner leaf with brickwork or rendered blockwork external facings, and each block has different thicknesses of wall insulation to reflect the different form factor of each block.

The ground floors of the houses comprise insulated concrete rafts and the flats have an insulated beam and block suspended ground floor. All roofs are timber with horizontal insulation at top floor ceiling level.

Each dwelling is serviced individually using the following:

- Ventilation: a single Paul Novus 300 heat recovery ventilation unit per dwelling
- Heating: electric towel rails and panel radiators
- Hot water: provided by solar thermal panels serving a hot water storage cylinder fitted with an electric immersion heater.

3. Elevation View of the Buildings

3.1 Block 1 (Plots A, B and C)

Block 1 (three houses) – elevation facing west

Elevation facing south, solar thermal panels not visible

Elevation facing north

3.2 Block 2 (Plots D, E, F and G)

Block 2 – terrace of four houses – front elevation facing north

Block 2 – elevation facing south – note solar thermal panels on roof

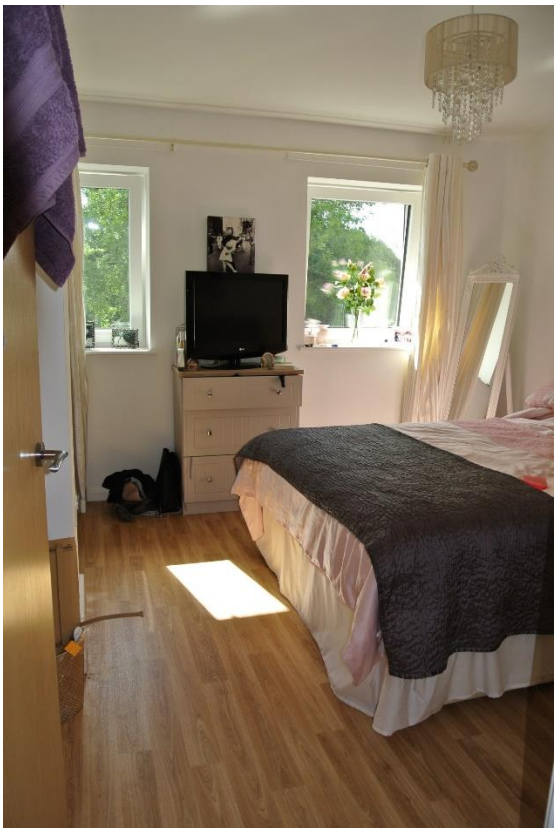
3.3 Block 3 (Plots H, J, K, L, M and N)

View of Block 3 from south west – note MVHR terminals on side wall and solar panels on roof

View of Block 3 from south

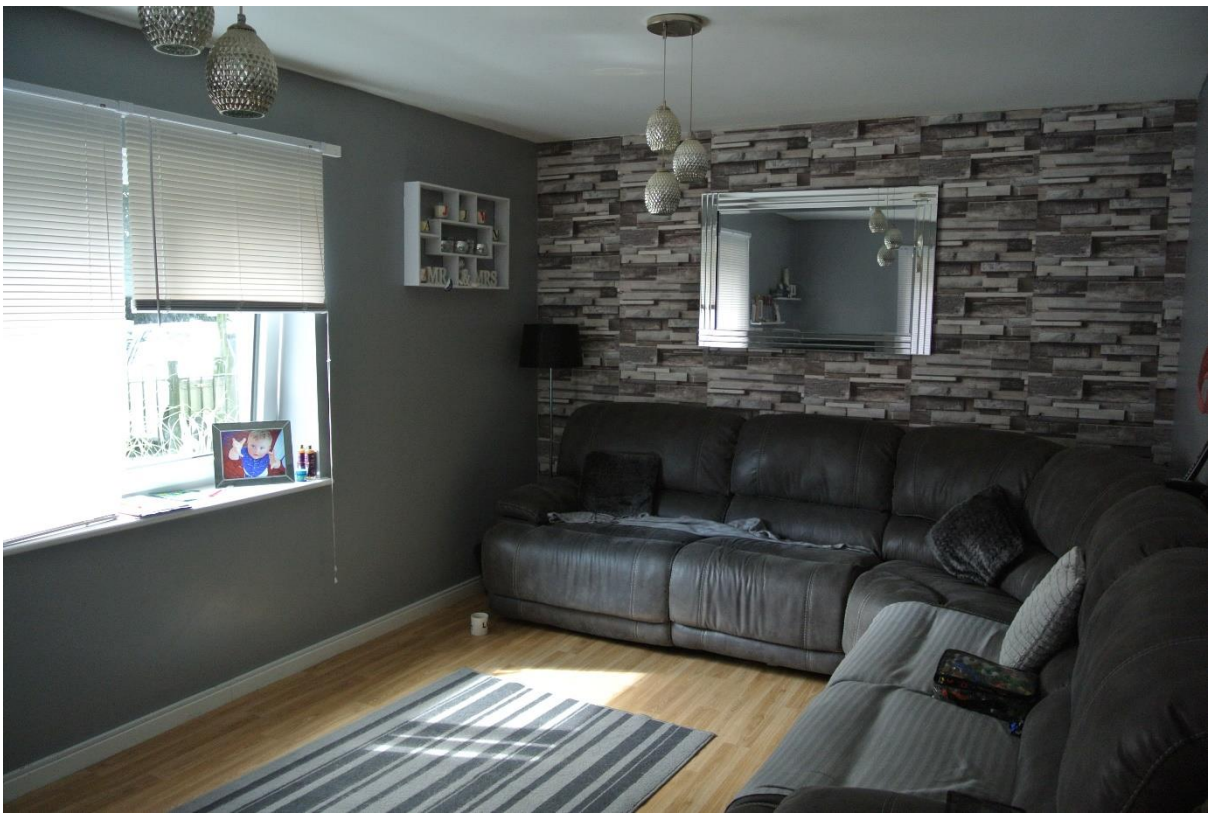
4. Exemplary Photos from Inside the Buildings

Living room in one bedroom flat in Block 3.



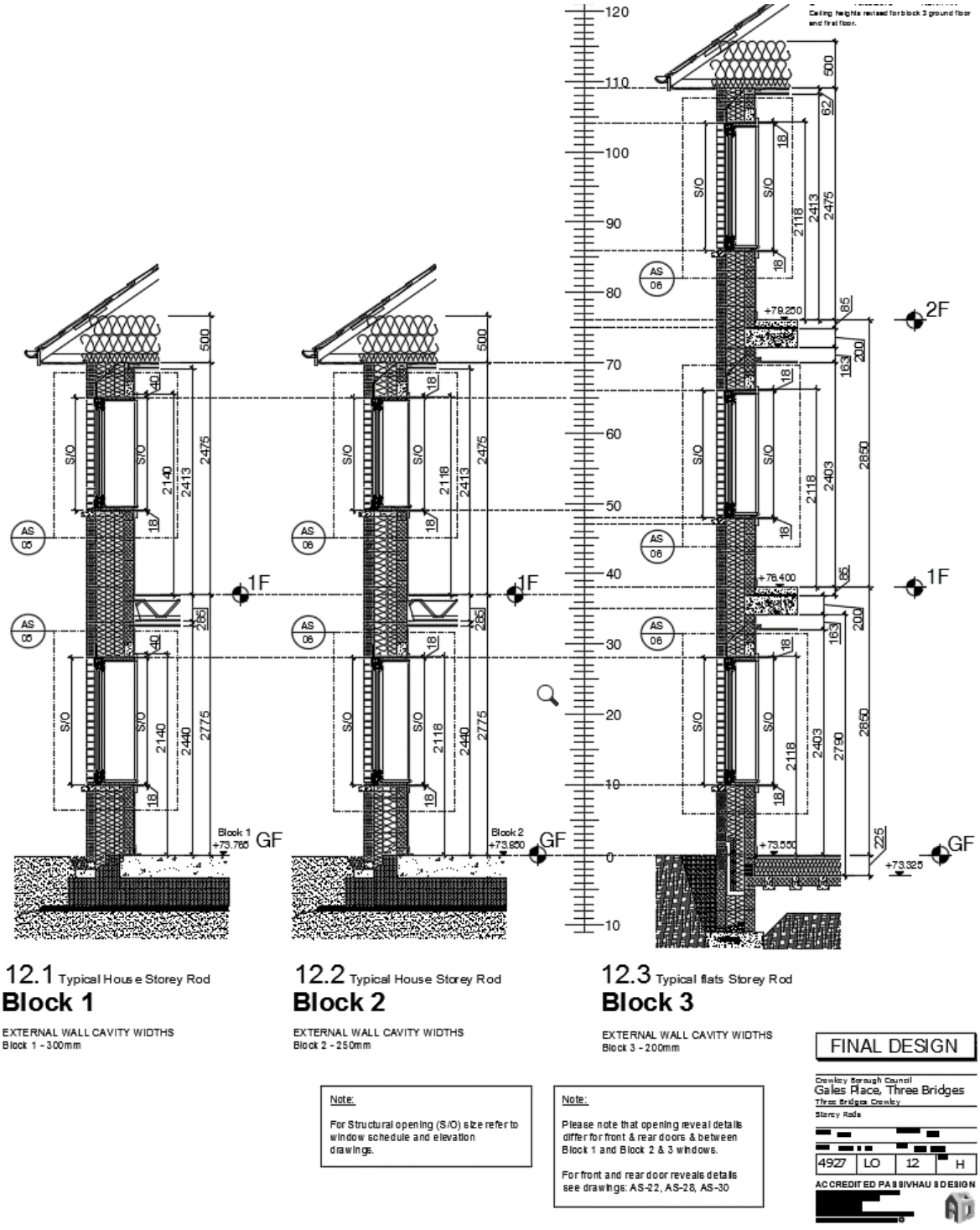
Main bedroom in house in Block 1

Kitchen in house of Block 1 (similar to those in Block 2)



Living room of house in Block 1, decorations by resident.

5. Sectional View of The Buildings



Part sections of each block – note differences in cavity wall insulation thickness and ground floor construction.

6. Floor Plans

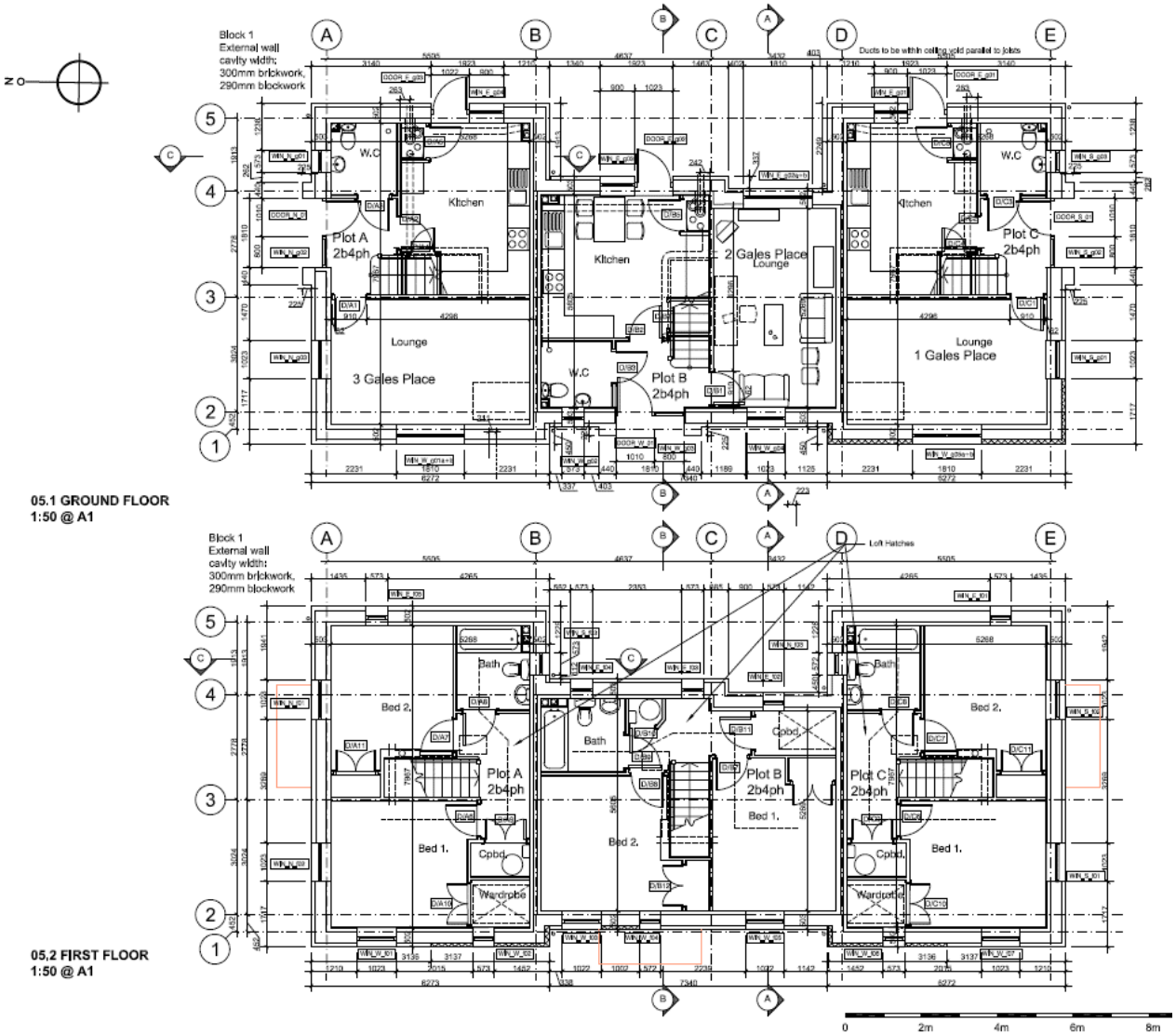
6.1 Houses (Blocks 1 and 2)

The plans of the houses are based on a core double fronted two bedroom layout, one room deep and where possible standard stair, bathroom and kitchen elements. For Block 1 the end houses are rotated 90 degrees relative to the central house to provide entrances in each front elevation. For Block 2 the end houses include an additional bedroom to create 2no. three bedroom houses.

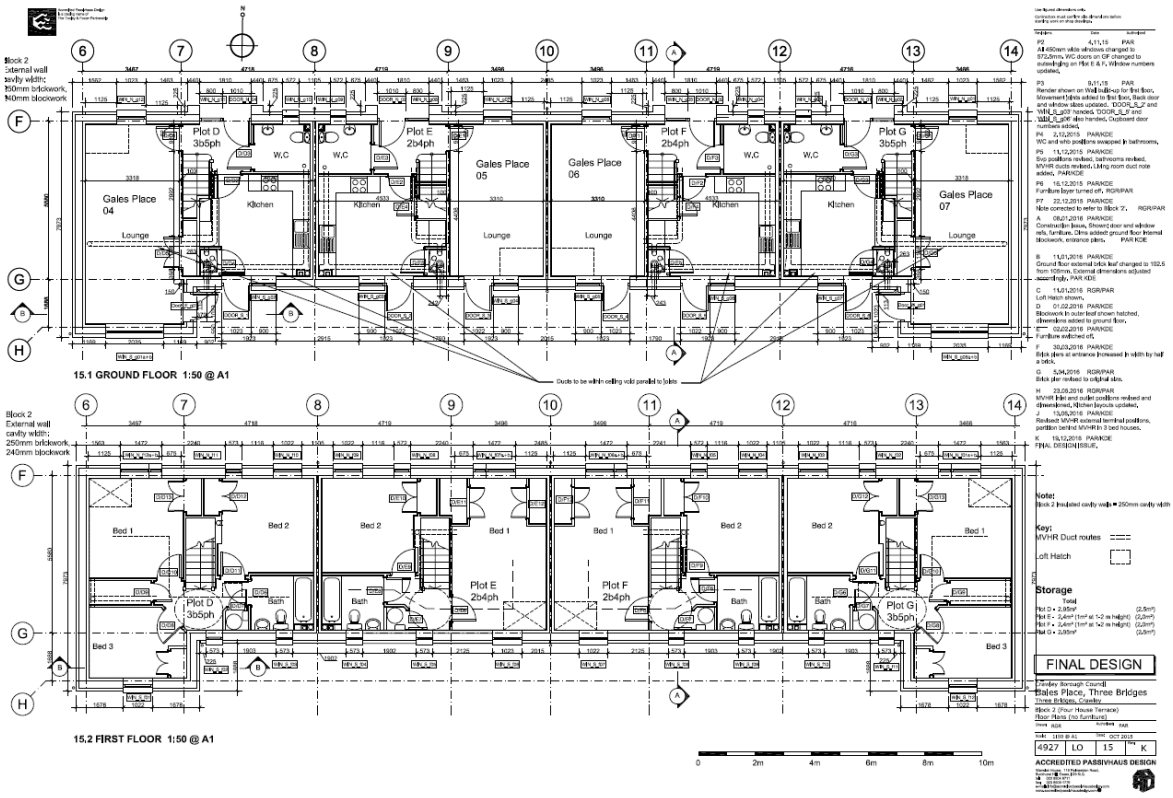
The single room depth of the core house layout allows cross ventilation through many living rooms and section ventilation via the stairs to upstairs landing windows.

Kitchens, bathrooms and ground floor shower/wc rooms (houses only) were designed to minimise pipe lengths between hot water storage and points of use of hot water.

Plans



Block 1 three house terrace floor plans

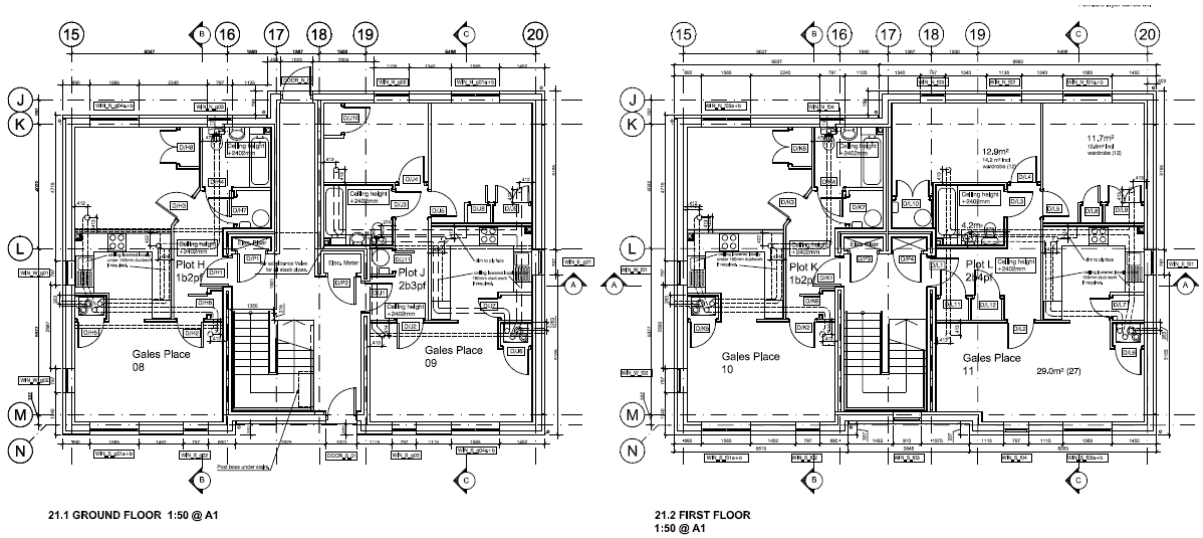


Block 2 four house terrace floor plans

6.2 Flats (Block 3)

Block 3 comprises 3no two bedroom flats and 3no 1 bedroom flats over three floors. Common kitchen and bathroom elements are included in each flat type.

Plans



Block 3 six apartments floor plans (second floor is identical to the first floor)

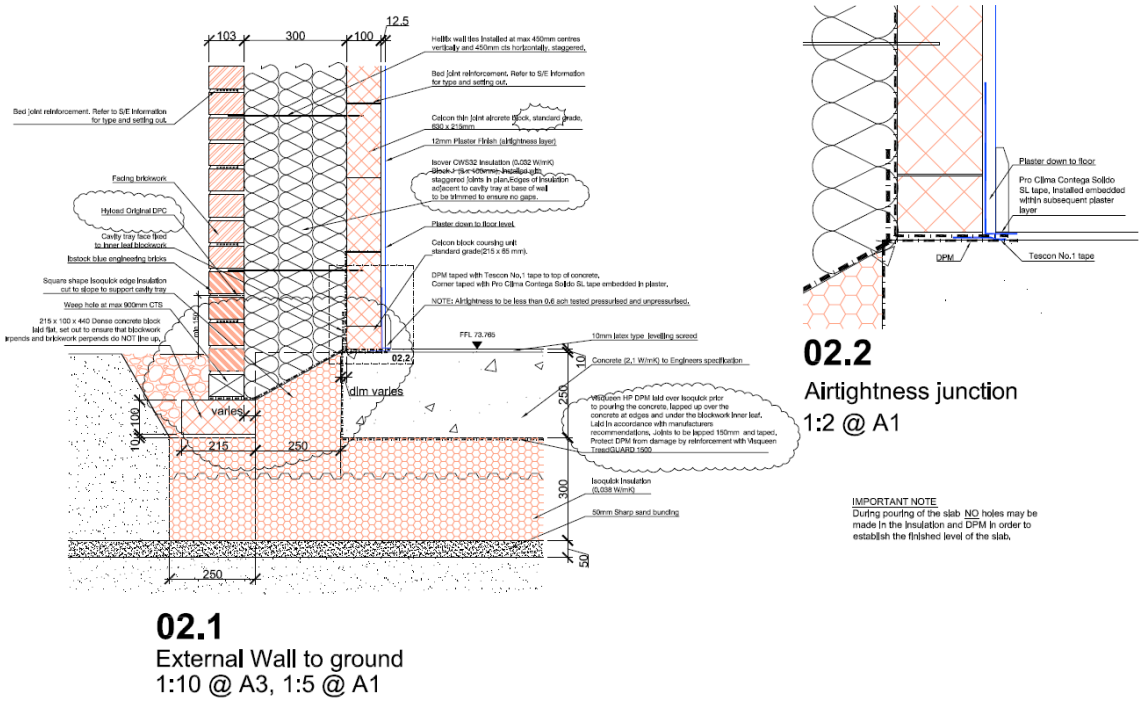
6.3 The floor layouts of these dwellings have proved popular with the client and similar layouts have been used on three other sites, one of which (Dobbins Place) has also been built for Passivhaus certification.

7. Construction of Floor Slab

7.1 Houses.

The houses are all two storey and the structural loadings of the main walls are low enough to allow for an insulated slab ground floor. This is a proprietary system by Isoquick, and allows a thermal bridge free junction between the ground floor slab and external walls.

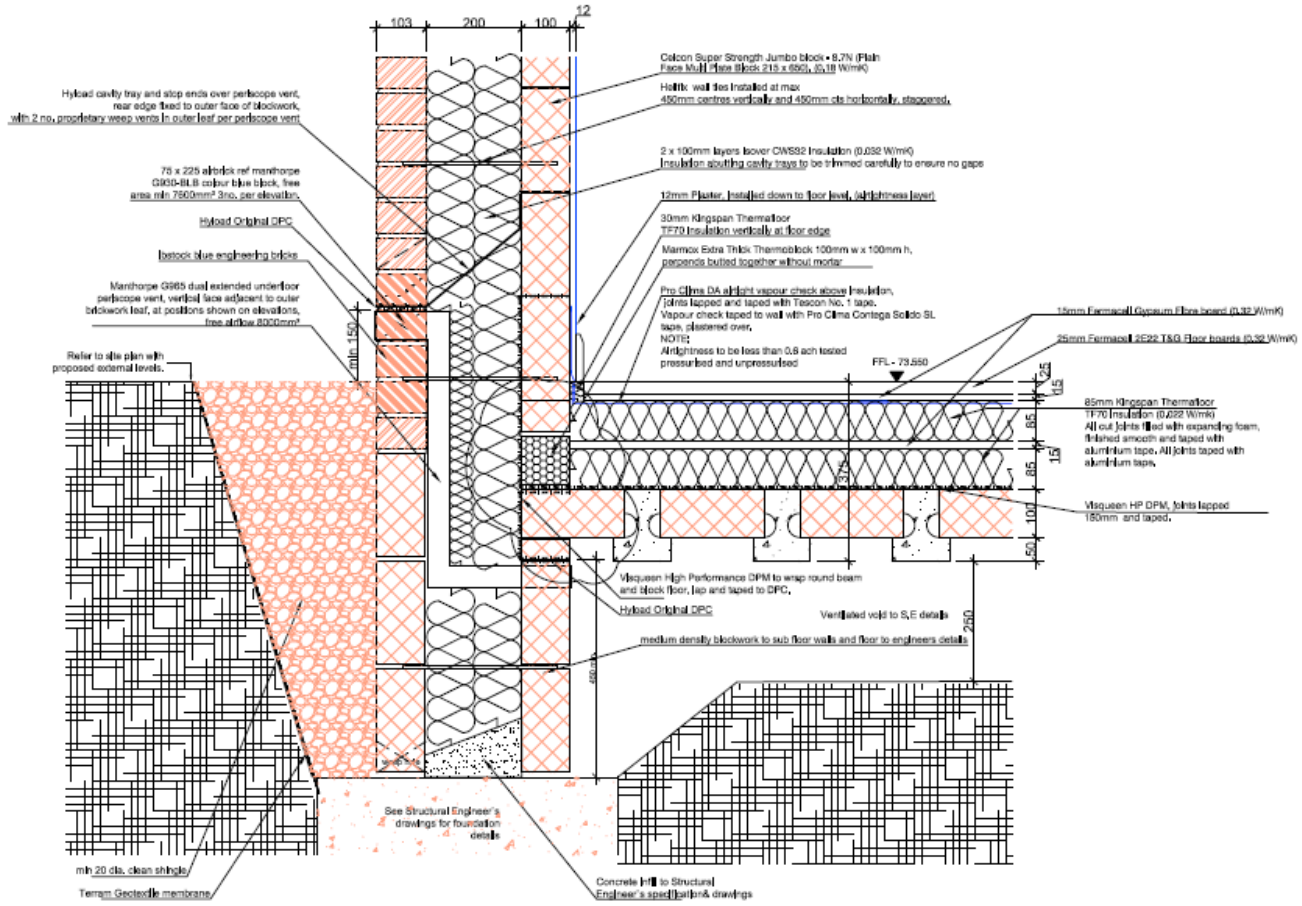
Block 2 insulated raft foundation before and after concrete was poured



Extract from detail drawing 4927 AS 02A for floor wall junction to the houses Block 1 (Block 2 similar)

7.2 Flats.

The structural loadings of the blockwork walls in the three storey block of flats are too great for an insulated slab construction and an insulated beam and block suspended floor is used. To mitigate the thermal bridge between the inner leaf of blockwork and the suspended floor load bearing insulation (by Marmox) is used. The resulting small thermal bridge has been calculated using Therm and included in PHPP.



Extract from detail drawing 4927 AS 01A for floor wall junction for the flats Block 3

8. Construction of the Exterior Walls

Following planning approval the project was tendered to potential contractors for construction using a design and build contract and the choice of an aircrete masonry construction was made by the successful contractor during the tender stage in conjunction with APD. This is a variant of conventional UK domestic masonry construction with a facing brick (or rendered block) outer leaf, full fill cavity insulation and an aerated blockwork inner leaf. The aircrete blocks used for the inner leaf have the following advantages over conventional medium dense block:

- Formed from recycled power station ash and cured, there is a large air content and improved lambda value:
    - Aircrete blocks 0.15 W/mK
    - Medium dense blockwork 0.79 W/mK
- Larger unit size reduces the length of thermal bridges formed by the mortar joints,
- Reduced bed joint mortar thickness (2mm vs 10mm) further reduces the area of thermal bridges formed by the mortar joints
- The reduced weights of the units (along with larger unit sizes and thinner bed joints) can give reduced construction times.

Each block has a different form factor (ratio of heat loss surface area to treated floor area), and whilst the same wall construction is used for all three blocks, the thickness of cavity wall insulation varies:

Block 1 (three houses) – cavity wall insulation thickness 300mm
Block 2 (four houses) – cavity wall insulation thickness 250mm
Block 3 (six flats, three storey) – cavity wall insulation thickness 200mm

Air leakage through the blockwork is prevented by site applied plaster. Plasterboard dry-lining is not used. In addition the contractor used liquid applied airtightness (Blowerproof) to additionally seal some areas of blockwork prior to plastering.

Cavity wall insulation – no gaps

Airtightness – Blowerproof to joints, sockets and windows before plaster applied

Typical external wall and top floor ceiling showing construction prior to plastering:

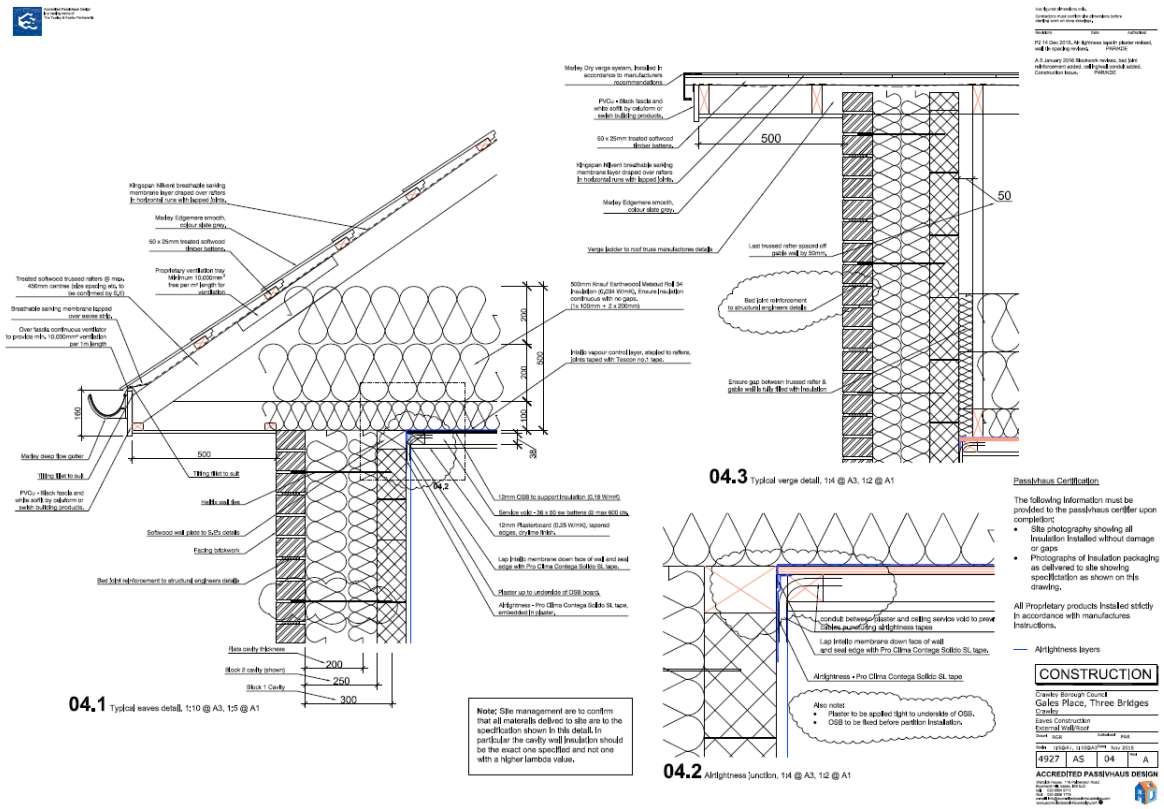
- Intello air tight membrane behind OSB ceiling
- Joints in OSB taped
- Intello membrane taped to wall, and painted with Blowerproof
- Intello membrane over lateral restraint straps, taped to wall and painted with Blowerproof
- Large format aircrete blocks with thin joints

9. Construction of the roof/ ceiling of the top floor

Conventional UK roof construction is used with trussed rafters, a ventilated roof void below roof tiles and horizontal insulation at ceiling level. The ceiling construction below the trussed rafters is as follows:

- Intello air tightness and vapour control membrane stapled and taped to underside of the rafters with taped air tight joints and at edges with external walls.
- OSB board to support 500mm mineral/glass wool insulation
- Battened service void
- Plasterboard and skim finish, lapping with plastered internal blockwork.

This construction can provide a relatively thermal bridge free junction with the external wall and is economical to construction. There were some issues on site with hard to detect damage/ vandalism to the Intello layer and for the subsequent Passivhaus project with the same contractor a rigid air tight board with taped joints was used to replace the Intello and OSB.



Detail drawing 4927 AS 04A for roof eaves (all blocks) including ceiling construction and airtightness.

Top floor ceiling installation showing Intello membrane, taped joints, OSB board and taped joints, battens for service void for cables etc.

10. Windows and the Installation of the Window

The windows and external doors were Internorm KF410 aluminium clad PVC-u, and are all triple glazed, with tilt and turn operation. The windows were installed within the insulation zone of the external walls within a plywood former, taped to the blockwork and plaster airtightness layer.

The thermal properties of the frames and glazing are as follows:

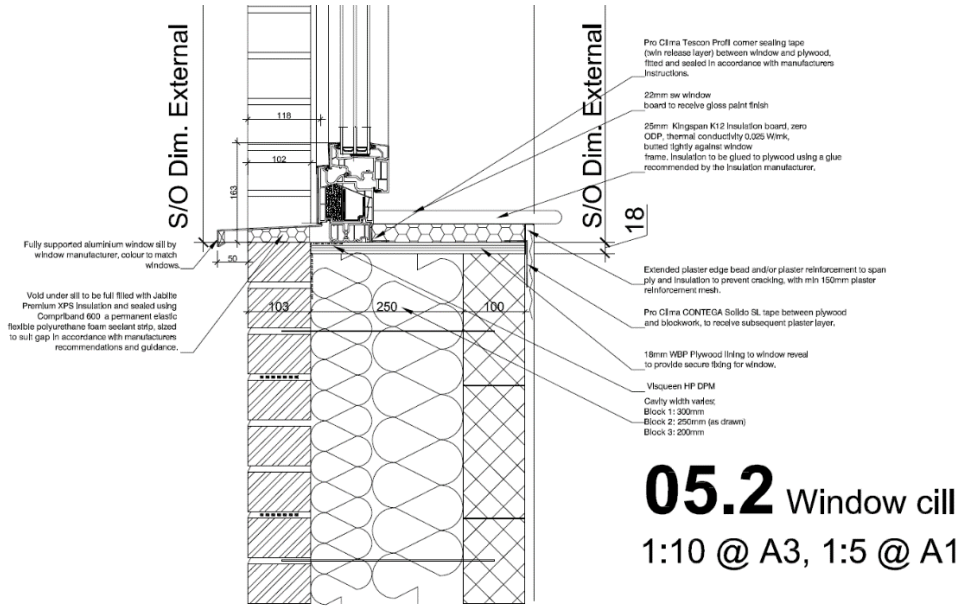
- U value of frame U_f 0.96 W/m^{2}K
- Glazing spacer Psi value 0.033 W/mK
- U value of glass Ug – these vary dependent on the type of glass used – an extract of the data included in PHPP for Block 1 in strong yellow is below (the same glass types were also used for the other blocks)
- G value of glazing – these also vary, and are also shown below

Window frame | Heat recovery DHW

Glazing			Glazing
	Recommended glazing type to start planning: Triple thermally insulated glazing (Please consider the comfort criterion!)		
ID	Description	g-Value	U_g-Value
			W/(m²K)
01ud	PH Glazing	0.50	0.80
02ud	Internorm 1 Saint Gobain 3N2 Light Std (std/std/std)	0.50	0.53
03ud	Internorm 4 Light SBD (lam/std/std)	0.47	0.62
04ud	Internorm 7 Saint Gobain Obs Light Safety (lam/std/lam)	0.49	0.53
05ud	Katzbeck/Interpane Design Safety tuf 4/18/4/18/4 Iso-therma	0.43	0.48
06ud	Internorm 6 Saint Gobain Obscure Light SbD	0.50	0.55
07ud	Internorm 2 Solar+ Std (std/std/std)	0.62	0.64
08ud	Internorm 3 Solar+ SBD (lam/std/std)	0.58	0.60
09ud	Internorm 5 Solar+ Safety (tgh/std/tgh)	0.62	0.64
10ud		0.00	0.00

Extract of Block 1 PHPP showing glazing Ug and g values used on all blocks (in strong yellow)

Manufacturer's information confirming this data is included in the appendices.



Extract from detail drawing 4927 AS 05A for window installation for all blocks

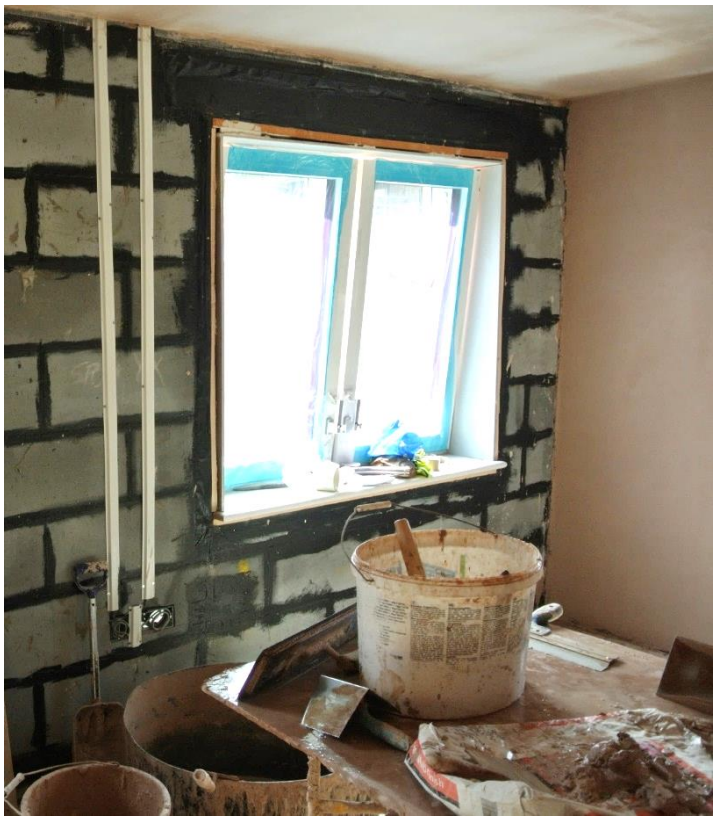


Photo of window installation showing plywood former. Note wet plaster airtightness layer to internal compartment wall between houses and additional Blowerproof airtightness paint applied to blockwork joints and adjacent to the window.

11. Airtight Building Envelope

Measures to reduce air leakage include:

- Walls – wet plaster finish to blockwork, with additional liquid airtight paint (Blowerproof) applied where necessary to blockwork before plastering.
- Ground floor in houses – in-situ concrete slab
- Ground floor in flats – airtightness membrane within layers of Fermacell board
- Roof – Intello membrane with taped joints fixed to underside of trussed rafters, edges taped to wall plaster
- Junctions – taped with airtight tape as shown on details, tape being ProClima Tescon No. 2 or Contega Solido SL or equivalent.

The air test results for each house and the block of flats follow.

Certificate of Test

Title: Air tightness test of Block 3, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25239

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Block 3
Issue date: 10th January 2016
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
S.Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

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1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front entrance door. The entire block was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	5 Jan 17	12.30
Building volume	1014	m^3 (calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.646**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	1013.5	m^3	
Plot No.	**Block 3**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.65		FAIL
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**12.30**	Air flow exponent, n	0.739		ok
Tested by	**S.Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.010		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.010		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.18	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.03	m^2	

Pressurisation Test	At start	At end	
Wind speed	0.8	1	$m.s^{-1}$
Barometric pressure	1023	1023	mbar
Internal temperature	11.3	10.4	°C
External temperature	1.6	1.6	°C
Zero flow +ve average	0.0	0.0	pascals
Zero flow -ve average	-1.0	-1.1	pascals
Overall Zero flow avera	-1.0	-1.1	pascals

pv (internal)	650.393	
pv (external)	343.464	
air density (internal)	1.252	kg/m^3
air density (external)	1.295	kg/m^3

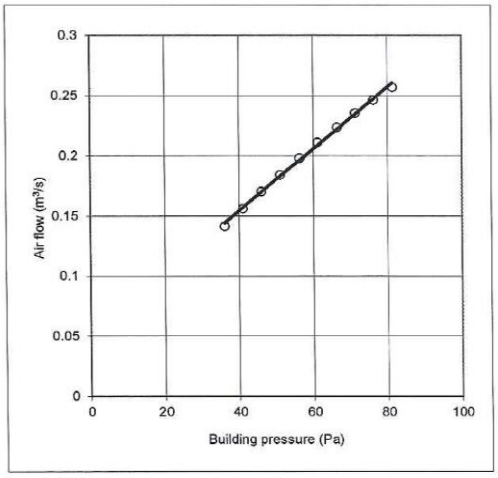
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	80.3	894
2	75.1	857
3	70.2	819
4	65.3	778
5	60.1	735
6	55.3	689
7	50.2	641
8	45.0	593
9	40.0	543
10	35.0	492

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
894				
857				
819				
778				
735				
689				
641				
593				
543				
492				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
81.4	0.26
76.2	0.25
71.3	0.24
66.4	0.22
61.2	0.21
56.4	0.20
51.3	0.18
46.1	0.17
41.1	0.16
36.1	0.14

log pressure	log flow
4.3988	-1.3587
4.3327	-1.4010
4.2662	-1.4464
4.1949	-1.4977
4.1133	-1.5546
4.0316	-1.6192
3.9367	-1.6914
3.8297	-1.7692
3.7148	-1.8573
3.5849	-1.9560



Calculated by: _____ Date: 10/1/17

Checked by: _____ Date: 10/1/17

Version 2 - Dec 2013
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Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	1013.5	m^3	
Plot No.	**Block 3**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.64		PASS
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**12.30**	Air flow exponent, n	0.756		ok
Tested by	**S.Maddison**	Correlation coefficient, r^2	0.997		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.009		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.009		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.18	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.03	m^2	

Depressurisation Test	**At start**	**At end**				
Wind speed	1.1	0.8	$m.s^{-1}$	pv (internal)	624.898	
Barometric pressure	1023	1023	mbar	pv (external)	344.697	
Internal temperature	10.5	10.0	°C	air density (internal)	1.255	kg/m^3
External temperature	1.6	1.7	°C	air density (external)	1.295	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-1.3	-0.6	pascals			
Overall Zero flow avera	-1.3	-0.6	pascals			

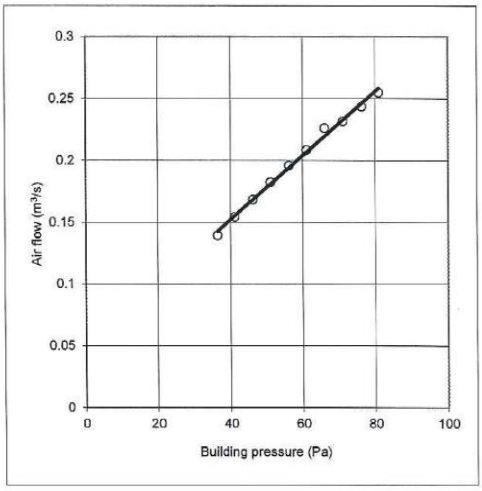
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	80.0	889
2	75.3	850
3	70.1	808
4	65.0	789
5	60.1	727
6	55.2	683
7	50.1	636
8	45.3	587
9	40.2	538
10	35.4	486

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
889				
850				
808				
789				
727				
683				
636				
587				
538				
486				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
81.0	0.25
76.3	0.24
71.1	0.23
66.0	0.23
61.1	0.21
56.2	0.20
51.1	0.18
46.3	0.17
41.2	0.15
36.4	0.14

log pressure	log flow
4.3938	-1.3667
4.3340	-1.4116
4.2634	-1.4623
4.1889	-1.4861
4.1117	-1.5679
4.0280	-1.6303
3.9328	-1.7016
3.8341	-1.7818
3.7172	-1.8690
3.5932	-1.9706



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Certificate of Test

Title: Air tightness test of Plot A, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25240

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot A
Issue date: 10th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

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TECHNOLOGY CENTRE

1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	5 Jan 17	13.25
Building volume	187 m^3	(calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.583**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	186.7	m^3	
Plot No.	**A**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.59		PASS
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**13.25**	Air flow exponent, n	0.700		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	0.997		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Pressurisation Test	**At start**	**At end**				
Wind speed	0.7	0.9	$m.s^{-1}$	pv (internal)	650.393	
Barometric pressure	1023	1023	mbar	pv (external)	354.699	
Internal temperature	11.3	10.4	°C	air density (internal)	1.252	kg/m^3
External temperature	2.0	2.1	°C	air density (external)	1.293	kg/m^3
Zero flow +ve average	0.1	0.0	pascals			
Zero flow -ve average	0.0	-0.3	pascals			
Overall Zero flow avera	0.1	-0.3	pascals			

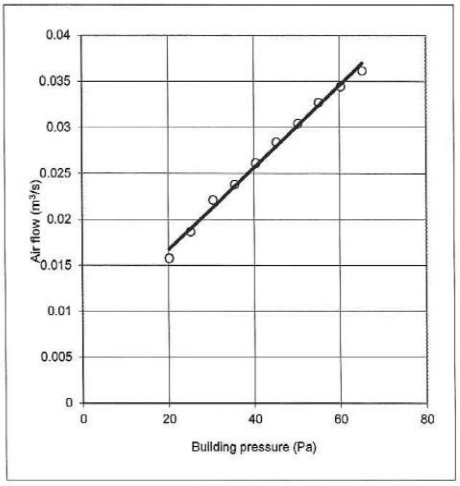
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.3	126
2	60.2	120
3	55.0	114
4	50.2	106
5	45.1	99
6	40.3	91
7	35.4	83
8	30.2	77
9	25.0	65
10	20.1	55

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
126				
120				
114				
106				
99				
91				
83				
77				
65				
55				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.4	0.04
60.3	0.03
55.1	0.03
50.3	0.03
45.2	0.03
40.4	0.03
35.5	0.02
30.3	0.02
25.1	0.02
20.2	0.02

log pressure	log flow
4.1805	-3.3198
4.0993	-3.3686
4.0091	-3.4199
3.9180	-3.4927
3.8111	-3.5610
3.6988	-3.6453
3.5695	-3.7373
3.4111	-3.8123
3.2229	-3.9817
3.0057	-4.1488



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Version 2 - Dec 2013
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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	186.7	m^3	
Plot No.	**A**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.57		PASS
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**13.25**	Air flow exponent, n	0.725		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	At start	At end				
Wind speed	1	1.2	$m.s^{-1}$	pv (internal)	616.598	
Barometric pressure	1023	1023	mbar	pv (external)	357.239	
Internal temperature	10.3	9.8	°C	air density (internal)	1.256	kg/m^3
External temperature	2.1	2.2	°C	air density (external)	1.293	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.5	-0.6	pascals			
Overall Zero flow avera	-0.5	-0.6	pascals			

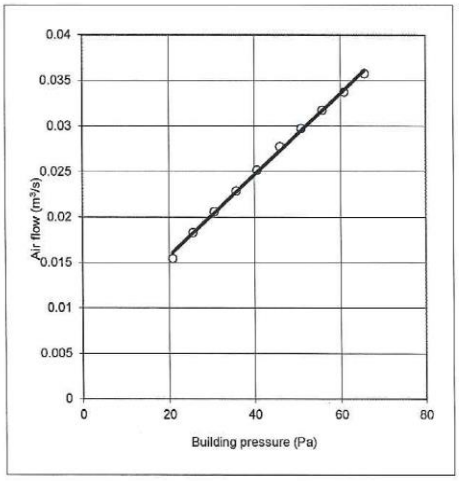
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.1	125
2	60.3	118
3	55.2	111
4	50.3	104
5	45.3	97
6	40.1	88
7	35.2	80
8	30.0	72
9	25.1	64
10	20.3	54

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
125				
118				
111				
104				
97				
88				
80				
72				
64				
54				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.7	0.04
60.9	0.03
55.8	0.03
50.9	0.03
45.9	0.03
40.7	0.03
35.8	0.02
30.6	0.02
25.7	0.02
20.9	0.02

log pressure	log flow
4.1843	-3.3311
4.1084	-3.3888
4.0209	-3.4499
3.9289	-3.5150
3.8254	-3.5847
3.7050	-3.6821
3.5766	-3.7774
3.4194	-3.8828
3.2445	-4.0006
3.0374	-4.1705



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TECHNOLOGY CENTRE

Certificate of Test

Title: Air tightness test of Plot B, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25241

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot B
Issue date: 10th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

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UKAS TESTING
0057

TECHNOLOGY CENTRE

1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	5 Jan 17	13.25
Building volume	189	m^3 (calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.623**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	188.9	m^3	
Plot No.	**B**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.63		PASS
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**13.25**	Air flow exponent, n	0.692		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	0.999		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MLT 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Pressurisation Test	At start	At end				
Wind speed	0.6	1	$m.s^{-1}$	pv (internal)	692.633	
Barometric pressure	1023	1023	mbar	pv (external)	366.257	
Internal temperature	12.4	11.2	°C	air density (internal)	1.247	kg/m^3
External temperature	2.5	2.5	°C	air density (external)	1.291	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.3	-0.6	pascals			
Overall Zero flow avera	-0.3	-0.6	pascals			

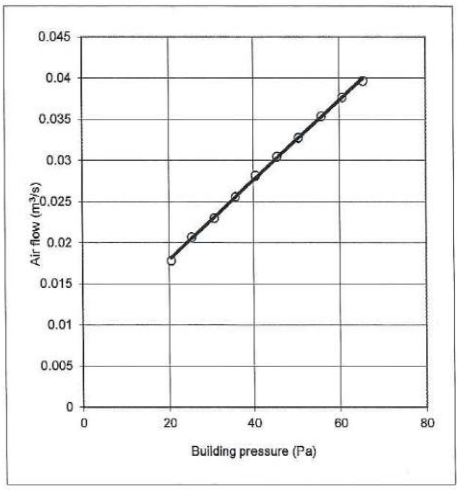
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.0	138
2	60.2	131
3	55.3	123
4	50.1	114
5	45.1	106
6	40.1	98
7	35.3	89
8	30.2	80
9	25.0	72
10	20.1	62

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
138				
131				
123				
114				
106				
98				
89				
80				
72				
62				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.5	0.04
60.7	0.04
55.8	0.04
50.6	0.03
45.6	0.03
40.6	0.03
35.8	0.03
30.7	0.02
25.5	0.02
20.6	0.02

log pressure	log flow
4.1813	-3.2270
4.1051	-3.2791
4.0209	-3.3421
3.9230	-3.4181
3.8188	-3.4909
3.7025	-3.5693
3.5766	-3.6657
3.4226	-3.7723
3.2367	-3.8776
3.0229	-4.0272



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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	188.9	m^3	
Plot No.	**B**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.61		PASS
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**14.20**	Air flow exponent, n	0.688		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	0.999		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MLT 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	At start	At end				
Wind speed	1.1	1.4	$m.s^{-1}$	pv (internal)	654.730	
Barometric pressure	1023	1023	mbar	pv (external)	368.870	
Internal temperature	11.2	10.7	°C	air density (internal)	1.251	kg/m^3
External temperature	2.6	2.6	°C	air density (external)	1.291	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.6	-0.9	pascals			
Overall Zero flow avera	-0.6	-0.9	pascals			

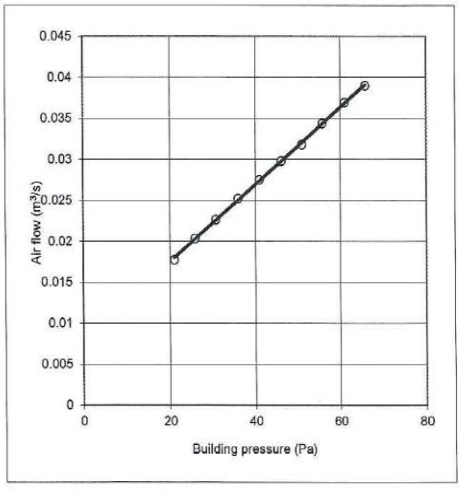
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.1	136
2	60.3	129
3	55.0	120
4	50.1	111
5	45.3	104
6	40.2	96
7	35.2	88
8	30.0	79
9	25.1	71
10	20.3	62

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
136				
129				
120				
111				
104				
96				
88				
79				
71				
62				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.9	0.04
61.1	0.04
55.8	0.03
50.9	0.03
46.1	0.03
41.0	0.03
36.0	0.03
30.8	0.02
25.9	0.02
21.1	0.02

log pressure	log flow
4.1874	-3.2451
4.1117	-3.2980
4.0209	-3.3703
3.9289	-3.4483
3.8297	-3.5134
3.7124	-3.5935
3.5821	-3.6805
3.4259	-3.7884
3.2523	-3.8951
3.0469	-4.0307



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TECHNOLOGY CENTRE

Certificate of Test

Title: Air tightness test of Plot C, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25242

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot C
Issue date: 9th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

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UKAS TESTING
0057

TECHNOLOGY CENTRE

1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	5 Jan 17	15.05
Building volume	187 m^3	(calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.606**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**
Project	**Gales Place**
Plot No.	**C**
Job No.	**B6014**
Test date	**5 Jan 17**
Time of test	**15.05**
Tested by	**Shaun Maddison**
Fan/Manometer No.	**CLR 698**
Calibration due	**18 Feb 17**
Thermo/Barom No.	**MTL 017**
Calibration due	**5 Jul 17**

Envelope area		m^2	
Building volume	186.7	m^3	
Target ach	0.649		
Measured ach	0.61		PASS
Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Air flow exponent, n	0.747		ok
Correlation coefficient, r^2	0.999		ok
Air flow coefficient, C_{env}	0.002		
Air leakage coefficient, C_L	0.002		
Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Equivalent leakage area	0.01	m^2	

Pressurisation Test	At start	At end	
Wind speed	0.8	0.9	$m.s^{-1}$
Barometric pressure	1023	1023	mbar
Internal temperature	10.4	9.7	°C
External temperature	2.7	2.7	°C
Zero flow +ve average	0.0	0.0	pascals
Zero flow -ve average	-0.4	-0.4	pascals
Overall Zero flow avera	-0.4	-0.4	pascals

pv (internal)	616.598	
pv (external)	371.500	
air density (internal)	1.256	kg/m^3
air density (external)	1.290	kg/m^3

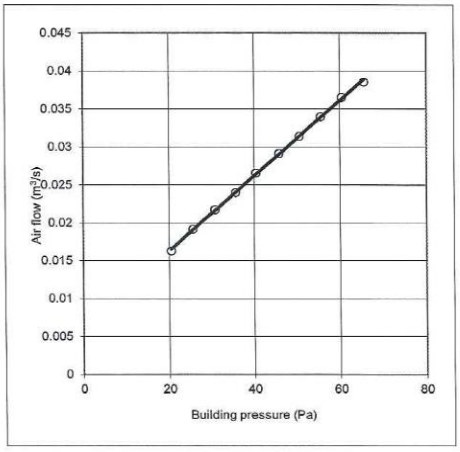
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.2	135
2	60.0	128
3	55.1	119
4	50.1	110
5	45.3	102
6	40.0	93
7	35.2	84
8	30.4	76
9	25.3	67
10	20.1	57

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
135				
128				
119				
110				
102				
93				
84				
76				
67				
57				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.6	0.04
60.4	0.04
55.5	0.03
50.5	0.03
45.7	0.03
40.4	0.03
35.6	0.02
30.8	0.02
25.7	0.02
20.5	0.02

log pressure	log flow
4.1836	-3.2562
4.1010	-3.3095
4.0164	-3.3824
3.9220	-3.4610
3.8221	-3.5365
3.6988	-3.6289
3.5723	-3.7307
3.4275	-3.8308
3.2465	-3.9568
3.0204	-4.1184



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Checked by: _____ Date: 10/1/17

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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	188.9	m^3	
Plot No.	**C**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.60		PASS
Test date	**5 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**15.20**	Air flow exponent, n	0.717		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	At start	At end				
Wind speed	1.2	1	$m.s^{-1}$	pv (internal)	586.329	
Barometric pressure	1023	1023	mbar	pv (external)	370.183	
Internal temperature	9.5	9.1	°C	air density (internal)	1.259	kg/m^3
External temperature	2.7	2.6	°C	air density (external)	1.290	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.8	-1.1	pascals			
Overall Zero flow avera	-0.8	-1.1	pascals			

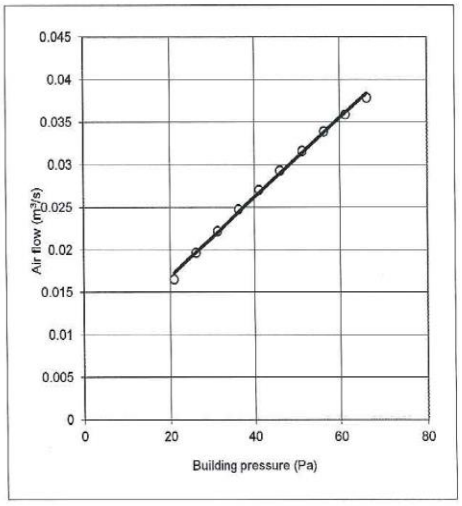
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.1	133
2	60.3	126
3	55.3	119
4	50.2	111
5	45.0	103
6	40.1	95
7	35.3	87
8	30.1	78
9	25.2	69
10	20.0	58

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
133				
126				
119				
111				
103				
95				
87				
78				
69				
58				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
66.1	0.04
61.3	0.04
56.3	0.03
51.2	0.03
46.0	0.03
41.1	0.03
36.3	0.02
31.1	0.02
26.2	0.02
21.0	0.02

log pressure	log flow
4.1904	-3.2737
4.1150	-3.3278
4.0298	-3.3849
3.9348	-3.4545
3.8276	-3.5293
3.7148	-3.6102
3.5904	-3.6982
3.4356	-3.8074
3.2638	-3.9300
3.0421	-4.1036



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Checked by: [signature] Date: 10/1/17

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TECHNOLOGY CENTRE

Certificate of Test

Title: Air tightness test of Plot D, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25243

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot D
Issue date: 10th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

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Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

VINCI Technology Centre UK Limited
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info@technology-centre.co.uk
www.technology-centre.co.uk
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Registered Office, Watford, England. Registered No.05640885

UKAS TESTING
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TECHNOLOGY CENTRE

1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	6 Jan 17	11.30
Building volume	226 m^3	(calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.599**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	226.3	m^3	
Plot No.	**D**	Target ach	0.649		
Job No.	**B6104**	Measured ach	0.61		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**11.30**	Air flow exponent, n	0.730		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.04	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Pressurisation Test	At start	At end				
Wind speed	0	0	$m.s^{-1}$			
Barometric pressure	1024	1024	mbar	pv (internal)	608.395	
Internal temperature	10.1	9.6	°C	pv (external)	327.793	
External temperature	0.9	1.0	°C	air density (internal)	1.258	kg/m^3
Zero flow +ve average	0.0	0.0	pascals	air density (external)	1.300	kg/m^3
Zero flow -ve average	-1.8	-0.9	pascals			
Overall Zero flow avera	-1.8	-0.9	pascals			

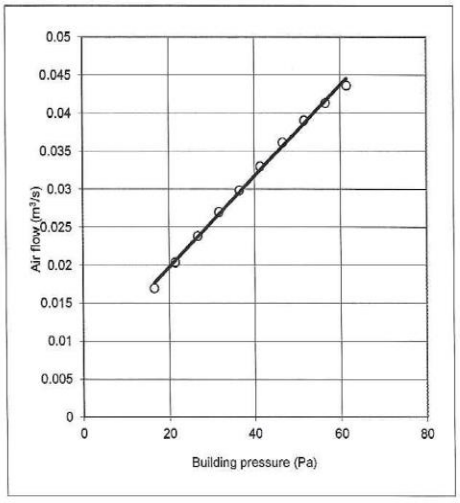
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	60.0	152
2	55.2	144
3	50.2	136
4	45.2	126
5	40.0	115
6	35.1	104
7	30.3	94
8	25.3	83
9	20.1	71
10	15.2	59

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
152				
144				
136				
126				
115				
104				
94				
83				
71				
59				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
61.4	0.04
56.6	0.04
51.6	0.04
46.6	0.04
41.4	0.03
36.5	0.03
31.7	0.03
26.7	0.02
21.5	0.02
16.6	0.02

log pressure	log flow
4.1166	-3.1318
4.0351	-3.1859
3.9426	-3.2430
3.8405	-3.3194
3.7221	-3.4108
3.5959	-3.5113
3.4547	-3.6124
3.2828	-3.7369
3.0657	-3.8930
2.8064	-4.0782



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Checked by: _____ Date: 10/1/17

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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	226.3	m^3	
Plot No.	**D**	Target ach	0.649		
Job No.	**B6104**	Measured ach	0.59		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**15.20**	Air flow exponent, n	0.743		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.04	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	**At start**	**At end**				
Wind speed	0	0	$m.s^{-1}$	pv (internal)	592.276	
Barometric pressure	1024	1024	mbar	pv (external)	331.352	
Internal temperature	9.6	9.3	°C	air density (internal)	1.260	kg/m^3
External temperature	1.0	1.2	°C	air density (external)	1.299	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-1.1	-1.0	pascals			
Overall Zero flow avera	-1.1	-1.0	pascals			

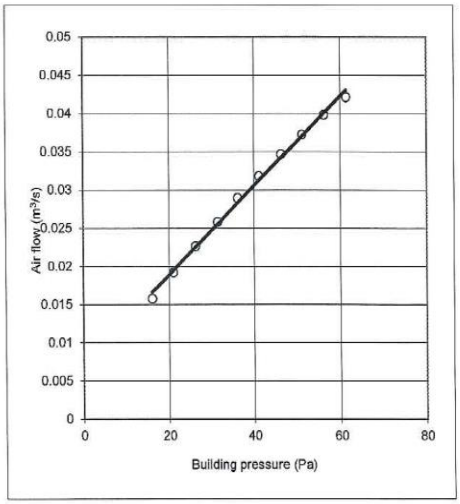
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	60.3	147
2	55.2	139
3	50.0	130
4	45.2	121
5	40.1	111
6	35.1	101
7	30.3	90
8	25.2	79
9	20.0	67
10	15.1	55

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
147				
139				
130				
121				
111				
101				
90				
79				
67				
55				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
61.4	0.04
56.3	0.04
51.1	0.04
46.3	0.03
41.2	0.03
36.2	0.03
31.4	0.03
26.3	0.02
21.1	0.02
16.2	0.02

log pressure	log flow
4.1166	-3.1673
4.0298	-3.2233
3.9328	-3.2902
3.8341	-3.3619
3.7172	-3.4482
3.5882	-3.5426
3.4452	-3.6579
3.2677	-3.7883
3.0469	-3.9530
2.7819	-4.1504



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TECHNOLOGY CENTRE

Certificate of Test

Title: Air tightness test of Plot E, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25244

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot E
Issue date: 10th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

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TECHNOLOGY CENTRE

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1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	6 Jan 17	12.15
Building volume	198 m^3	(calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.631**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	198	m^3	
Plot No.	**E**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.64		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**12.15**	Air flow exponent, n	0.735		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	0.999		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Pressurisation Test	At start	At end				
Wind speed	0	0	$m.s^{-1}$			
Barometric pressure	1024	1024	mbar	pv (internal)	685.807	
Internal temperature	11.9	11.4	°C	pv (external)	362.368	
External temperature	2.3	2.4	°C	air density (internal)	1.249	kg/m^3
Zero flow +ve average	0.0	0.0	pascals	air density (external)	1.293	kg/m^3
Zero flow -ve average	-0.6	-0.1	pascals			
Overall Zero flow avera	-0.6	-0.1	pascals			

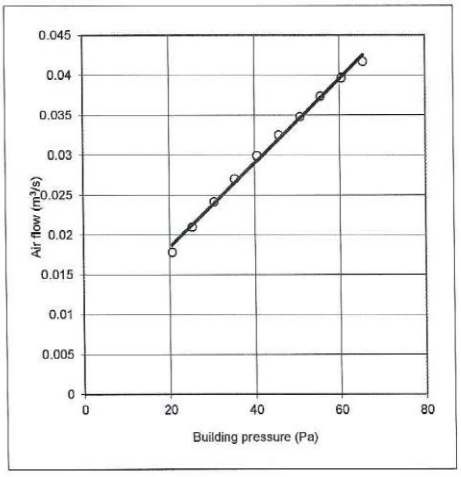
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.2	145
2	60.1	138
3	55.1	130
4	50.3	121
5	45.3	113
6	40.2	104
7	35.0	94
8	30.1	84
9	25.0	73
10	20.3	62

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
145				
138				
130				
121				
113				
104				
94				
84				
73				
62				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.6	0.04
60.5	0.04
55.5	0.04
50.7	0.03
45.7	0.03
40.6	0.03
35.4	0.03
30.5	0.02
25.4	0.02
20.7	0.02

log pressure	log flow
4.1828	-3.1776
4.1018	-3.2270
4.0155	-3.2868
3.9249	-3.3585
3.8210	-3.4269
3.7025	-3.5099
3.5653	-3.6110
3.4161	-3.7235
3.2328	-3.8638
3.0277	-4.0272



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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	198	m^3	
Plot No.	**E**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.63		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**15.20**	Air flow exponent, n	0.705		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.03	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	At start	At end	
Wind speed	0	0	$m.s^{-1}$
Barometric pressure	1024	1024	mbar
Internal temperature	11.3	11.0	°C
External temperature	2.5	2.6	°C
Zero flow +ve average	0.0	0.0	pascals
Zero flow -ve average	-0.1	-0.9	pascals
Overall Zero flow avera	-0.1	-0.9	pascals

pv (internal)	663.480	
pv (external)	367.562	
air density (internal)	1.252	kg/m^3
air density (external)	1.292	kg/m^3

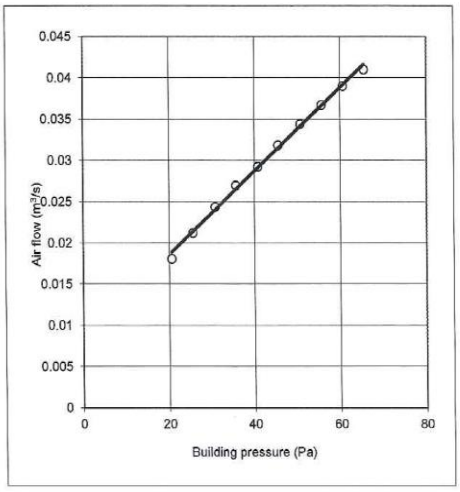
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.0	143
2	60.1	136
3	55.1	128
4	50.2	120
5	45.0	111
6	40.3	102
7	35.1	94
8	30.2	85
9	25.0	74
10	20.1	63

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
143				
136				
128				
120				
111				
102				
94				
85				
74				
63				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.5	0.04
60.6	0.04
55.6	0.04
50.7	0.03
45.5	0.03
40.8	0.03
35.6	0.03
30.7	0.02
25.5	0.02
20.6	0.02

log pressure	log flow
4.1821	-3.1940
4.1043	-3.2442
4.0182	-3.3048
3.9259	-3.3694
3.8177	-3.4473
3.7087	-3.5319
3.5723	-3.6136
3.4243	-3.7142
3.2387	-3.8528
3.0253	-4.0137



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Checked by: _____ Date: 10/1/17

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TECHNOLOGY CENTRE

Certificate of Test

Title: Air tightness test of Plot F, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25245

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot F
Issue date: 10th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

VINCI Technology Centre UK Limited
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info@technology-centre.co.uk
www.technology-centre.co.uk
Stanbridge Road, Leighton Buzzard, Bedfordshire, LU7 4QH
Registered Office, Watford, England. Registered No.05640885

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UKAS TESTING 0057

TECHNOLOGY CENTRE

1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	6 Jan 17	10.00
Building volume	198	m^3 (calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.647**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	198	m^3	
Plot No.	**F**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.65		FAIL
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**10.00**	Air flow exponent, n	0.751		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.04	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Pressurisation Test	**At start**	**At end**				
Wind speed	0	0	$m.s^{-1}$	pv (internal)	596.270	
Barometric pressure	1025	1025	mbar	pv (external)	308.257	
Internal temperature	9.8	9.3	°C	air density (internal)	1.260	kg/m^3
External temperature	0.1	0.1	°C	air density (external)	1.305	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.1	-0.2	pascals			
Overall Zero flow avera	-0.1	-0.2	pascals			

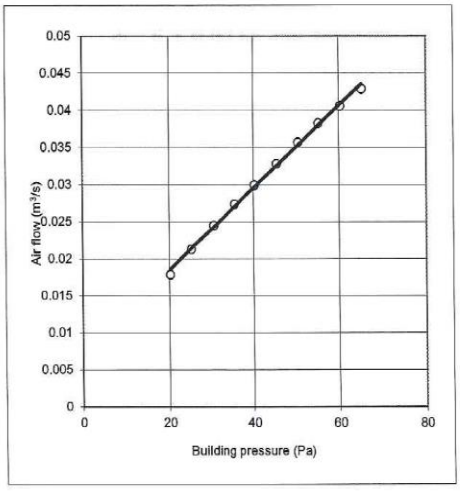
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.0	149
2	60.1	141
3	55.0	133
4	50.2	124
5	45.2	114
6	40.1	104
7	35.3	95
8	30.3	85
9	25.2	74
10	20.1	62

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
149				
141				
133				
124				
114				
104				
95				
85				
74				
62				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.2	0.04
60.3	0.04
55.2	0.04
50.4	0.04
45.4	0.03
40.3	0.03
35.5	0.03
30.5	0.02
25.4	0.02
20.3	0.02

log pressure	log flow
4.1767	-3.1497
4.0985	-3.2049
4.0101	-3.2633
3.9190	-3.3333
3.8144	-3.4174
3.6951	-3.5092
3.5681	-3.5997
3.4161	-3.7110
3.2328	-3.8496
3.0082	-4.0265



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Checked by: _____ Date: 10/1/17

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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	198	m^3	
Plot No.	**F**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.64		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**10.15**	Air flow exponent, n	0.764		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	0.999		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.04	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	**At start**	**At end**				
Wind speed	0	0	$m.s^{-1}$	pv (internal)	578.482	
Barometric pressure	1025	1025	mbar	pv (external)	311.628	
Internal temperature	9.3	8.9	°C	air density (internal)	1.262	kg/m^3
External temperature	0.2	0.3	°C	air density (external)	1.305	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.1	-0.5	pascals			
Overall Zero flow avera	-0.1	-0.5	pascals			

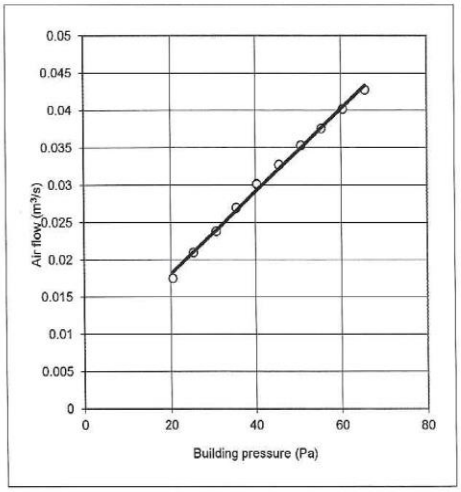
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.3	149
2	60.1	140
3	55.1	131
4	50.2	123
5	45.2	114
6	40.0	105
7	35.1	94
8	30.3	83
9	25.1	73
10	20.2	61

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
149				
140				
131				
123				
114				
105				
94				
83				
73				
61				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.6	0.04
60.4	0.04
55.4	0.04
50.5	0.04
45.5	0.03
40.3	0.03
35.4	0.03
30.6	0.02
25.4	0.02
20.5	0.02

log pressure	log flow
4.1836	-3.1519
4.1010	-3.2142
4.0146	-3.2806
3.9220	-3.3437
3.8177	-3.4196
3.6964	-3.5019
3.5667	-3.6126
3.4210	-3.7370
3.2347	-3.8654
3.0204	-4.0450



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Checked by: [signature] Date: 10/1/17

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TECHNOLOGY CENTRE

Certificate of Test

Title: Air tightness test of Plot G, Gales Place, Crawley in accordance with The Passivhaus Standard (generally in accordance with BS EN 13829:2001 [method B])

Certificate of Test Number: 25246

Customer's name & address
Westridge Construction Limited
Ruskin House
Junction Road
Bodiam
East Sussex
TN32 5UP

Our Ref: N950/TR0088
VTC Job No.: 3UL6
Your Ref: Plot G
Issue date: 10th January 2017
Date sample(s) received: N/A
Sample(s) received from: N/A
Sample No.: B6014

Tested by: .....*see adjacent text.*.....
Shaun Maddison
(position: Engineer)
Authorised by: .....
S. Collins
(position: Principal Engineer)

VINCI Technology Centre UK Limited
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info@technology-centre.co.uk
www.technology-centre.co.uk
Stanbridge Road, Leighton Buzzard, Bedfordshire, LU7 4QH
Registered Office, Watford, England. Registered No.05640885

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UKAS TESTING
0057

TECHNOLOGY CENTRE

1. BUILDING DETAILS

All combustion appliances were turned off and flues sealed. All mechanical ventilation systems were turned off and sealed at grilles. All internal doors were open during the test. Sufficient internal openings were provided to ensure pressure equalisation throughout the dwelling. All drainage traps were filled or sealed over. All external doors and windows were closed. All natural ventilation openings were temporarily sealed. Carpets were partly fitted. The single blower door fan was connected to the building via the front door. The entire dwelling was tested.

2. RESULTS

Estimated construction date	2016	
Date and time of test	6 Jan 17	8.45
Building volume	226 m^3	(calculated by Warm Low Energy Building Practice)
Measured air changes per hour	**0.567**	
Target air changes per hour	0.649	

These calculations comply with ATTMA Technical Standard Appendix A

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	226.3	m^3	
Plot No.	**G**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.57		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**8.45**	Air flow exponent, n	0.689		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	0.997		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.04	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Pressurisation Test	At start	At end	
Wind speed	0	0	$m.s^{-1}$
Barometric pressure	1025	1025	mbar
Internal temperature	9.1	8.4	°C
External temperature	-0.6	-0.5	°C
Zero flow +ve average	0.0	0.0	pascals
Zero flow -ve average	-0.2	-0.3	pascals
Overall Zero flow avera	-0.2	-0.3	pascals

pv (internal)	564.972		
pv (external)	294.022		
air density (internal)	1.264	kg/m^3	
air density (external)	1.308	kg/m^3	

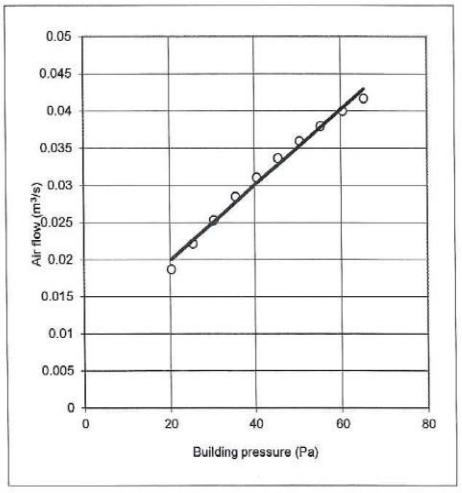
	pressure (Pa)	flow ($m^3.hour^{-1}$)
1	65.1	145
2	60.2	139
3	55.0	132
4	50.1	125
5	45.1	117
6	40.3	108
7	35.2	99
8	30.0	88
9	25.2	77
10	20.1	65

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
145				
139				
132				
125				
117				
108				
99				
88				
77				
65				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	corrected flow ($m^3.s^{-1}$)
65.4	0.04
60.5	0.04
55.3	0.04
50.4	0.04
45.4	0.03
40.6	0.03
35.5	0.03
30.3	0.03
25.5	0.02
20.4	0.02

log pressure	log flow
4.1798	-3.1774
4.1018	-3.2197
4.0119	-3.2713
3.9190	-3.3258
3.8144	-3.3920
3.7025	-3.4720
3.5681	-3.5590
3.4095	-3.6768
3.2367	-3.8103
3.0131	-3.9798



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Checked by: _____ Date: 10/1/17

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TECHNOLOGY CENTRE

Passivhaus Air Tightness Test

Customer	**Westridge**	Envelope area		m^2	
Project	**Gales Place**	Building volume	226.3	m^3	
Plot No.	**G**	Target ach	0.649		
Job No.	**B6014**	Measured ach	0.56		PASS
Test date	**6 Jan 17**	Measured permeability	#DIV/0!	$m^3/(h.m^2)$	
Time of test	**9.00**	Air flow exponent, n	0.729		ok
Tested by	**Shaun Maddison**	Correlation coefficient, r^2	1.000		ok
Fan/Manometer No.	**CLR 698**	Air flow coefficient, C_{env}	0.002		
Calibration due	**18 Feb 17**	Air leakage coefficient, C_L	0.002		
Thermo/Barom No.	**MTL 017**	Air leakage rate, Q_{50}	0.04	$m^3.s^{-1}$	
Calibration due	**5 Jul 17**	Equivalent leakage area	0.01	m^2	

Depressurisation Test	**At start**	**At end**				
Wind speed	0	0	$m.s^{-1}$	pv (internal)	538.783	
Barometric pressure	1025	1025	mbar	pv (external)	296.173	
Internal temperature	8.3	7.8	°C	air density (internal)	1.267	kg/m^3
External temperature	-0.5	-0.4	°C	air density (external)	1.308	kg/m^3
Zero flow +ve average	0.0	0.0	pascals			
Zero flow -ve average	-0.6	-0.6	pascals			
Overall Zero flow avera	-0.6	-0.6	pascals			

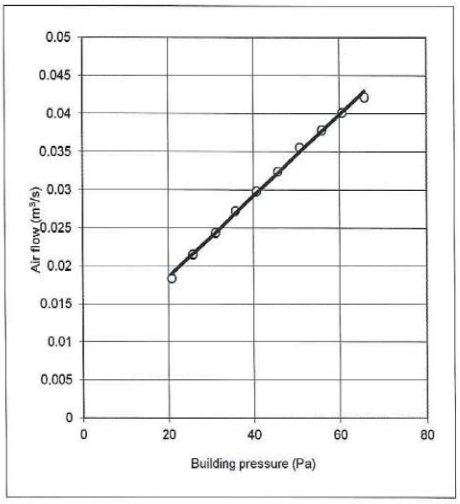
	pressure (Pa)	**flow** ($m^3.hour^{-1}$)
1	65.2	147
2	60.0	140
3	55.3	132
4	50.2	124
5	45.0	113
6	40.1	104
7	35.1	95
8	30.3	85
9	25.1	75
10	20.2	64

Minneapolis door blower ($m^3.hour^{-1}$)	Retrotec 219 open (Pa)	Retrotec 218 open (Pa)	Retrotec 269 open (Pa)	G54 ($m^3.s^{-1}$)
147				
140				
132				
124				
113				
104				
95				
85				
75				
64				

	219 GF	219 offset	218 GF	218 offset	269 GF	269 offset	G54 GF
A ring	467.1291	10.562					
B ring	287.5859	46.584					
C8 ring	144.6206	-105.663					
open	980.169	39.272	1041.283	-371.786	991.4565	-189.398	0.9426

corrected pressure (Pa)	**corrected flow ($m^3.s^{-1}$)**
65.8	0.04
60.6	0.04
55.9	0.04
50.8	0.04
45.6	0.03
40.7	0.03
35.7	0.03
30.9	0.02
25.7	0.02
20.8	0.02

log pressure	**log flow**
4.1866	-3.1667
4.1043	-3.2155
4.0236	-3.2743
3.9279	-3.3368
3.8199	-3.4297
3.7062	-3.5127
3.5752	-3.6032
3.4308	-3.7144
3.2465	-3.8396
3.0350	-3.9982



Calculated by: _____ Date: _____

Checked by: mcaud Date: 10/1/17

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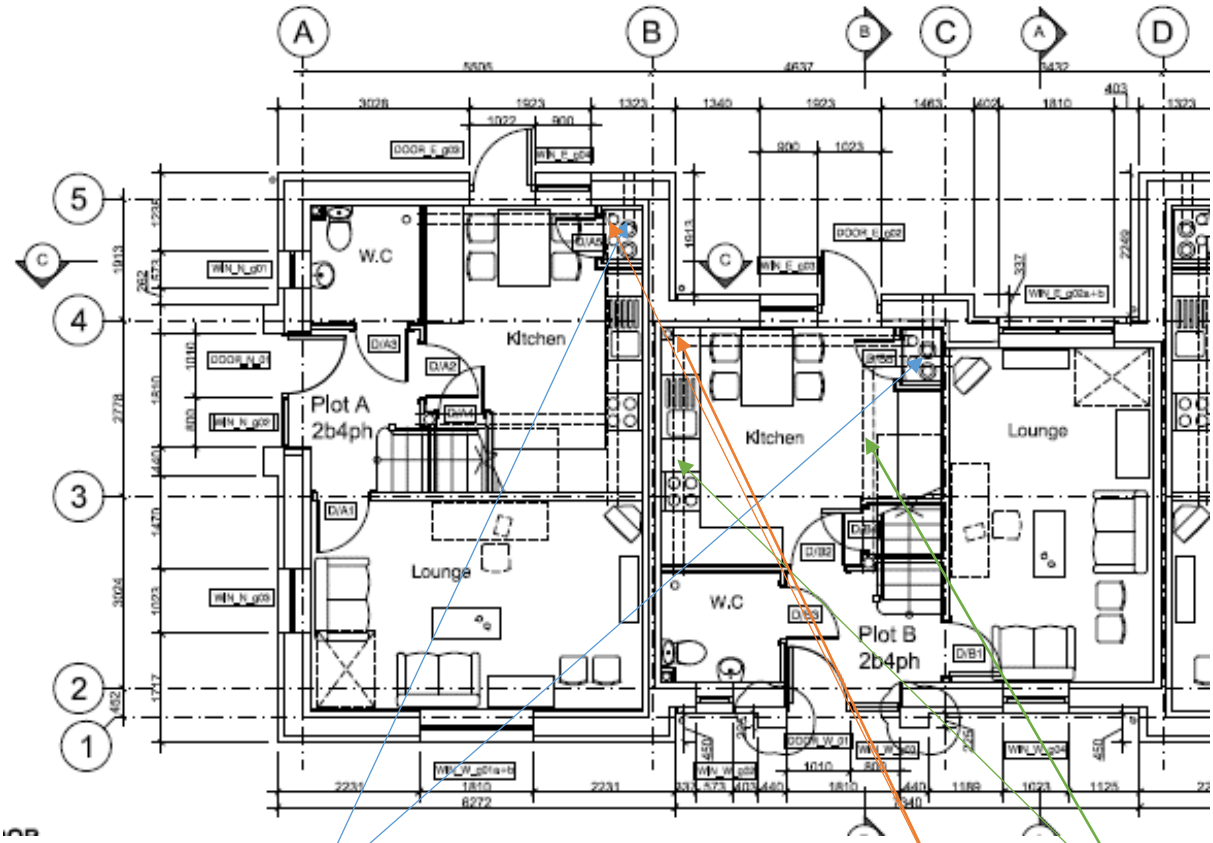
TECHNOLOGY CENTRE

12. Layout of the Ventilation System Ducting

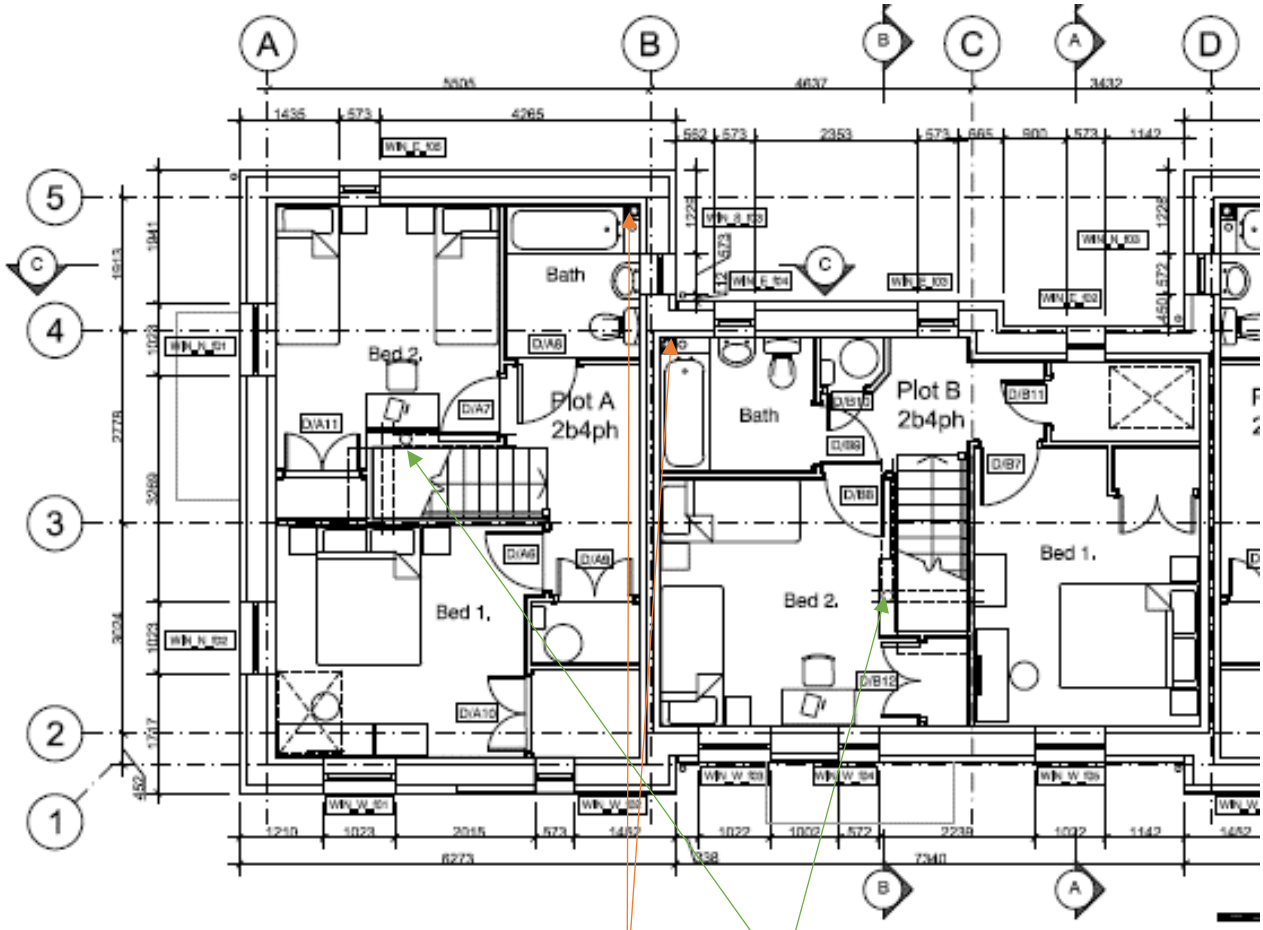
Concept duct layouts were prepared by Peter Ranken and included in the general arrangement plans. Detailed installation layouts were prepared by suppliers and installers Built Environment Technology. Copies of the installation drawings are included in the appendices.



- MVHR cupboards
- Supply Ducts above kitchen units/ above ceiling to vertical duct in partition on first floor
- Extract Ducts above ceiling/ adjacent to svps to bathrooms on first floor

Extract of tender ground floor drawing showing the positions of MVHR units and ductwork.

The MVHR units are installed in cupboards in each kitchen adjacent to external walls. This allows for easy access by residents to controls and for the replacement and/or cleaning of filters. The MVHR cupboards face the rear gardens of the houses or side elevations of the flats and therefore clean sources of fresh intake air. The same installation was used for each dwelling.



- Vertical extract duct adjacent bathroom svp
- Vertical supply duct in wider partition to serve bedrooms

Extract from tender drawing of first floor of Block 1 houses showing positions of MVHR ductwork

Tempered supply air is provided to habitable spaces (living rooms, bedrooms) and air is extracted from bathrooms, wcs and kitchens. Circulation spaces in each dwelling are used for air transfer and enlarged gaps at the bottom of doors allow air movement when doors are closed.

13. Ventilation Unit

Individual Paul Novus 300 MVHR units were used in each dwelling, installed against external walls with insulated inlet and discharge ducts, these ducts being insulated with 50mm of Armaflex vapour resistant insulation. Inlet and discharge duct lengths are kept to a reasonable minimum to minimise heat loss and to maintain separation of air flow externally.

Technical data for the Paul Novus 300 unit is included in the appendices, and this information includes the following data from the Passivhaus Institut certificate for this unit:

- Effective heat recovery of 93%
- Electrical efficiency P_{el} of 0.24 Wh/m^3

Typical installation of heat recovery ventilation unit.

The installed efficiency was calculated by Passivhaus Certifier WARM Low Energy Practice as follows;

- Three House Terrace 87.4%
- Four House Terrace 88.9%
- Block of Flats 88.6%

14. Heat Supply

After sunlight, appliances and people, each dwelling is electrically heated with panel heaters in living rooms and electric towel rails in bathrooms.

The equipment specified is as follows:

Electric towel rails, in bathroom and ground floor WC: *350W output*

Dimplex TDTR 350W colour white, 843mm (h) x 602mm (w), with air temperature thermostatic control and connected to separate timer controlled circuit and individual on/off switches.

Electric panel heater, in living rooms: *500W output*

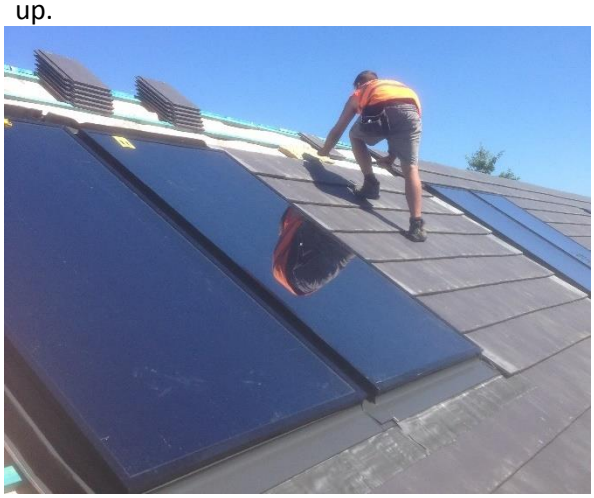
Dimplex EPX 500 panel heater 450mm (h) x 450mm (w), with thermostatic control, connected to separate timer controlled circuit and individual switch.

Timer control for heating circuit to include:

- 30 minute boost button
- 24h / day control
- Weekend / weekday control

Living room in Block A showing electric panel heater in living room

Hot water is provided by Viridian solar thermal panels and cylinders with immersion heater back up.

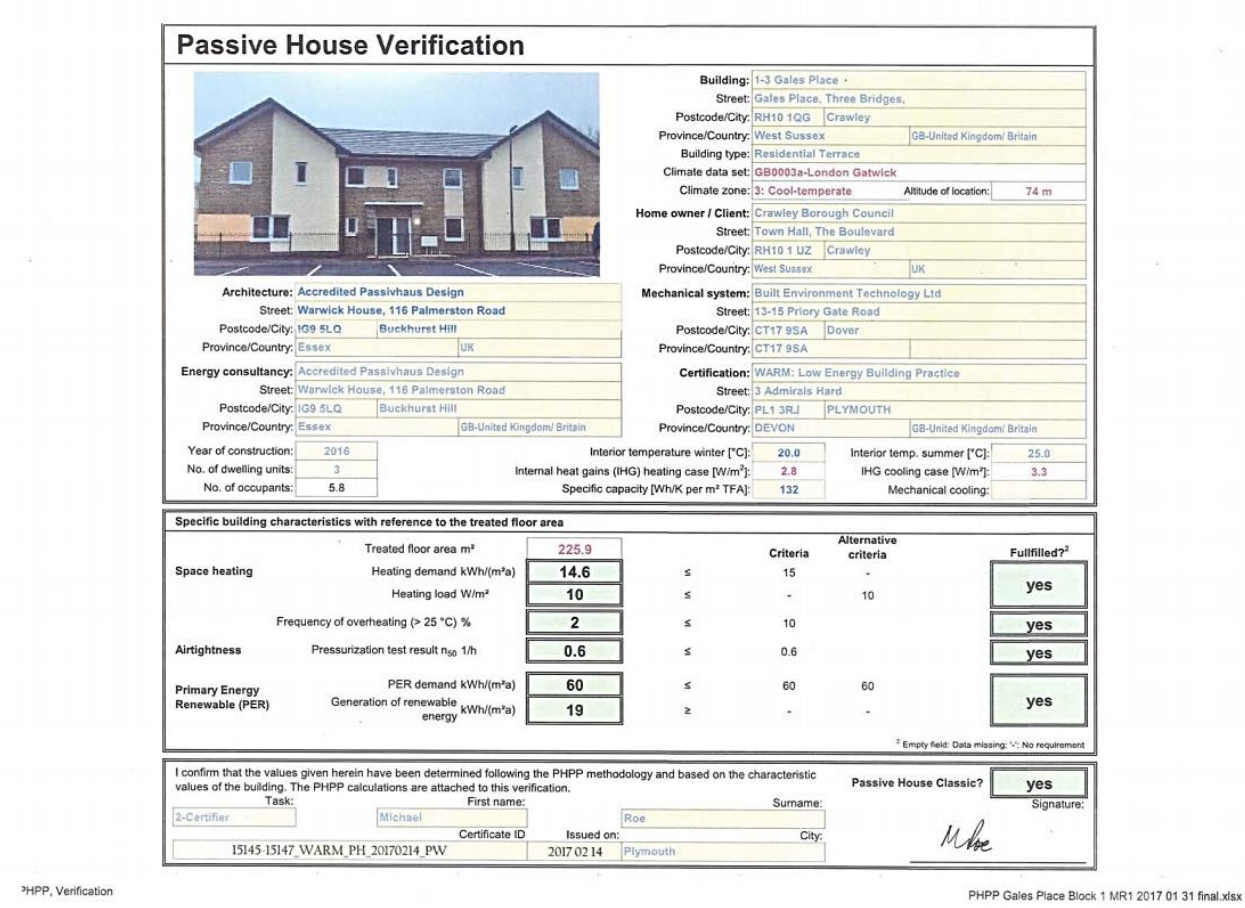


Solar thermal panels during construction – Block 2

Solar hw cylinder – Block 1 – pipes to be insulated

15. Short Documentation of PHPP (Verification Sheets)

Copies of the PHPP verification sheets for each block, as issued by WARM Low Energy Practice, are below:



Passive House Verification

Building:	1-3 Gales Place				
Street:	Gales Place, Three Bridges,				
Postcode/City:	RH10 1QG	Crawley			
Province/Country:	West Sussex		GB-United Kingdom/ Britain		
Building type:	Residential Terrace				
Climate data set:	GB0003a-London Gatwick				
Climate zone:	3: Cool-temperate		Altitude of location:	74 m	
Home owner / Client:	Crawley Borough Council				
Street:	Town Hall, The Boulevard				
Postcode/City:	RH10 1 UZ	Crawley			
Province/Country:	West Sussex		UK		
Architecture:	Accredited Passivhaus Design				
Street:	Warwick House, 116 Palmerston Road				
Postcode/City:	IG9 5LQ	Buckhurst Hill			
Province/Country:	Essex		UK		
Mechanical system:	Built Environment Technology Ltd				
Street:	13-15 Priory Gate Road				
Postcode/City:	CT17 9SA	Dover			
Province/Country:	CT17 9SA				
Energy consultancy:	Accredited Passivhaus Design				
Street:	Warwick House, 116 Palmerston Road				
Postcode/City:	IG9 5LQ	Buckhurst Hill			
Province/Country:	Essex		GB-United Kingdom/ Britain		
Certification:	WARM: Low Energy Building Practice				
Street:	3 Admirals Hard				
Postcode/City:	PL1 3RJ	PLYMOUTH			
Province/Country:	DEVON		GB-United Kingdom/ Britain		

Year of construction:	2016	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	3	Internal heat gains (IHG) heating case [W/m²]:	2.8	IHG cooling case [W/m²]:	3.3
No. of occupants:	5.8	Specific capacity [Wh/K per m² TFA]:	132	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	225.9				
Space heating	Heating demand kWh/(m²a)	14.6	≤	15	-	yes
	Heating load W/m²	10	≤	-	10	
	Frequency of overheating (> 25 °C) %	2	≤	10		yes
Airtightness	Pressurization test result n_{50} 1/h	0.6	≤	0.6		yes
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	60	≤	60	60	yes
	Generation of renewable energy kWh/(m²a)	19	≥	-	-	

[2] Empty field: Data missing; "-": No requirement

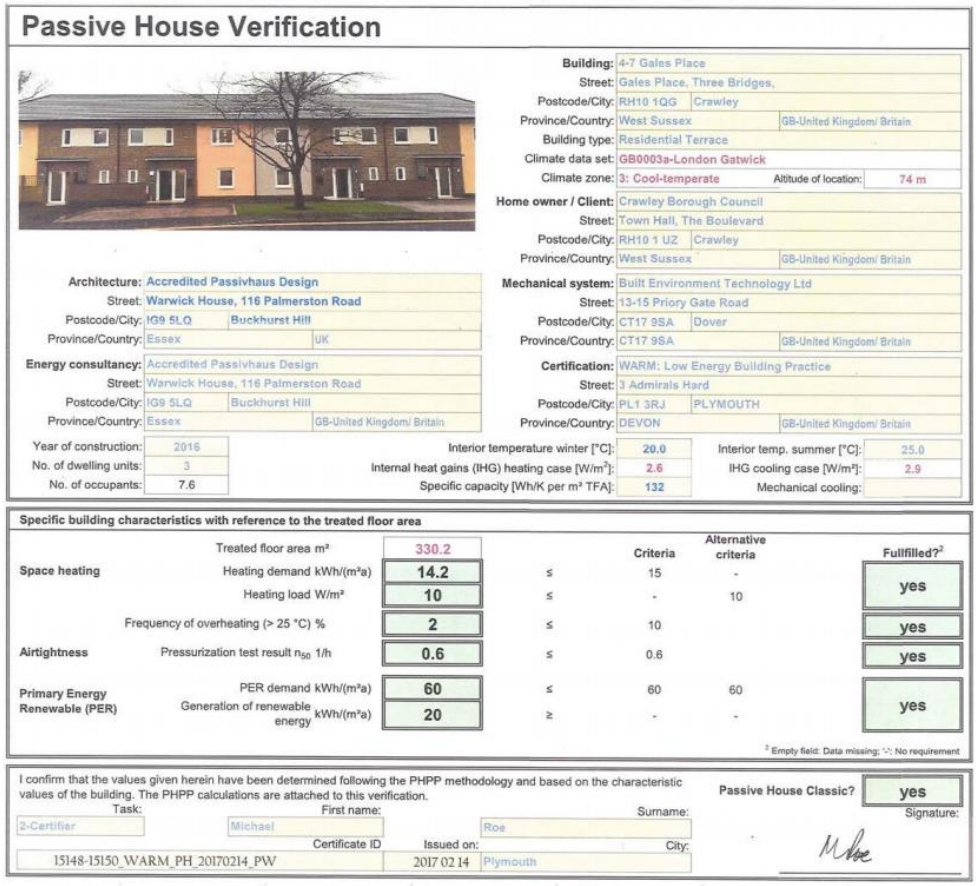
I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive House Classic? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Michael	Roe	

Certificate ID	Issued on:	City:
15145-15147_WARM_PH_20170214_PW	2017 02 14	Plymouth

Block 1 PHPP Verification page



Passive House Verification

Building:	4-7 Gales Place		
Street:	Gales Place, Three Bridges,		
Postcode/City:	RH10 1QG	Crawley	
Province/Country:	West Sussex		GB-United Kingdom/ Britain
Building type:	Residential Terrace		
Climate data set:	GB0003a-London Gatwick		
Climate zone:	3: Cool-temperate	Altitude of location:	74 m
Home owner / Client:	Crawley Borough Council		
Street:	Town Hall, The Boulevard		
Postcode/City:	RH10 1 UZ	Crawley	
Province/Country:	West Sussex		GB-United Kingdom/ Britain

Architecture:	Accredited Passivhaus Design		
Street:	Warwick House, 116 Palmerston Road		
Postcode/City:	IG9 5LQ	Buckhurst Hill	
Province/Country:	Essex		UK
Energy consultancy:	Accredited Passivhaus Design		
Street:	Warwick House, 116 Palmerston Road		
Postcode/City:	IG9 5LQ	Buckhurst Hill	
Province/Country:	Essex		GB-United Kingdom/ Britain
Mechanical system:	Built Environment Technology Ltd		
Street:	13-15 Priory Gate Road		
Postcode/City:	CT17 9SA	Dover	
Province/Country:	CT17 9SA		GB-United Kingdom/ Britain
Certification:	WARM: Low Energy Building Practice		
Street:	3 Admirals Hard		
Postcode/City:	PL1 3RJ	PLYMOUTH	
Province/Country:	DEVON		GB-United Kingdom/ Britain

Year of construction:	2016	Interior temperature winter [°C]:	20.0
No. of dwelling units:	3	Internal heat gains (IHG) heating case [W/m²]:	2.6
No. of occupants:	7.6	Specific capacity [Wh/K per m² TFA]:	132
		Interior temp. summer [°C]:	25.0
		IHG cooling case [W/m²]:	2.9
		Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	330.2				
Space heating	Heating demand kWh/(m²a)	14.2	≤	15	-	yes
	Heating load W/m²	10	≤	-	10	
	Frequency of overheating (> 25 °C) %	2	≤	10		yes
Airtightness	Pressurization test result n_{50} 1/h	0.6	≤	0.6		yes
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	60	≤	60	60	yes
	Generation of renewable energy kWh/(m²a)	20	≥	-	-	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive House Classic? yes

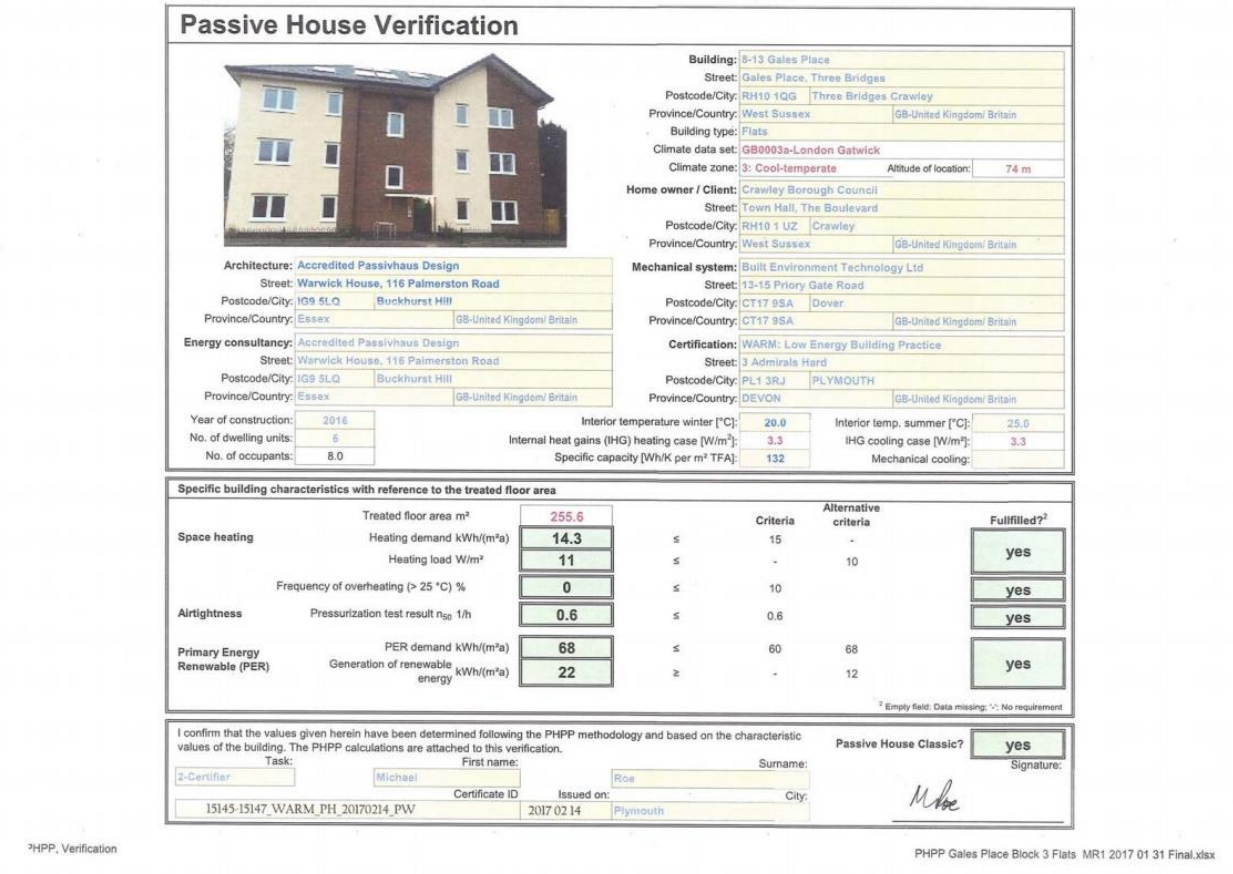
Task:	First name:	Surname:	Signature:
2-Certifier	Michael	Roe	

Certificate ID	Issued on:	City:
15148-15150_WARM_PH_20170214_PW	2017 02 14	Plymouth

[2]HPP, Verification

PHPP Gales Place Block 2 MR1 2017 01 31 final.xlsx

Block 2 PHPP verification page



Passive House Verification

Building:	8-13 Gales Place		
Street:	Gales Place, Three Bridges		
Postcode/City:	RH10 1QG	Three Bridges Crawley	
Province/Country:	West Sussex	GB-United Kingdom/ Britain	
Building type:	Flats		
Climate data set:	GB0003a-London Gatwick		
Climate zone:	3: Cool-temperate	Altitude of location:	74 m
Home owner / Client:	Crawley Borough Council		
Street:	Town Hall, The Boulevard		
Postcode/City:	RH10 1 UZ	Crawley	
Province/Country:	West Sussex	GB-United Kingdom/ Britain	

Architecture:	Accredited Passivhaus Design		
Street:	Warwick House, 116 Palmerston Road		
Postcode/City:	IG9 5LQ	Buckhurst Hill	
Province/Country:	Essex	GB-United Kingdom/ Britain	
Energy consultancy:	Accredited Passivhaus Design		
Street:	Warwick House, 116 Palmerston Road		
Postcode/City:	IG9 5LQ	Buckhurst Hill	
Province/Country:	Essex	GB-United Kingdom/ Britain	

Mechanical system:	Built Environment Technology Ltd		
Street:	13-15 Priory Gate Road		
Postcode/City:	CT17 9SA	Dover	
Province/Country:	CT17 9SA	GB-United Kingdom/ Britain	
Certification:	WARM: Low Energy Building Practice		
Street:	3 Admirals Hard		
Postcode/City:	PL1 3RJ	PLYMOUTH	
Province/Country:	DEVON	GB-United Kingdom/ Britain	

Year of construction:	2016	Interior temperature winter [°C]:	20.0
No. of dwelling units:	6	Internal heat gains (IHG) heating case [W/m²]:	3.3
No. of occupants:	8.0	Specific capacity [Wh/K per m² TFA]:	132
		Interior temp. summer [°C]:	25.0
		IHG cooling case [W/m²]:	3.3
		Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	255.6				
Space heating	Heating demand kWh/(m²a)	14.3	≤	15	-	yes
	Heating load W/m²	11	≤	-	10	
	Frequency of overheating (> 25 °C) %	0	≤	10		yes
Airtightness	Pressurization test result n_{50} 1/h	0.6	≤	0.6		yes
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	68	≤	60	68	yes
	Generation of renewable energy kWh/(m²a)	22	≥	-	12	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive House Classic? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Michael	Roe	

Certificate ID	Issued on:	City:
15145-15147_WARM_PH_20170214_PW	2017 02 14	Plymouth

[2]HPP, Verification

PHPP Gales Place Block 3 Flats MR1 2017 01 31 Final.xlsx

Block 3 verification page

16. Building Costs

Whilst Crawley Borough Council owned part of the building site, parts of the site were owned by West Sussex College and a land transfer had to be negotiated between these parties. The cost of this was not known to the design team.

17. Construction Costs

Tender base date. The project was tendered in 2015.
Build period. This was 56 weeks, completing in February 2017.
Cost details. Costed quantities are not available, but contractor Westridge have confirmed that the build cost was based on £2234/m2 (Gross internal floor area not Treated floor area).

They have also confirmed the following:

- *Were there any elements of the project that were difficult to price? If yes, why?* No
- *Would you complete the project again at the same price (not taking into account of TPI)? Yes plus increase costs*

18. Year of Construction

Construction started in November 2015 and completed in February 2017. The contractor was Westridge Construction, and Gales Place was their first Passivhaus project. On the recommendation of the architect and Passivhaus designer Westridge ensured that the site manager, contracts manager and one director received Passivhaus Tradespersons training.

19. Design and Architect.

Accredited Passivhaus Design (a part of architects The Tooley & Foster Partnership) designed the buildings on behalf of Crawley Borough Council (Crawley Homes), achieved planning consent from Crawley Borough Council and prepared construction drawings for contractor Westridge. The team was led by Peter Ranken, an architect with extensive experience of social housing masterplanning and design, and he also holds an MSc in Environmental Design and Engineering from University College London. At the time of design he was a Certified Passivhaus Designer.

Within a site with complex pedestrian and vehicle access routes, the blocks were laid out to provide safe external areas for residents and others visiting nearby shops, community centre and school. Each block includes south facing roofs for solar hot water, double windows in principal rooms and an energy efficient envelope as well as attractive spaces to live in.

Like most construction projects the construction of Gales Place provided lessons for future Passivhaus projects. The same design team (Peter Ranken of Accredited Passivhaus Design/ Tooley & Foster) were appointed to design Dobbins Place, the second Passivhaus development for Crawley Borough Council and subsequently Westridge were appointed as contractors for this project working with the same contract manager and site agents as Gales Place. The following detailed design and construction changes were made to Dobbins Place following the experience of building Gales Place:

- Airtight OSB to the window surrounds and the top floor ceilings to assist airtightness. The rigid board at top floor ceiling level shows damage more readily than an Intello membrane and is easier to repair.
- MVHR systems with semi-rigid duct installed via manifolds to improve sound insulation and to ease commissioning (one duct per terminal).
- Metal web floor joists in the houses for the following reasons:

    - Semi-rigid ventilation ductwork can be included in the floor depth to avoid dropped ceiling/ additional boxing in the kitchens
    - Floors can span front to back and thereby omitting load bearing partitions and foundations under them

- Aluminium clad timber windows with narrower sections than PVCu to improve solar gain, and to reduce mullion thicknesses.
- Order load bearing insulation (Marmox) well in time to minimise delays.

20. Information about the building services design

Detailed building services design was carried out by:

- Built Environment Technology Ltd (Ventilation systems) and
- JWS Maintenance Kent Ltd (Electrical services)
- White Associates (Mechanical services)

The building services strategy was determined by Peter Ranken in accordance with Passivhaus principles to include the following:

- Efficient ventilation with heat recovery, with high performance units, located and installed to maintain efficient operation with minimal lengths of ducts containing air at external temperatures.
- Separate heating system using direct electric heaters in bathrooms (towel rails) and living rooms (panel heaters)
- Solar hot water, installed on south facing roofs at optimum roof pitches with back up electric immersion heaters.

The building services concept was intended to provide simple systems to install, operate and maintain and was agreed with Crawley Homes (building managers) in advance of tender and construction.

Concept pipe routes and lengths were determined by the architect Peter Ranken and entered into PHPP.

21. Information about the Planner Of The Building Physics

PHPP energy and comfort analysis of each block was carried out by architect and Passivhaus designer Peter Ranken. This also included thermal bridge analysis using Therm software.

22. Information about the Structural Designer

The structural engineer was Graham Waller of the Eastbourne office of Stephen Wilson Partnership Ltd.

23. User's Experiences

In June 2018 Peter Ranken visited Gales Place to interview a number of residents to understand their experience of their homes after more than one year of occupation. The notes of this visit are attached as an appendix.

24. Appendices

Appendices

1. iPHA database pages for projects 5406, 5414, 5415
2. Floor and roof plans
3. Typical construction details
4. Window manufacturers information
5. MVHR installers drawings
6. MVHR unit technical information - Paul Novus 300
7. Final PHPP files for each block
8. Thermal bridge reports
9. Notes of Post Occupancy visit held on 20 June 2018
10. Confirmation of Peter Ranken's RIBA membership
11. List of specified items included in PHPP
12. Building Passivhaus Certification