Taylor Wimpey – Thermal Imaging Project

LEEDS BECKETT UNIVERSITY

Leeds Sustainability Institute

Site: Newton Farm
Cambuslang
G72 8QF

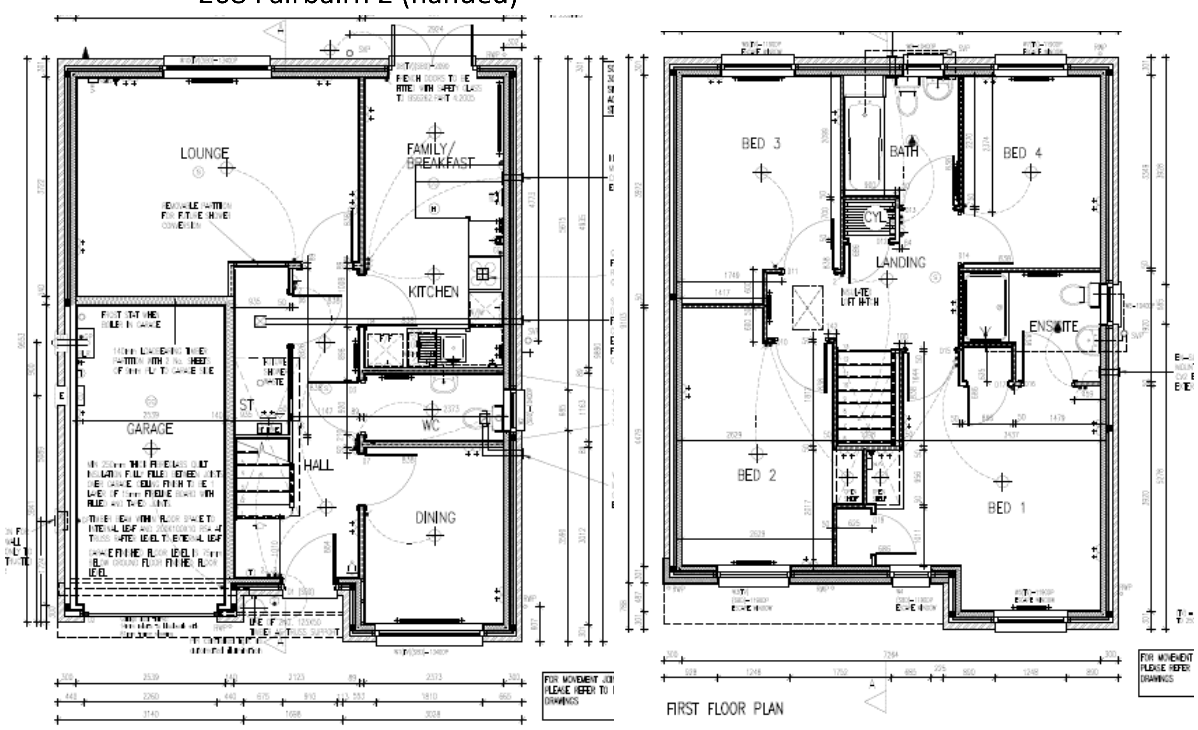
Visit Date: 13th November 2017

Plot(s): 268
267

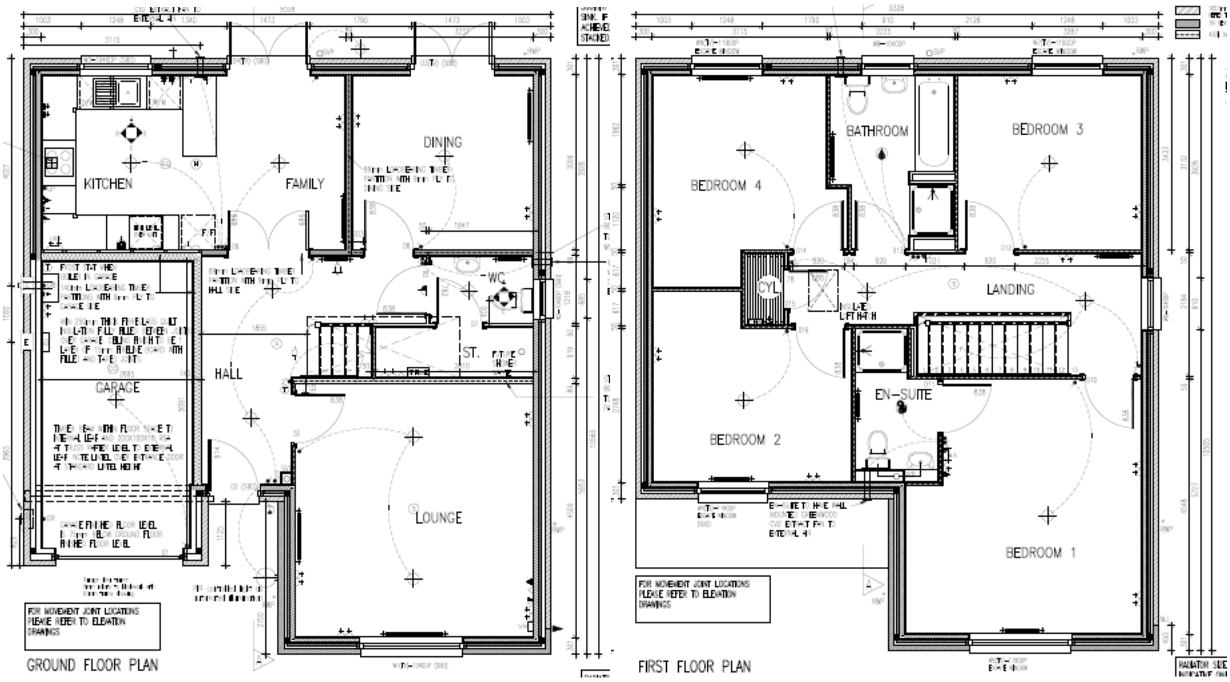
House Type: 268 Fairbairn 2
267 Maxwell 2
Timber Frame, 2-Storey, Detached, Integral Garage

Floor Plans:

268 Fairbairn 2 (handed)



267 Maxwell 2 (handed)



Environmental Conditions:

Internal Temperature	19.8 / 18.0 °C	External Temperature	3.8 / 3.4 °C
Internal RH	51 %	External RH	73 / 72 %
Wind Speed	0.0 ms^{-1}	Wind Direction	n/a

Overcast skies, no rain in preceding 36 hours.

Pressure Test Results:

268 Fairbairn 2								
Depressurisation Only			Pressurisation Only			Mean		
$m^3/(h.m^2)$@50Pa	ach^{-1}	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}	
2.82	2.92	1.000	3.11	3.22	1.000	2.96	3.07	
267 Maxwell 2								
Depressurisation Only			Pressurisation Only			Mean		
$m^3/(h.m^2)$@50Pa	ach^{-1}	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}	r^2	$m^3/(h.m^2)$@50Pa	ach^{-1}	
3.41	3.37	0.998	3.91	3.86	0.999	3.66	3.61	

Observations:

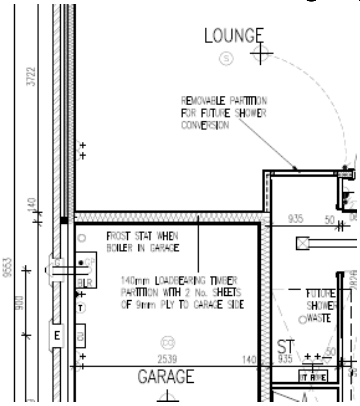
The thermal images below are shown on varying temperature scales to highlight what was being observed, please take into account these different image spans when directly comparing images. The minimum span used is 5° so as not to over-exaggerate any thermal anomalies observed.

Plot 268

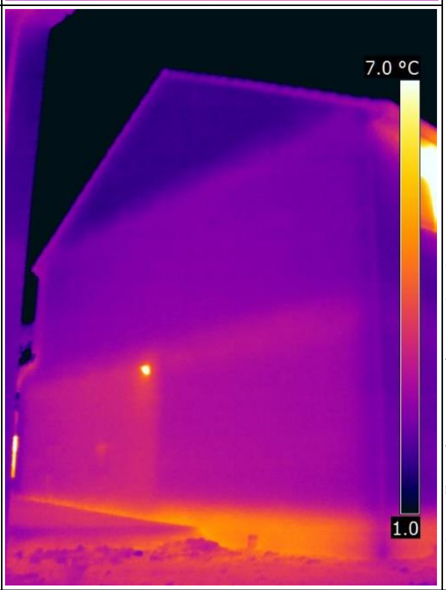
Thermal images under depressurisation were captured at an average pressure of -51.8 Pa.

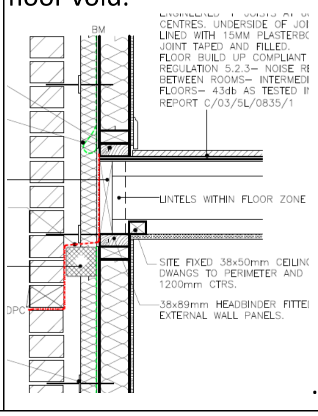
External - Under natural conditions

As expected the house appears cooler at loft level on the gables, not so expected was that the gable wall would be warmer than the external surface of the rest of the house. This appeared due to the boiler placement in the garage and the much lower thermal resistance of the external wall at the garage:

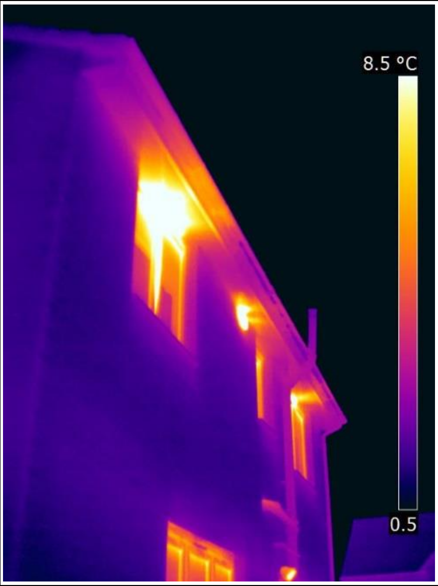


A warmer strip was visible on both gable walls around the intermediate floor void, where the floor joists run normal to the walls, but less so on the front and rear façades where the joists run parallel to the external walls. The difference in elevations suggests that may be due to difference in floor perimeter detailing, but is complicated by heating pipes running through the floor void:

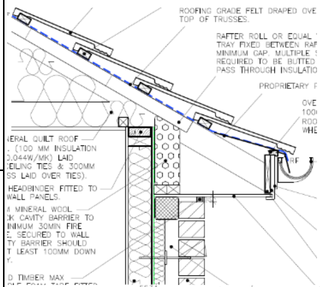


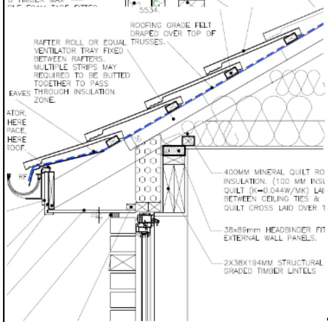


The ground floor perimeter was much warmer than the rest of the external wall. It was unclear whether this was expected or unintended heat loss at ground floor perimeter.
Additional heat loss was observed at the patio door threshold which was not completely finished.

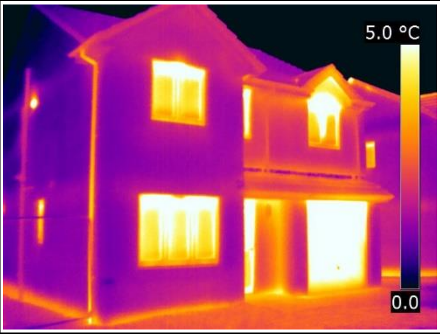


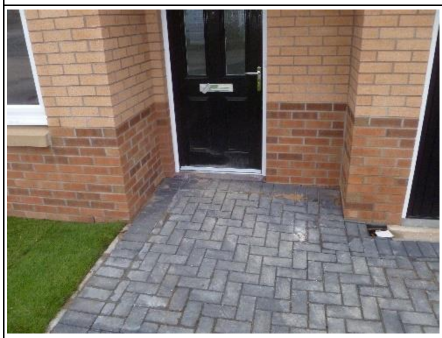
As the trickle vents had been left open it was difficult to see if the warmer sections of boxed eaves were due to thermal anomalies or due to warm air venting out. As such, any potential difference between the thermal performance of the solid timber above the windows and the insulated panels between them could not be observed from outside:

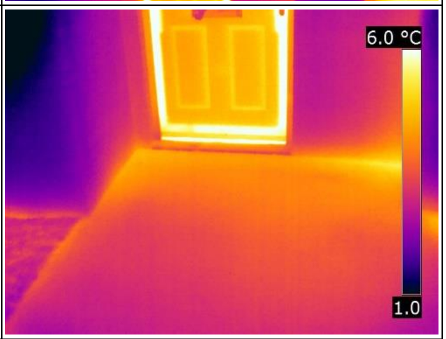




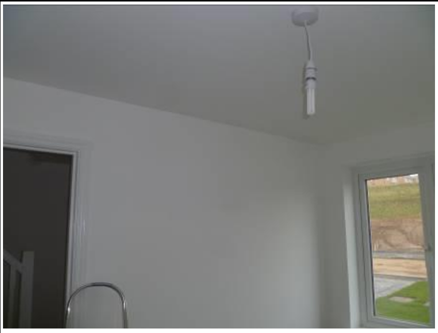
Similarly, the gable windows on the front elevation appeared to show different levels of thermal performance from outside, particularly at the window heads and gable above. However, on internal inspection it appears most probably due to the trickle vents being left open in Bedroom 2 (above the garage) and closed in Bedroom 1 prior to the thermal survey being undertaken.

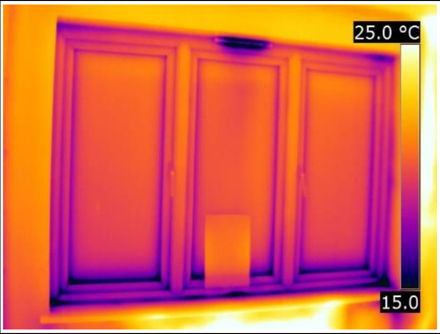


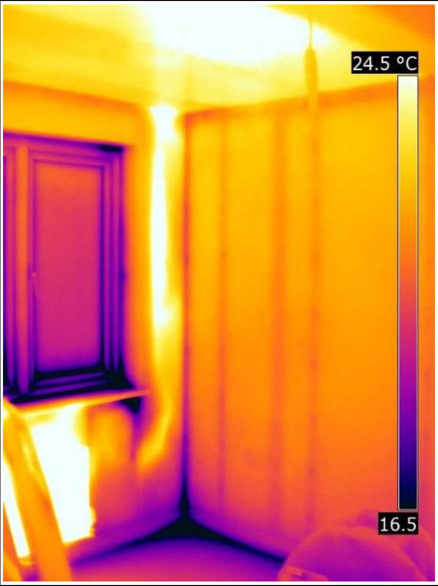


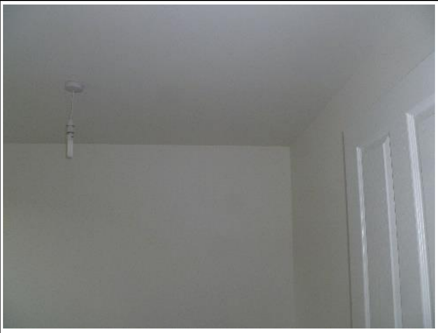


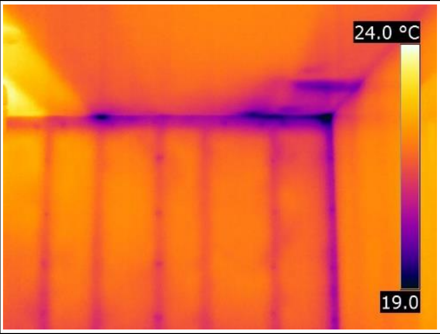
Dining – Under natural conditions









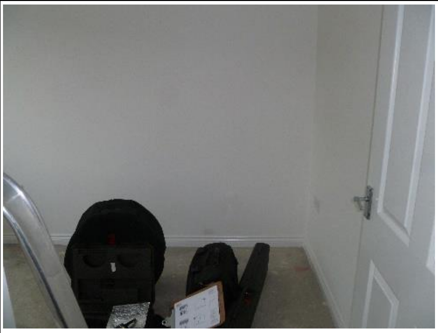
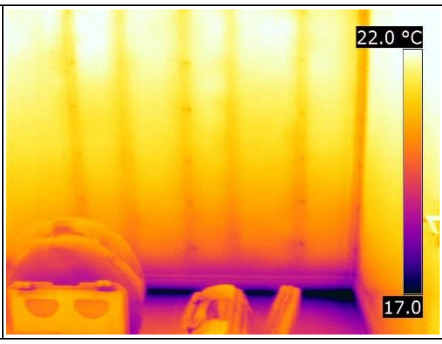


Where the internal wall with the hall becomes external wall there is a sharp drop in surface temperature, particularly at patches just above the base of the wall panel.

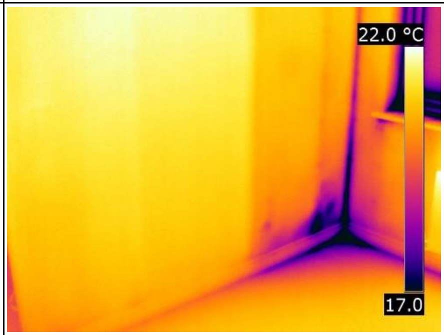
Even under natural pressures some infiltration could be observed around the window, particularly beneath the sill board edges.

The cooler vertical members of the timber frame were clear on the thermal images, with warmer insulated sections between. Cooler horizontal timers at the ground floor and intermediate floor coincided with warmer areas viewed from outside.

Stratification of the voids between the joists in the intermediate floor appeared to be driven by the positioning of the heating system pipework.

<table>
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Dining – Under depressurisation</td></tr>
<tr><td></td><td>
</td><td rowspan="3">The differences in surface temperature of the hall/external sections of the same wall appeared to increase under depressurisation, with a number of points at the top and bottom of the external wall section indicating air movement into the wall panels.

Although the window seals appeared to work well, infiltration between the window frame and opening was apparent, particularly around the sill board.

The stratification of the intermediate floor void and cooler sections at the floor junctions did not seem to change much under depressurisation for their appearances under natural pressures, suggesting these were due to thermal issues rather than air movement.</td></tr>
<tr><td></td><td>
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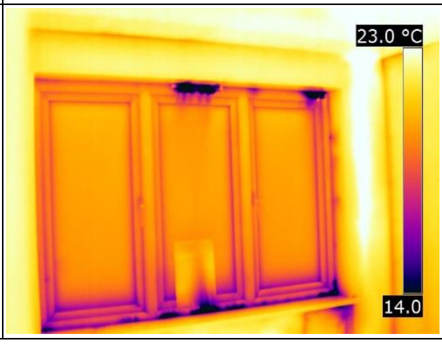
<tr><td></td><td>
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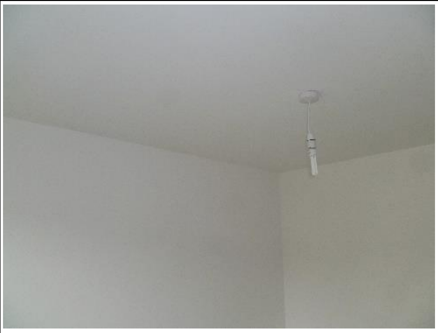
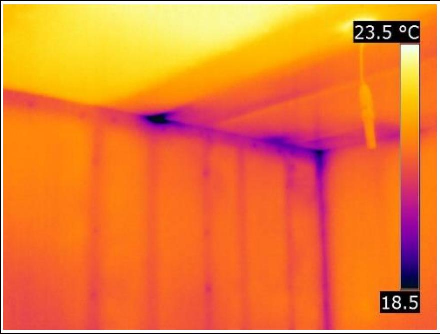
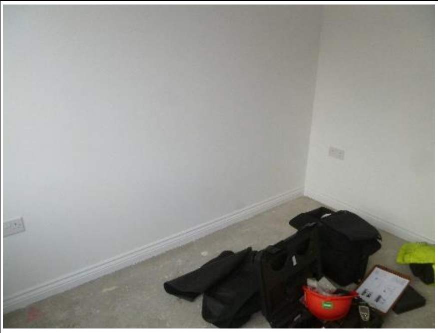
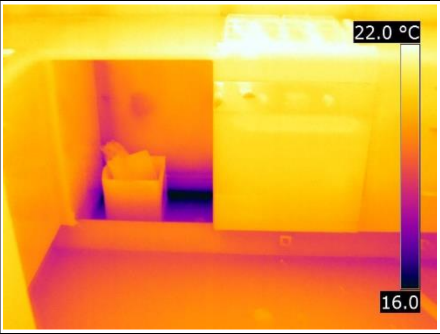
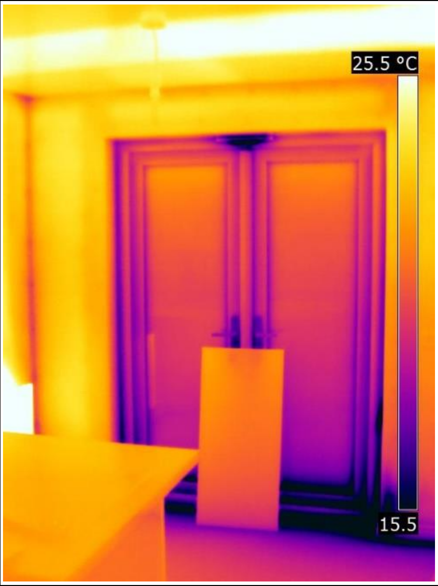
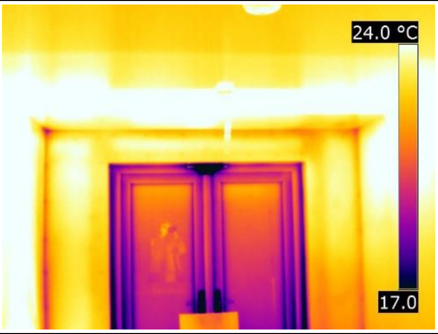
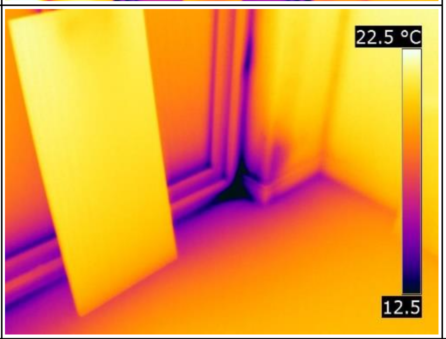
		
		
Family / Kitchen – Under natural conditions		
		As in the Dining Room, cooler areas where noticeable at both the ground floor and intermediate floor junctions. This was most severe at the patio door threshold and the infilled section of floor between the slab and patio door frame.

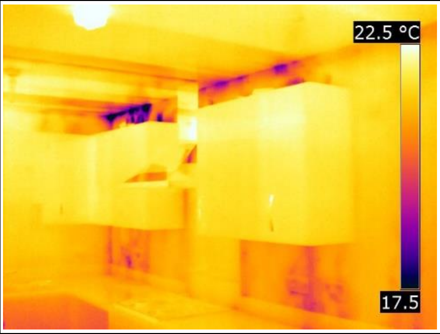


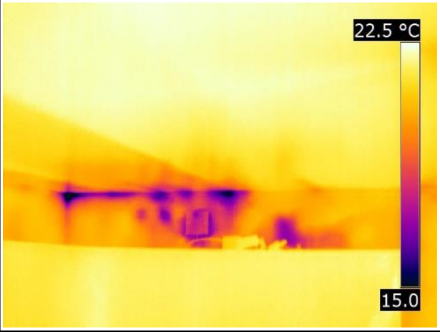


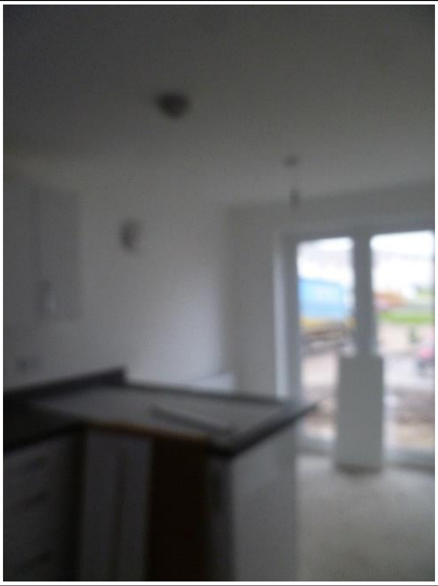


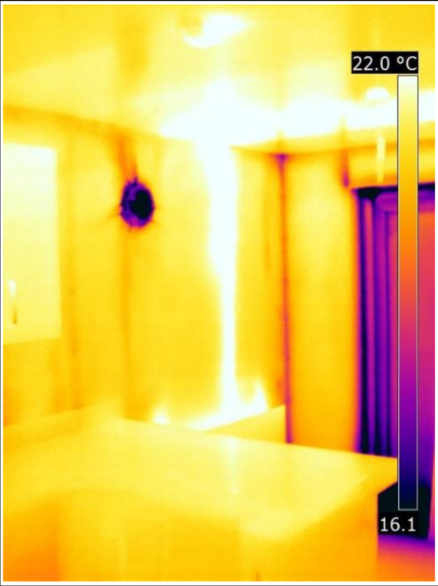


Family / Kitchen – Under depressurisation



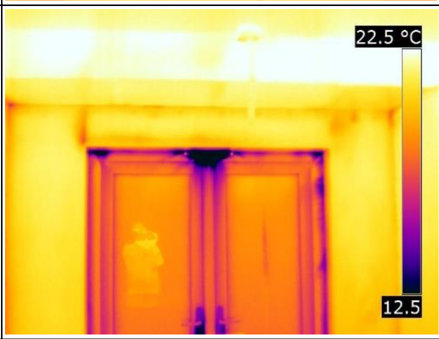


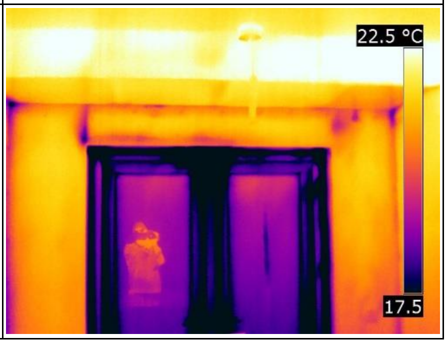


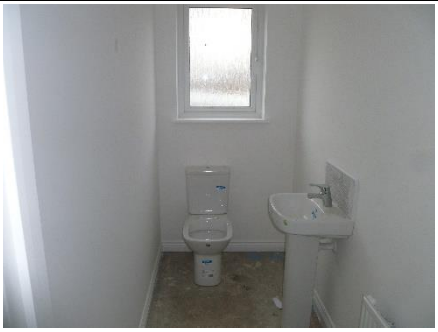
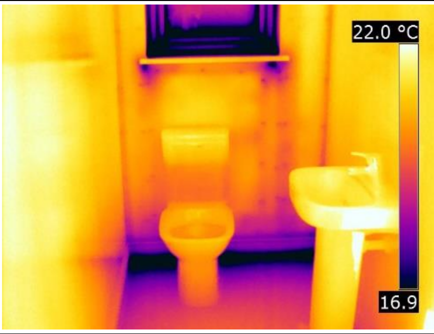
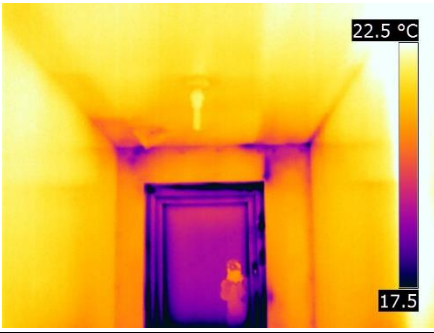


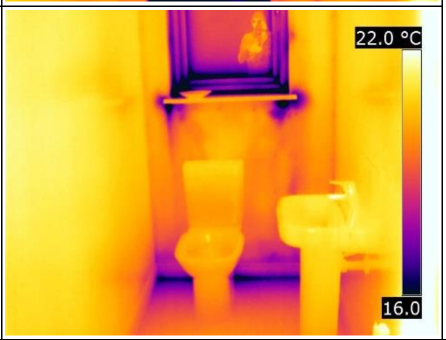
Under depressurisation air infiltration was detected emerging around a number of service penetrations; above the kitchen units this air appeared to be drawn from the intermediate floor perimeter as this was where it looked coolest, below the kitchen units the emerging air appeared to be spreading up from the ground floor.

Infiltration around the patio doors was also observed; directly into the room around the doors and frame, and indirectly into the walls around the solid timber lintel and at the base of the jambs.





<table>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Ground Floor WC – Under natural conditions</td></tr>
<tr><td></td><td></td><td rowspan="2">Some cooler patches were evident at the sill board, as seen in the dining room.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="3">Ground Floor WC – Under depressurisation</td></tr>
<tr><td></td><td></td><td rowspan="2">Infiltration detected around the window as previously observed; around the window frame, at the sill board and window head.

Slightly lower temperatures of the intermediate floor void appear to be spreading inwards from the external wall junction.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="3">Lounge – Under natural conditions</td></tr>
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<tr>
<td></td>
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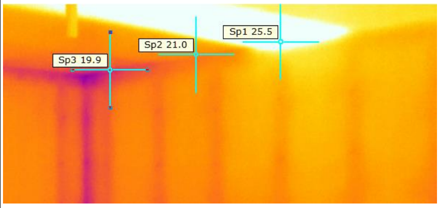
<td rowspan="3">The cold spot on the rear wall near the ceiling coincides with the position of the external light.

The gable wall and wall to the garage show similar internal surface temperatures at the bottom and middle of the panels.

The compartmentation temperatures across the intermediate floor void is amplified by heating pipes running through the void from the adjacent garage with a large temperature gradient observed over the short distance to the gable wall:

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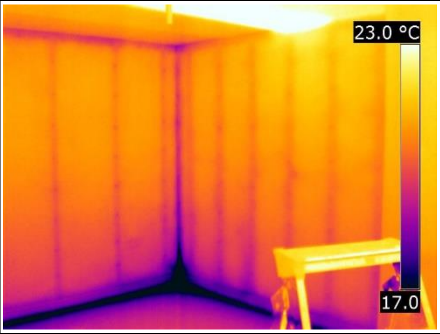
<td>
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<tr>
<td colspan="3">Lounge – Under depressurisation</td>
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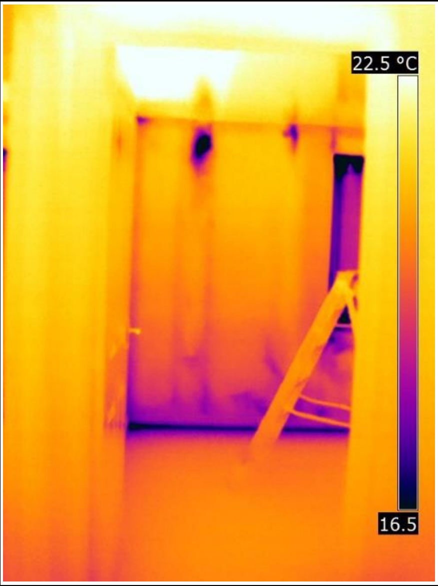
<td>
</td>
<td>Air infiltration at the external light is significantly worse.

Increased air infiltration is also seen again around the window; around the frame, beneath the sill and indirectly around the lintel.

Increased heat loss was detected at the floor plate on the rear wall, gable wall and the wall to the garage, due to infiltration.</td>
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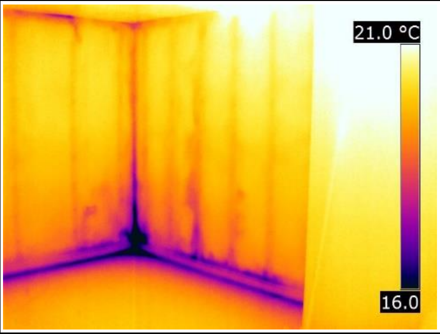
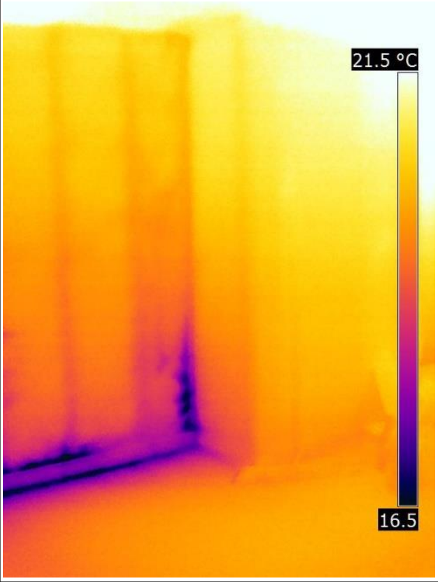
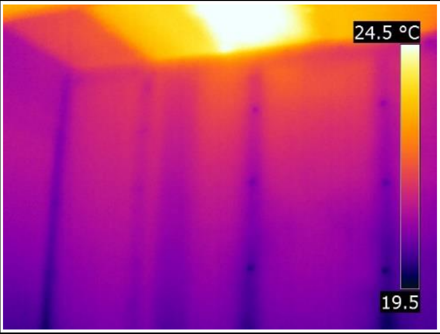
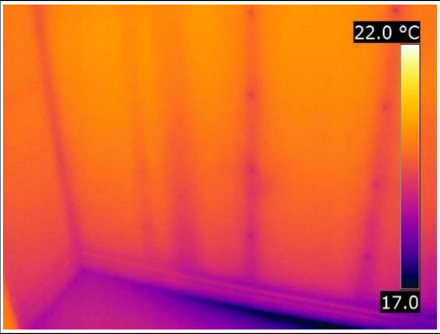
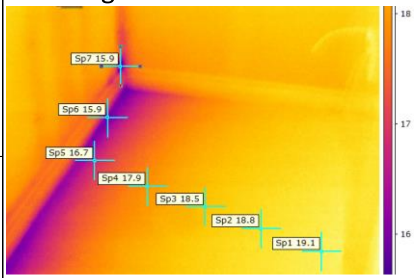
		
		
Hall – Under natural conditions		
		As in the Lounge, there is a cold spot on the external wall which corresponds to the position of the exterior light.

		
		Cupboard under the stairs backing onto the garage shows similar pattern to that observed from the Lounge.
		
Hall – Under depressurisation		
		As in the Lounge, the exterior light fitting/penetration appears to be a greater issue under depressurisation. Again, there is increased air movement around the floor plate, but this appears to move into the wall panels and not around the skirting into the room itself. At the intermediate floor above the garage cooler air is also observed. In the cupboard under the stairs that backs onto the garage the only

noticeable change appears to be at the floor junction, with a cooler spot in the corner and a thermal gradient going across the cupboard floor of greater than 3°



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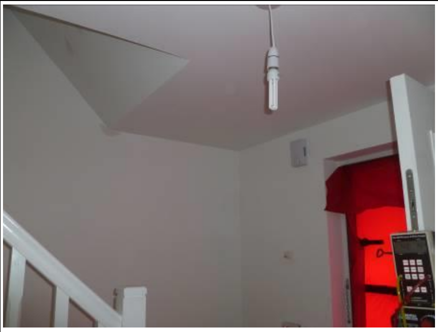
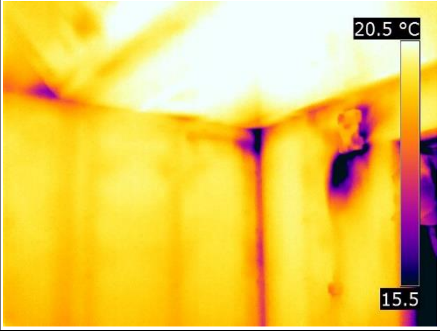
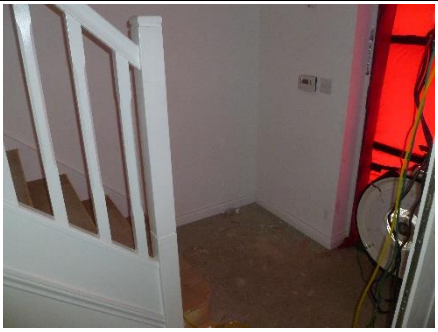
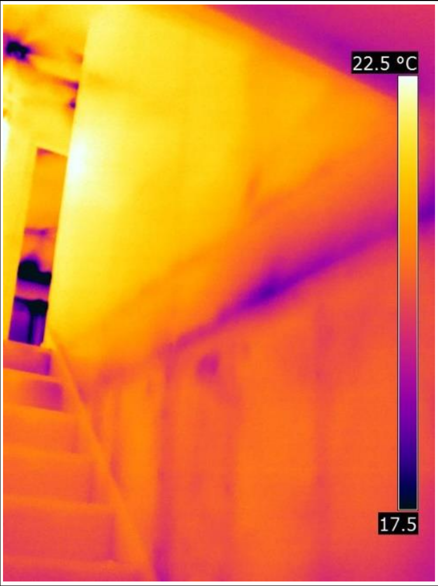
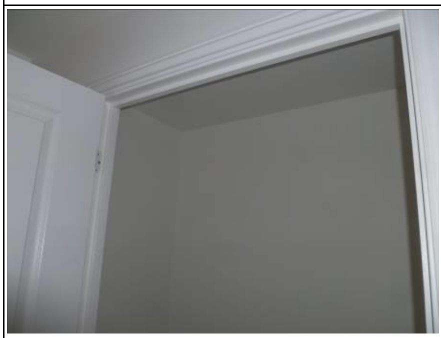
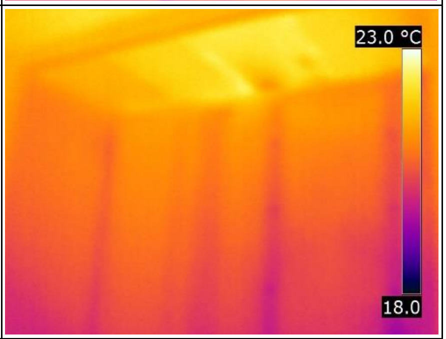


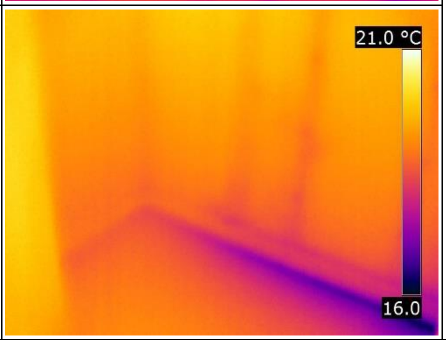


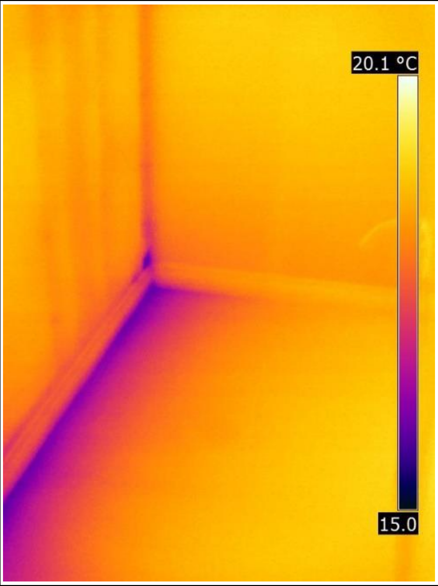
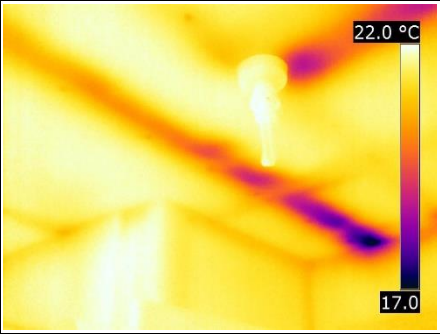


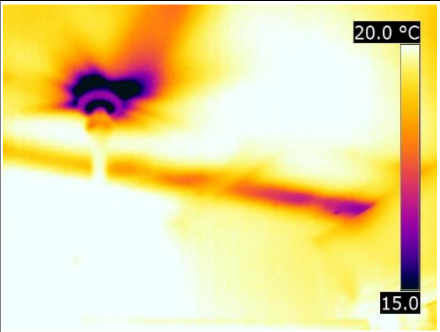
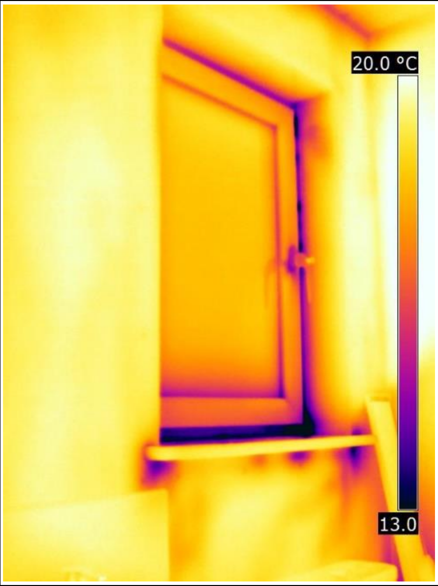
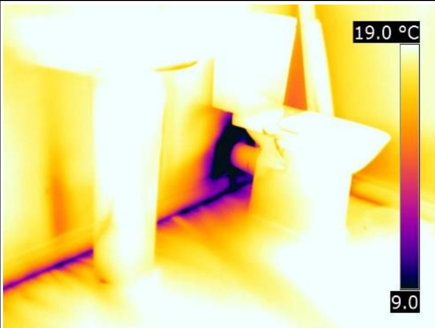
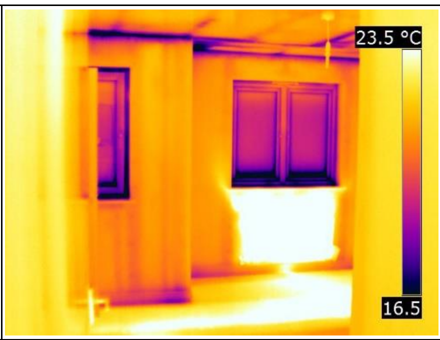








		
En-Suite – Under natural conditions		
		Colder areas are visible around the wall penetration to the external soil pipe from the toilet and on the ceiling where the loft insulation might not be in direct contact with the ceiling plasterboard.
		
En-Suite – Under depressurisation		
		Under depressurisation the usual issues are apparent around the window as seen elsewhere throughout the house. Air infiltration around the soil pipe penetration appears significantly worse, as does the air flow from the loft being drawn in around the central light fixing. Air is also detected entering at the intermediate floor junction with the external wall, it is unclear whether this is entering around the soil pipe penetration and tracking across

		behind the skirting and there is a only a very slight increase in emerging air temperature moving away from the penetration.
		
		
Bedroom 1 – Under natural conditions		
		The ceiling at the eaves junction is very cold in places suggesting that there is a lack of insulation in places, with additional roof timbers present to support the gable roof this may have presented difficulty in installing the loft insulation adequately. The result is a 6° difference between surface

<table>
<tr>
<td></td>
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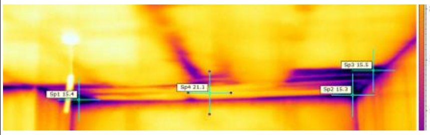
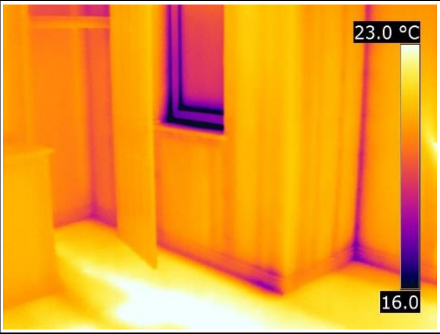
<td rowspan="4">temperatures at the centre and sides of the ceiling directly in front of the window:

With ceiling temperatures actually appearing colder than temperatures at the window frame.

Another issue with the loft insulation was seen with colder strips observed in a number of places</td>
</tr>
<tr>
<td></td>
<td>
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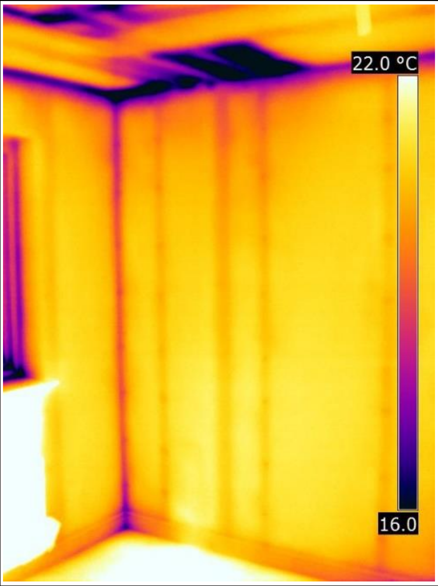
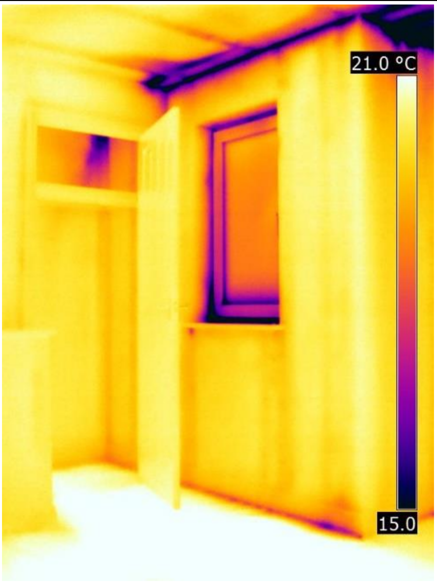
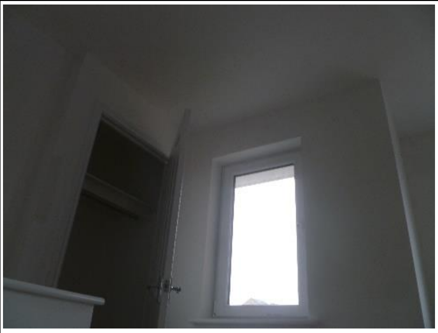
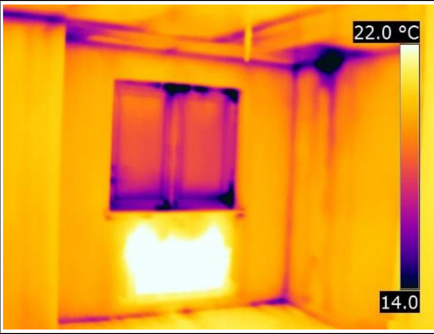
<td>
</td>
</tr>
<tr>
<td colspan="3">Bedroom 1 – Under depressurisation</td>
</tr>
</table>

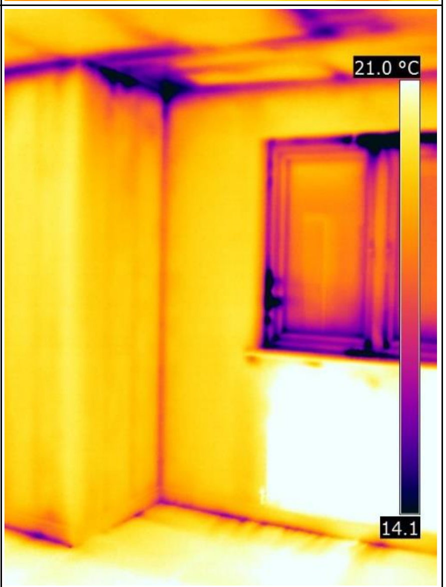
Under depressurisation cold air could be observed spreading out from the previously identified colder areas and being drawn down the external wall panels.

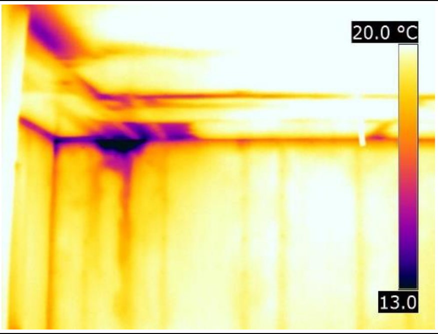
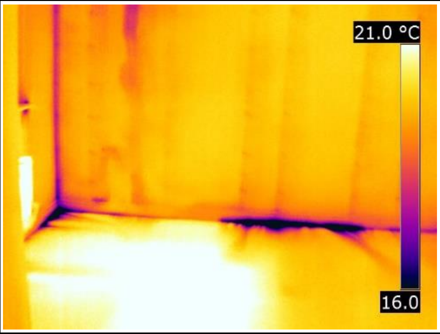
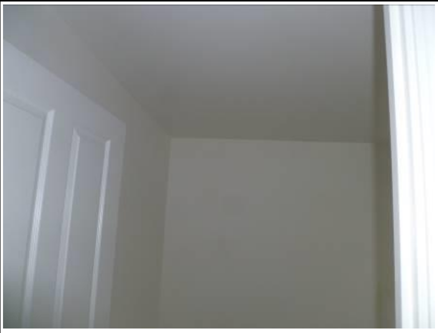
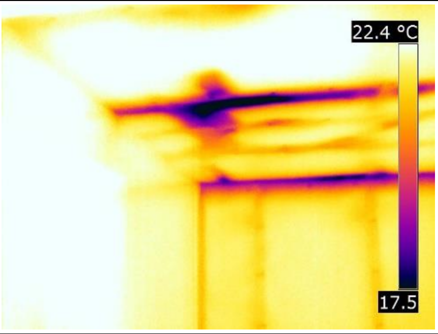
Air infiltration was detected again around the window and at the intermediate floor junctions with the external walls



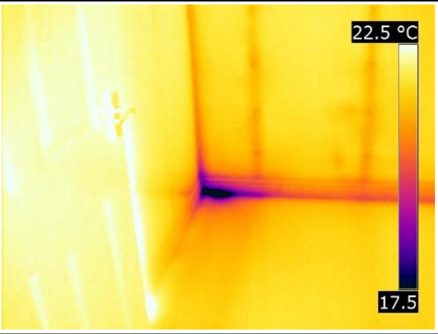






<table>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Bedroom 4 – Under natural conditions</td></tr>
<tr><td></td><td></td><td rowspan="2">As observed in Bedroom 1, with cold sections of ceiling, at the floor and external wall junctions and issues at the eaves. The loft insulation at the eaves again appears not to form a complete and continuous thermal layer with sections of the ceiling appearing cooler than the window again.

An area of floor that backed onto the En-suite near the toilet also appeared markedly cooler.

It is possible to see some difference between the top of the external wall at the eaves over the window and to the side of the window (as</td></tr>
<tr><td></td><td></td></tr>
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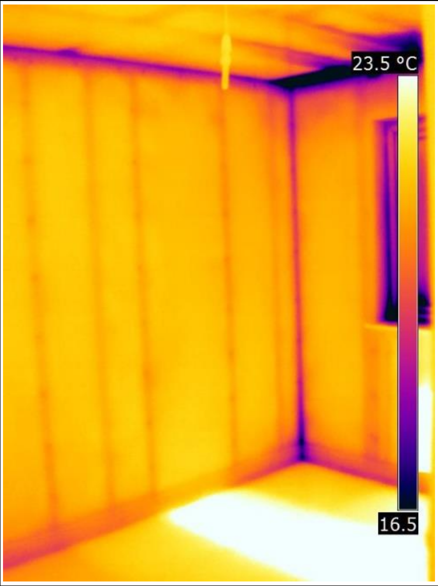
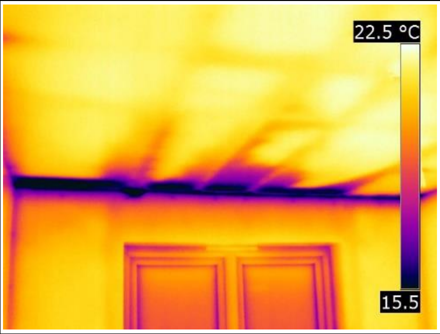
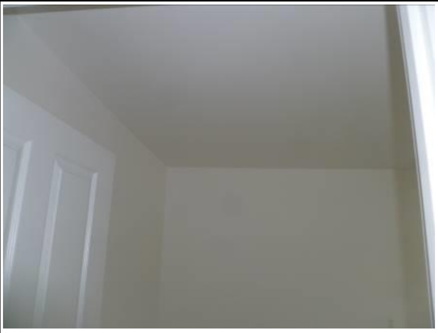
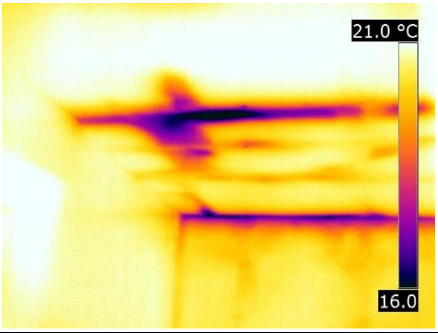
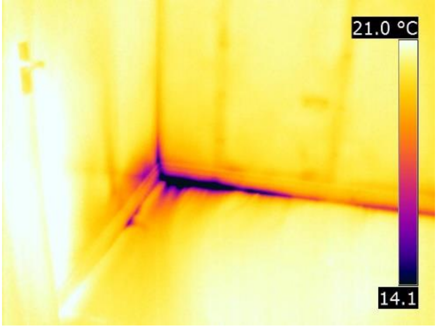
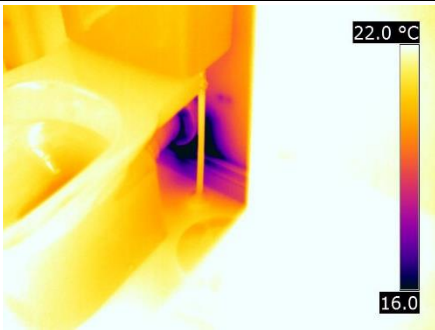
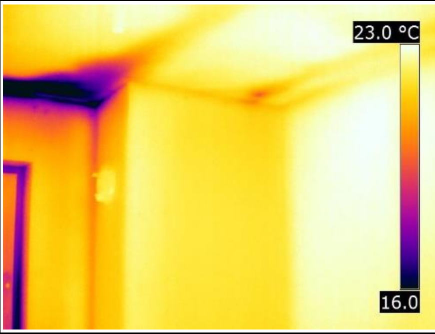
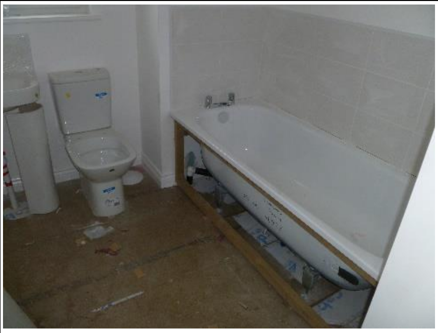
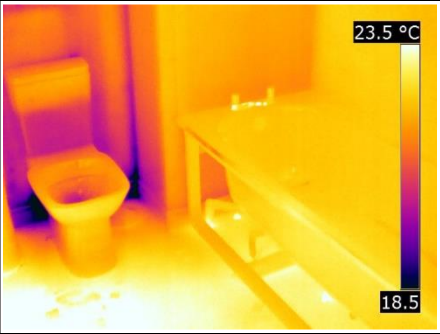
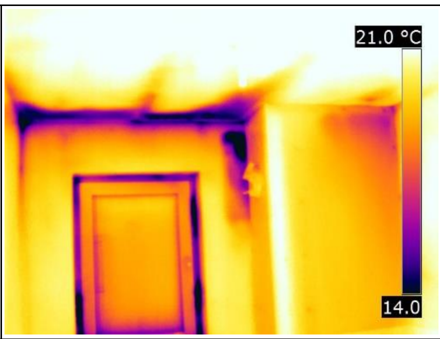
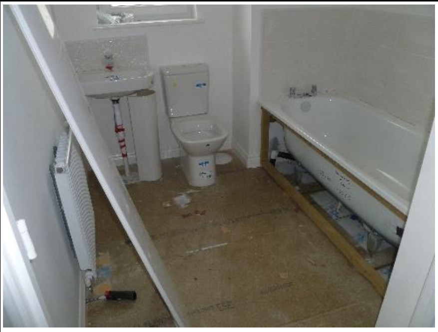
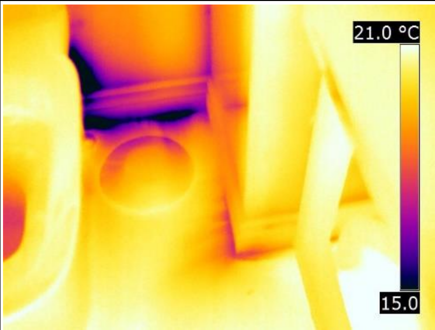
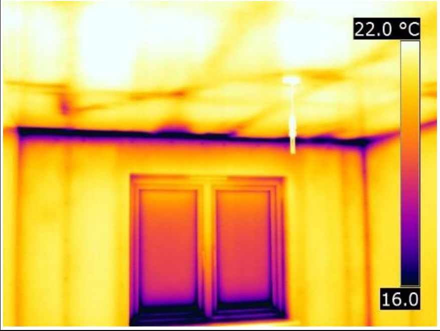
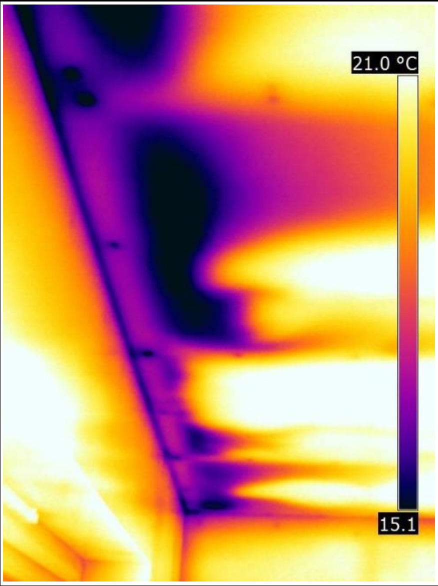
		noted on page 4) but this is only slight.
		
		
Bedroom 4 – Under depressurisation		
		Most of the observations made under natural conditions were exacerbated under depressurisation. Air infiltration was again detected around the window and intermediate floor perimeter.

<table>
<tr><td></td><td>
</td><td rowspan="3">The cooler areas in the middle of the ceiling identified previously appeared to spread under depressurisation.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="3">Bathroom – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td rowspan="2">Once again there are questions about cold areas at the eaves junction and at the penetration for the external soil pipe.</td></tr>
<tr><td></td><td>
</td></tr>
</table>

		
		
		
Bathroom – Under depressurisation		
		As previously observed but worsened. Cooler air could also be observed being drawn down the boxed-in service void, emerging at the intermediate floor.
		

		
Bedroom 3 – Under natural conditions		
		As Bedroom 4, but loft insulation issues at the eaves appear even more severe.
		
		

<table>
<tr>
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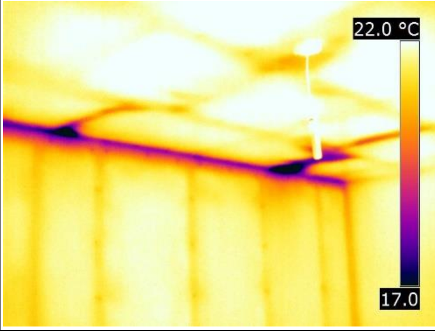
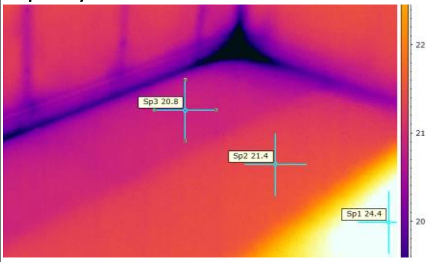
<td></td>
<td rowspan="3">The temperature compartmentation of the intermediate floor void observed from below in the Lounge was equally visible from above:
</td>
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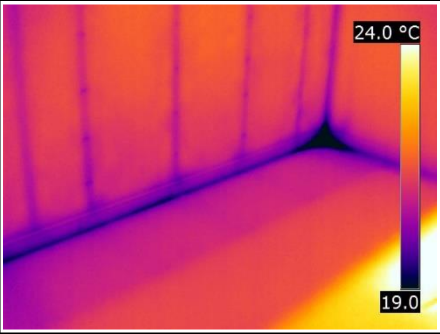
<td></td>
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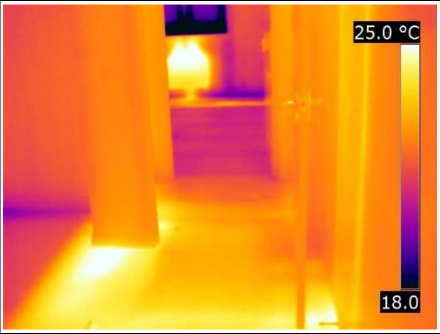
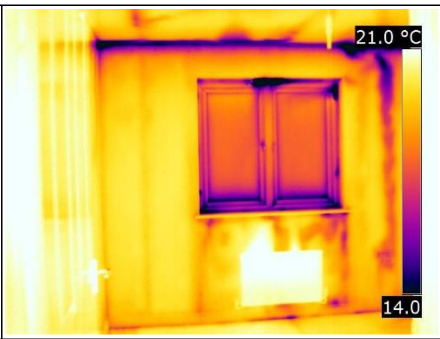
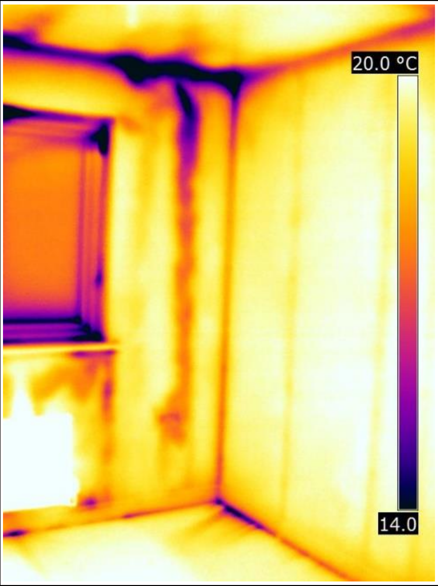
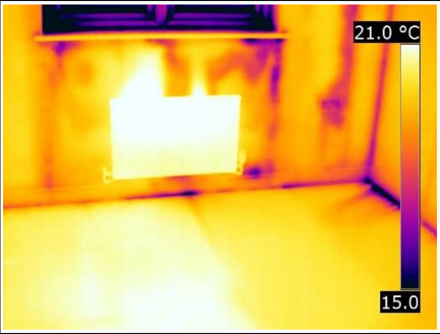
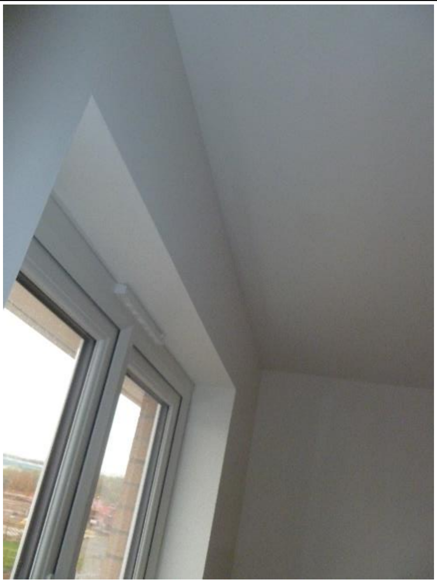
<td></td>
<td></td>
</tr>
<tr>
<td colspan="3">Bedroom 3 – Under depressurisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cold air could be seen coming down from the loft and emerging at the electrical socket on the rear wall.

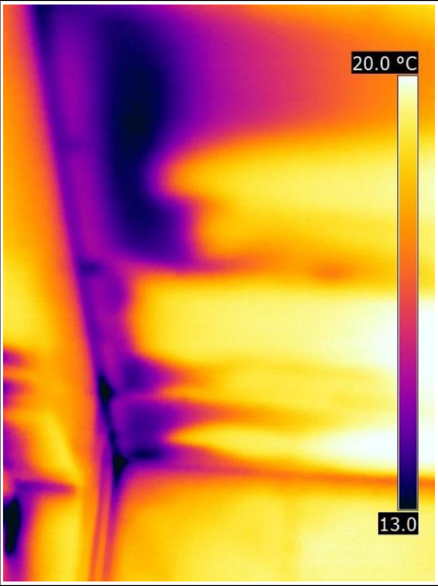
Once again there was infiltration all around the window, and air from the window sill could be seen moving through the wall panel beneath.</td>
</tr>
</table>

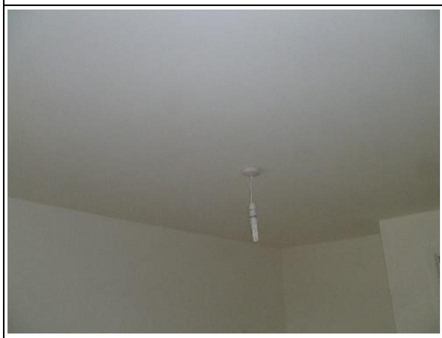


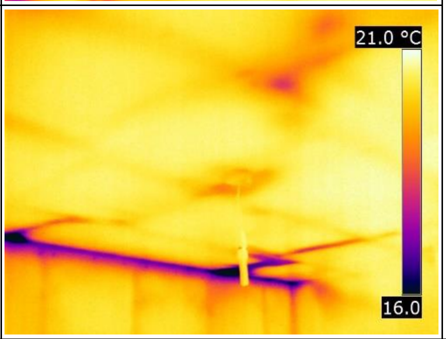
Some air leakage was also detected at the intermediate floor junctions with the external walls and at the internal wall backing on to the built-in wardrobe in Bedroom 2 above the garage.

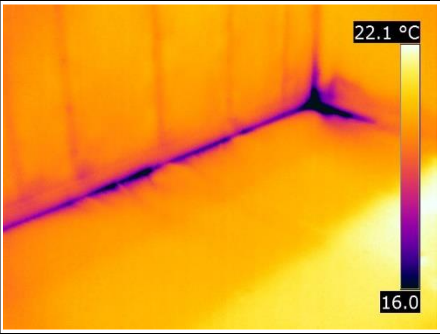
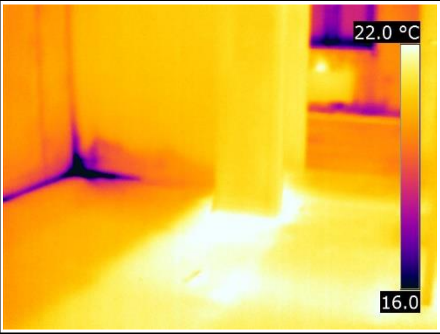
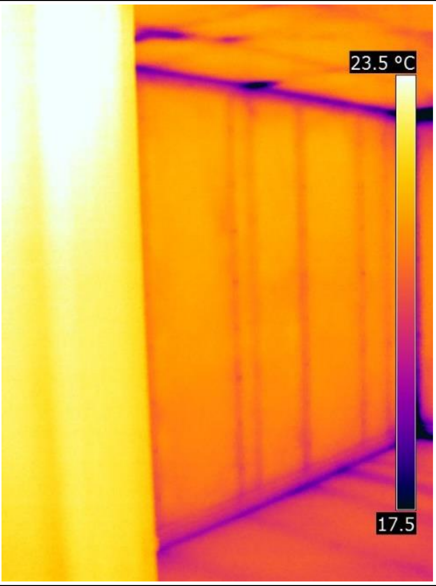
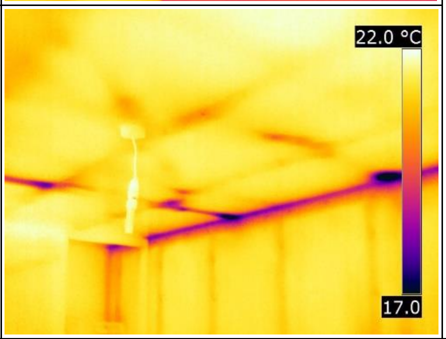


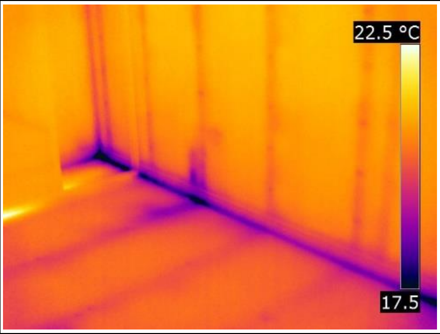
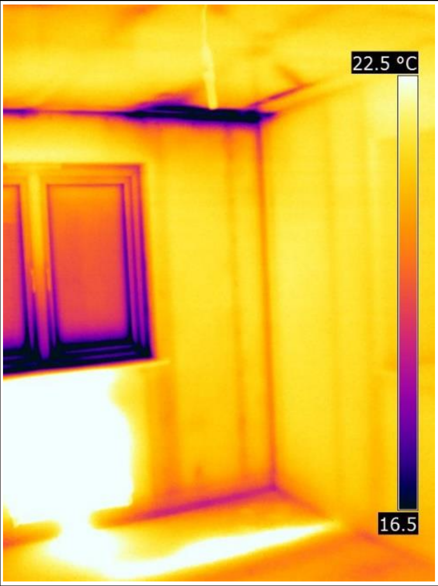
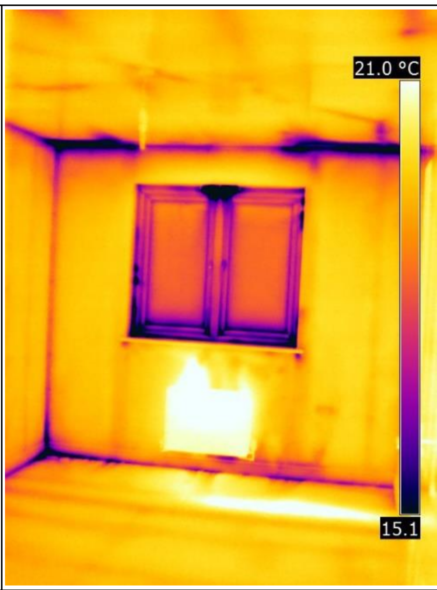


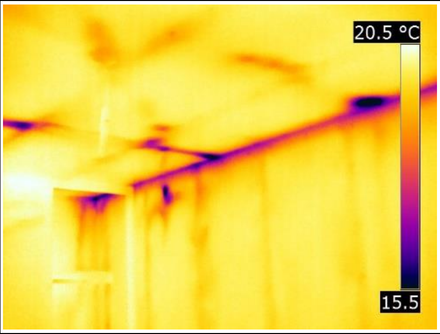


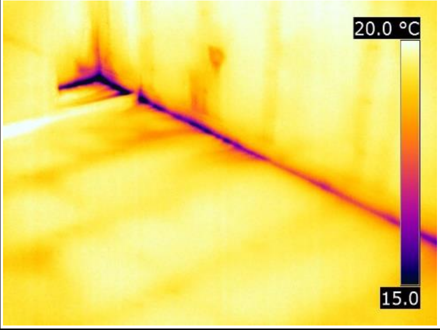


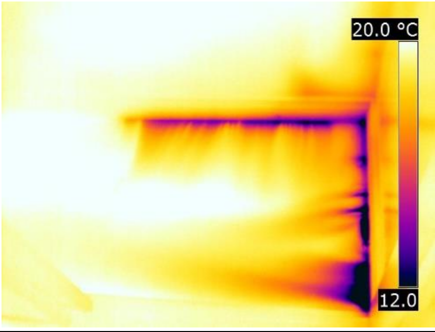


		
		
Bedroom 2 – Under natural conditions		
		As observed in Bedroom 1; again there are issues at either side of the ceiling above the window and issues at the intermediate floor junction with the gable wall appear slightly worse.
		

		
		
		
Bedroom 2 – Under depressurisation		
		Repeating what was seen in the other bedrooms; however, with increased infiltrations observed around the intermediate floor perimeter, particularly at the built-in wardrobe.

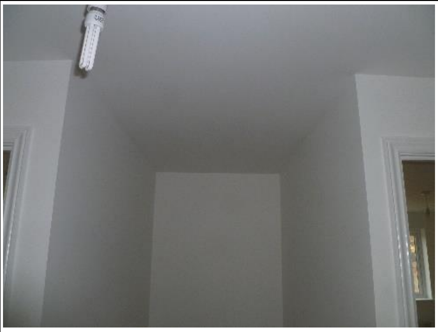


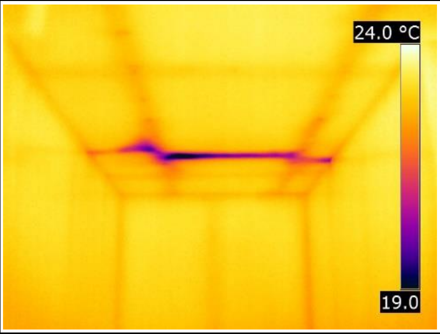


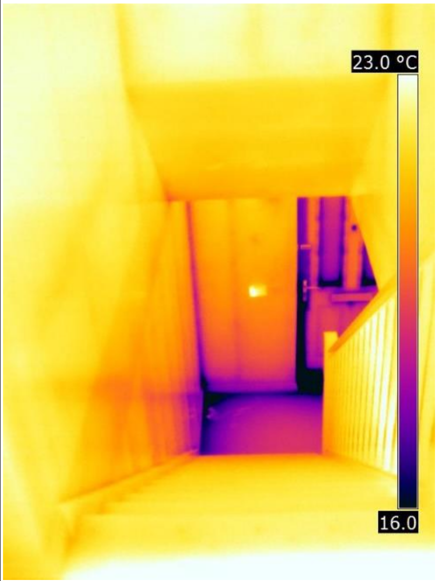


Landing – Under natural conditions

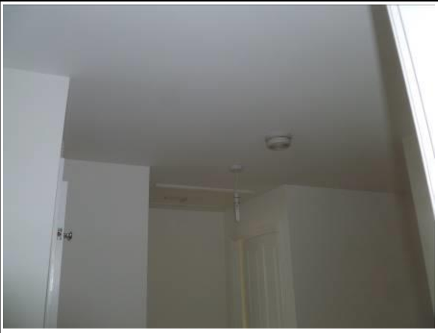
Some colder areas are visible where the loft insulation appears to not be in direct contact with the ceiling plasterboard.

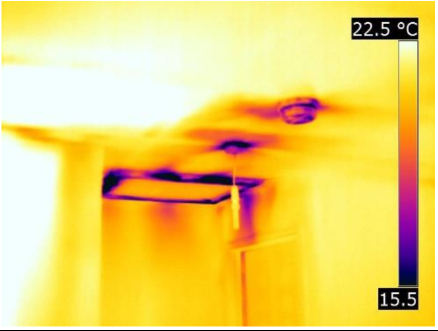




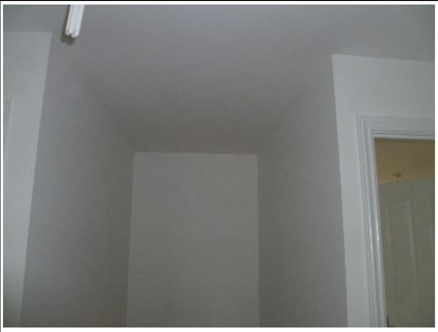


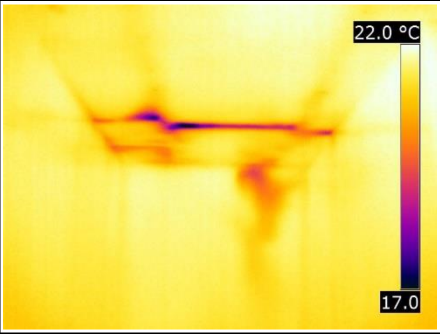
Landing – Under depressurisation

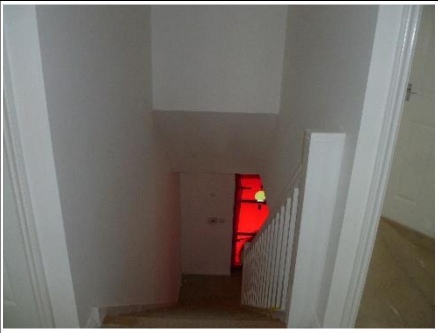


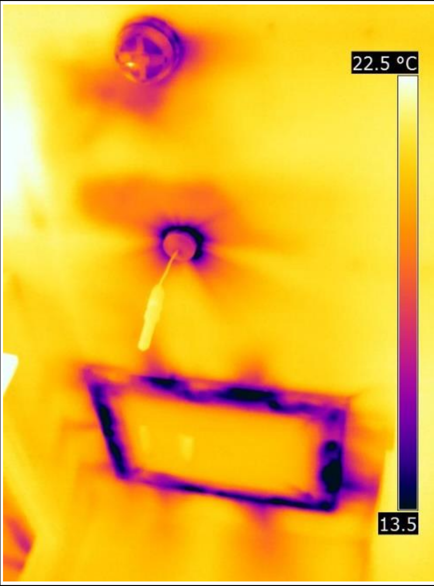


Significant infiltration was observed drawn down from the loft under depressurisation which was not visible under natural conditions as this was then an exfiltration zone. Air can be seen entering the landing around the ceiling penetrations and being drawn into some of the internal partition walls.

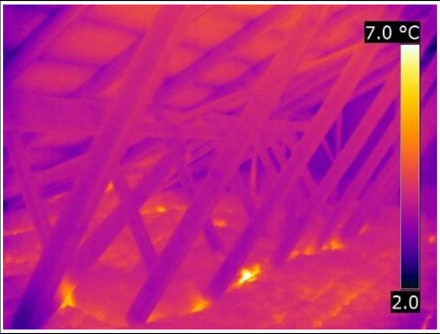
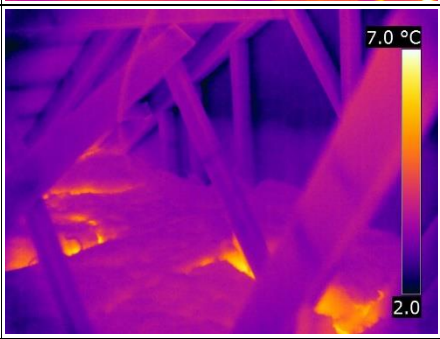


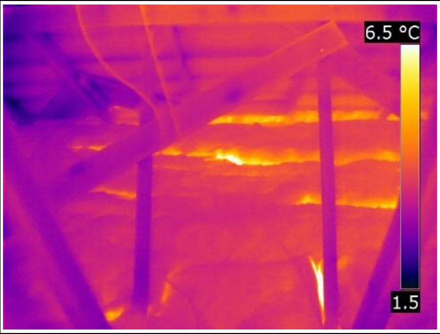






Loft – Under natural conditions

		Looking towards the gable wall above garage hot spots can be seen around the angled junctions of the trussed rafters and between gaps in the uppermost layer of loft insulation between the rolls.
		
		
		Looking towards the opposing gable wall similar observations are made.
		



Plot 267

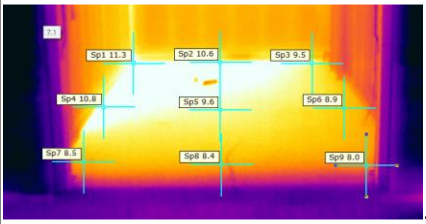
Thermal images under depressurisation were captured at an average pressure of -51.7 Pa.

Unfortunately, I was not informed that this property had not yet had loft insulation installed. The heating was turned off by site staff shortly after 10:30 am, by the time I conducted the survey just over 2 hours later the house had cooled considerably, particularly upstairs where there was no thermal mass to retain the heat.

No trickle vents had been fitted in the windows, these were sealed using airtightness sealing film on entering the dwelling immediately after completing the external thermographic survey.

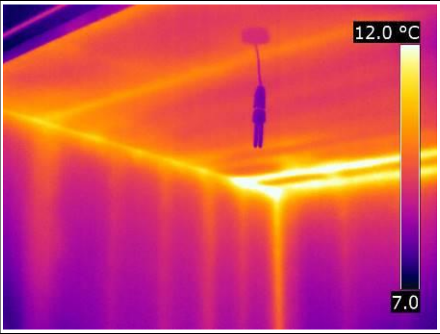
External - Under natural conditions

The garage was open in this property so it was possible to also look inside and see the extent to which the boiler and heat transfer from inside the property were heating the garage. Again the garage appeared warmer than the rest of the house from the external imaging of the gable wall. The thermal gradient across the garage floor is only 3° but looks more sever due to the colder temperatures around it:



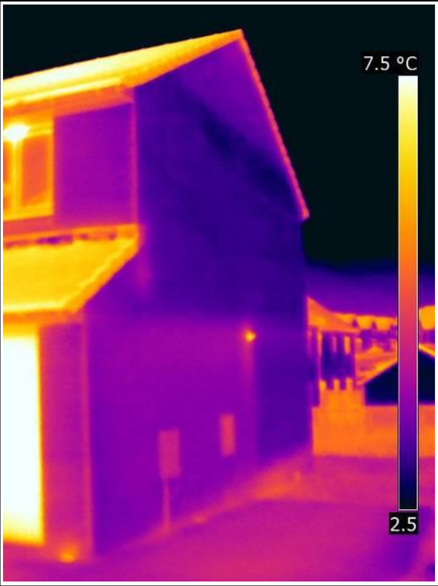
.

The heating and hot water pipes from the boiler can be seen providing additional heat to the garage.



The gable wall at the loft appears warmer due to there being no insulation in the loft with a cold strip directly underneath where the rigid board insulation extended up above the wallplate.

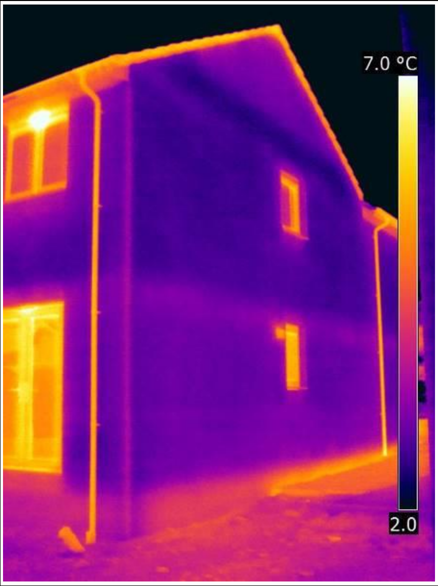
As in plot 268, warmer strips could be seen at the intermediate floor level and at the ground floor perimeter on all sides of the house.



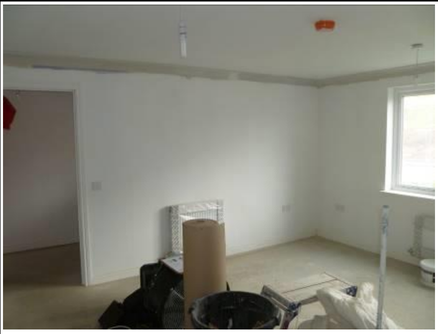
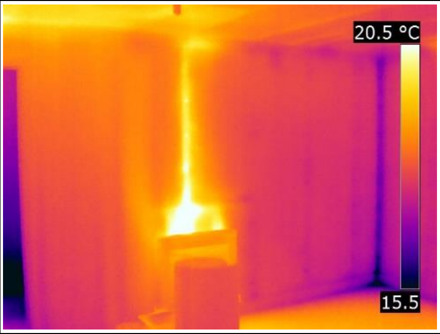

7.0 °C
2.0

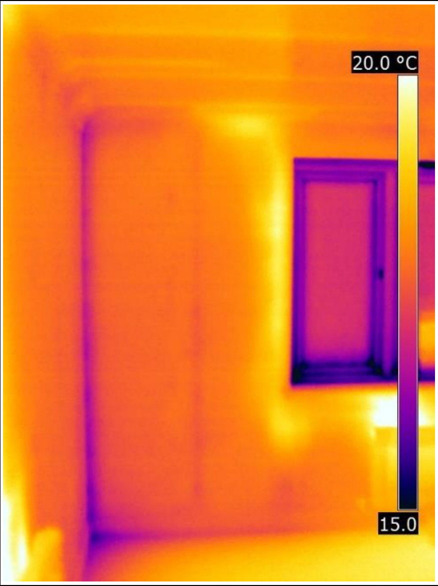
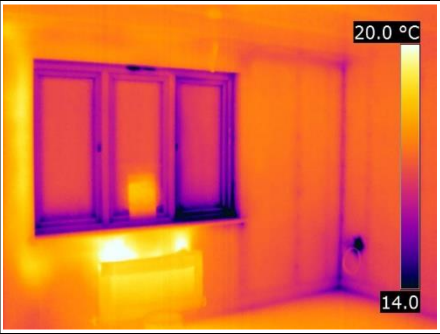

7.0 °C
2.0

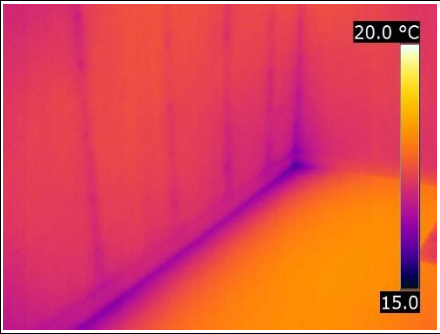
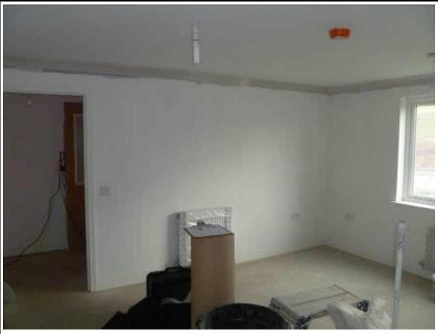
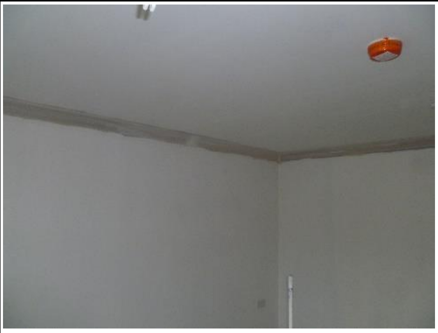
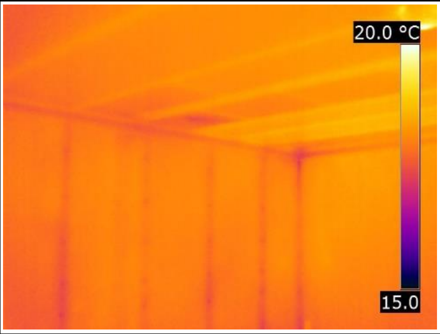
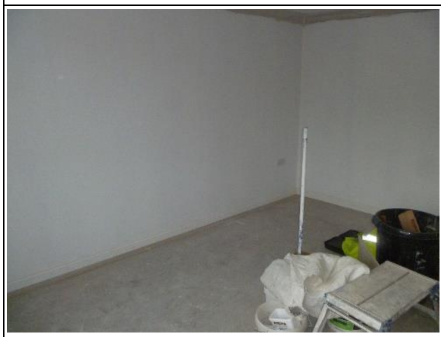
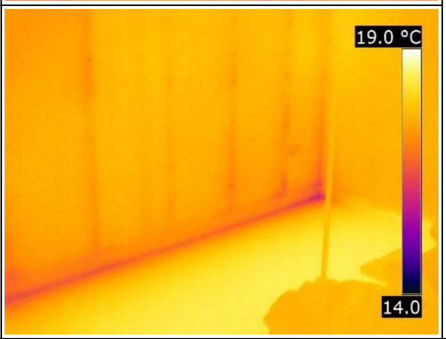

7.0 °C
2.0

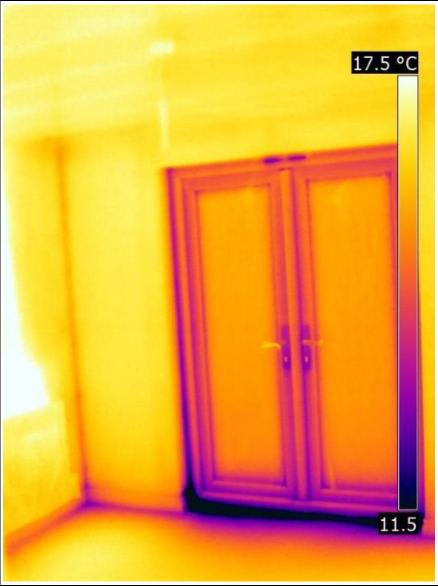
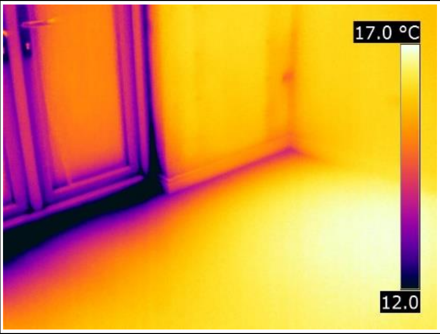
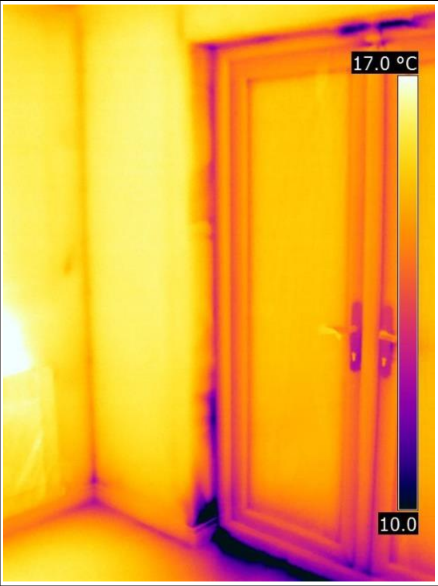

7.0 °C
2.0

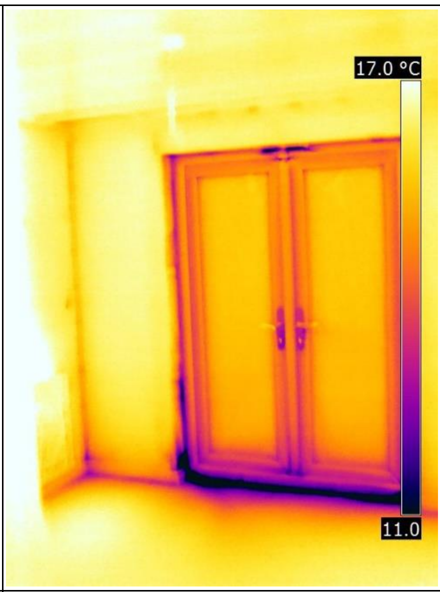

7.0 °C
2.0

<table>
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Lounge – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td rowspan="3">With lower internal temperatures, and hence a lower internal/external temperature differential, similar issues were observed as in plot 268 but do not show up on the thermal images quite as strikingly.

The timber frames were again clearly visible, and some infiltration observed around the window and at the open pattress box on the external wall.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td></td><td>
</td></tr>
</table>

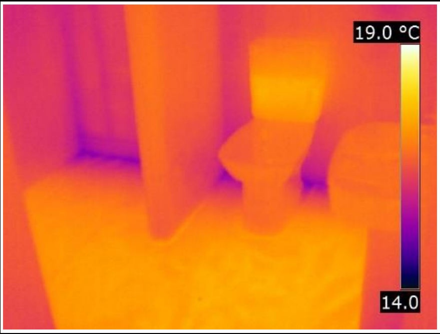
		
Lounge – Under depressurisation		
		Under depressurisation the previously observed infiltration paths understandably worsened, as in plot 268 there were noticeable air paths around the sill board.
		
		
		
Dining – Under natural conditions		

<table>
<tr>
<td></td>
<td>
</td>
<td rowspan="2">The patio doors appeared much like those in the Family/Breakfast Room in plot 268, with a very cold section at the infilled section at the threshold.</td>
</tr>
<tr>
<td></td>
<td>
</td>
</tr>
<tr>
<td colspan="3">Dining – Under depressurisation</td>
</tr>
<tr>
<td></td>
<td>
</td>
<td>The patio doors themselves appeared to prevent air movement through them very well, with just a small amount coming through at the top and bottom of the doors; however there was more significant air movement around the frame and up into the walls on either side of the infilled section between the floor slab and door frame.</td>
</tr>
</table>

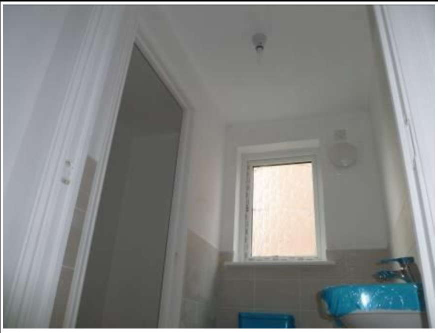


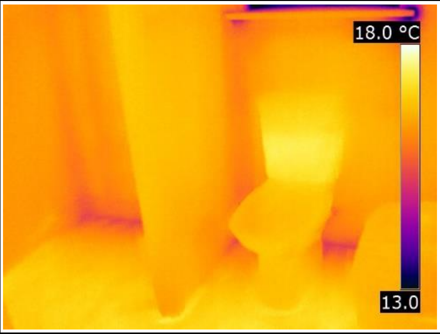
Ground Floor WC – Under natural conditions

No significant issues with the thermal imaging on a 5° span.



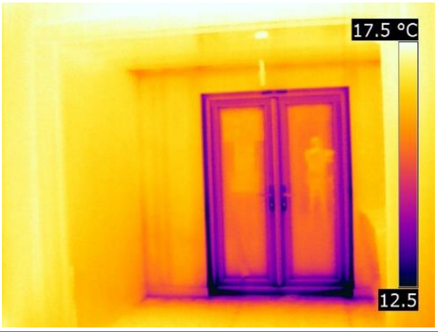
Ground Floor WC – Under depressurisation

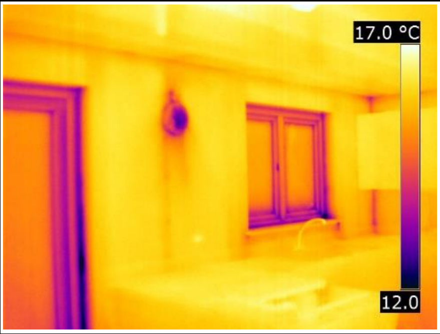


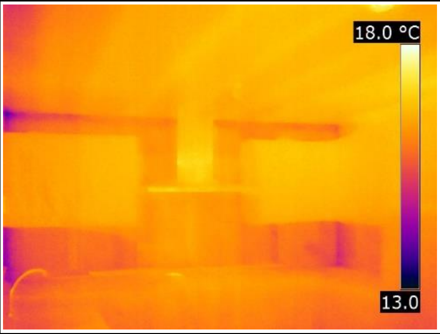


Again, there were no major issues detected on a 5° span, there may be some air infiltration into the wall around the penetration for the extract fan but nothing significant.

Family / Kitchen – Under natural conditions

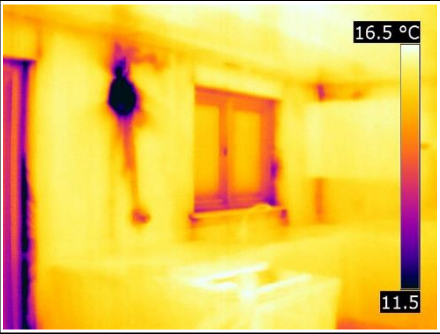
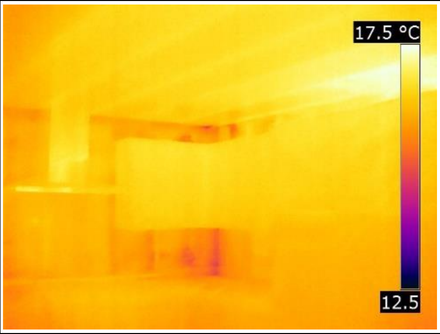
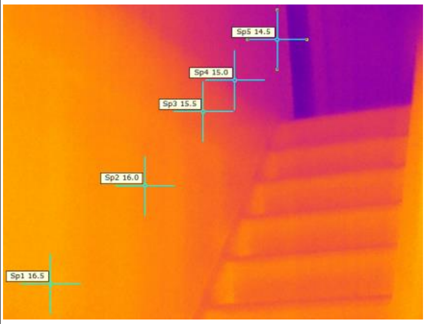


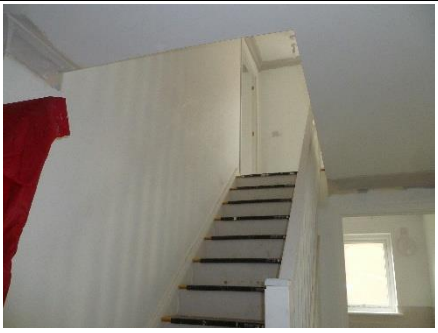


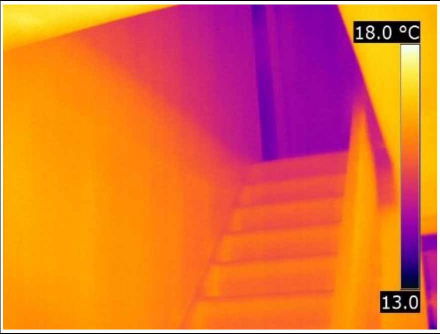


The patio doors appeared to be marginally better than in the Dining Room and there appeared to be some air movement into the wall around the extract fan, nut otherwise there were again no significant issues with the thermal imaging on a 5° span.

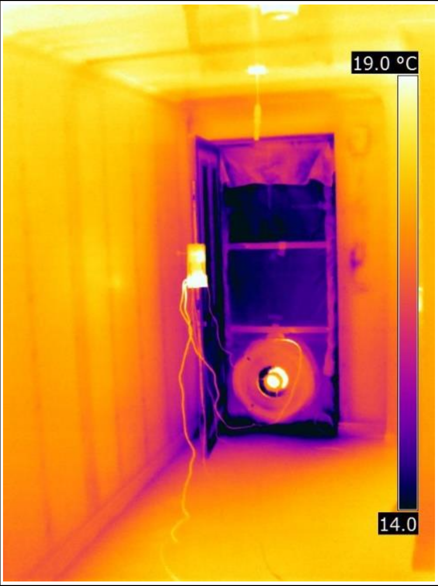
Family / Kitchen – Under depressurisation

	 	Under depressurisation the previously observed infiltration paths worsened and air leakage around and below the windows were now apparent.
	 	
	 	
Hall – Under natural conditions		
	 	The garage wall appeared to have a similar surface temperature to the other internal walls. Without loft insulation the temperature of the wall surface backing onto the Lounge going up the stairs:  .
	 	





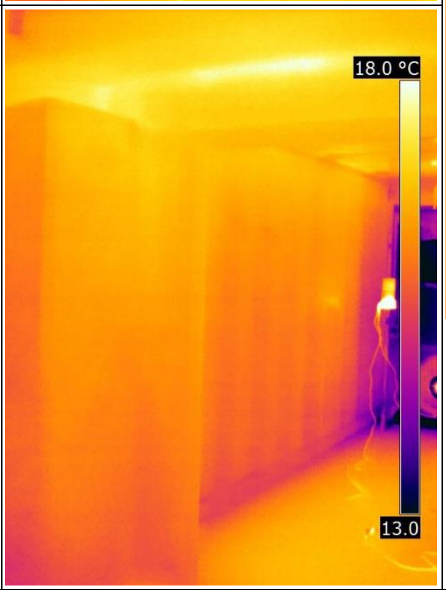
Hall – Under depressurisation



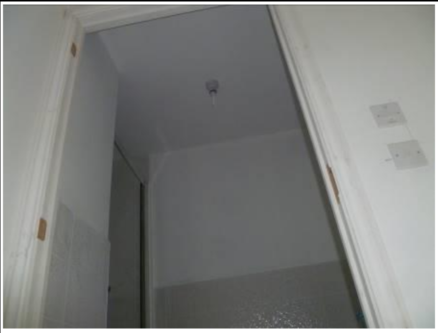
The ground floor and the water in the heating/DHW system appeared to have retained their heat more than the rest of the dwelling, with the floor and the section of intermediate floor containing the pipework remaining the warmest areas in the images opposite.

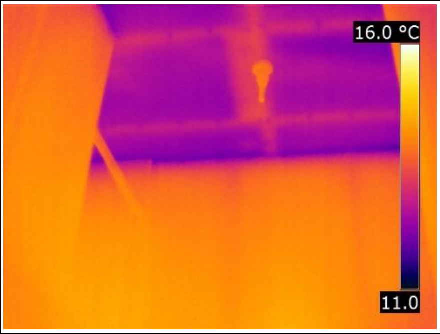
The internal walls did not lose much additional heat over the 40 minutes between the thermal survey under natural conditions and under depressurisation:

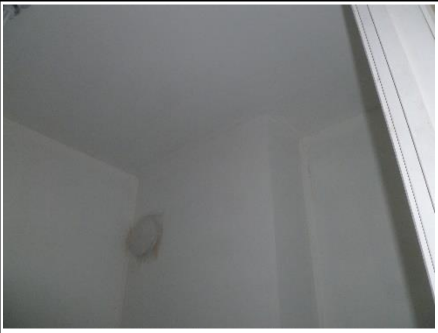
.

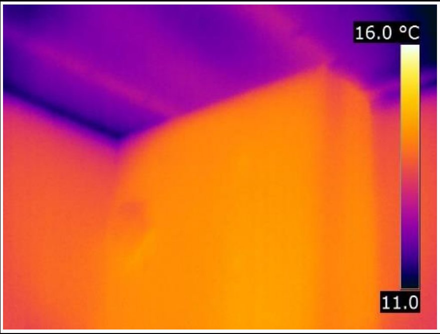


En-Suite – Under natural conditions



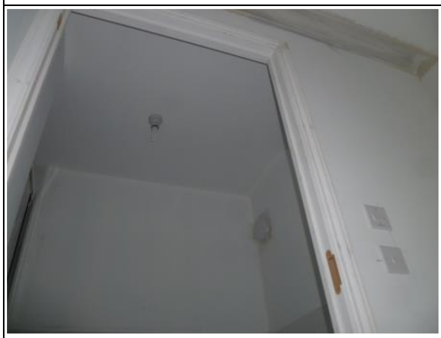


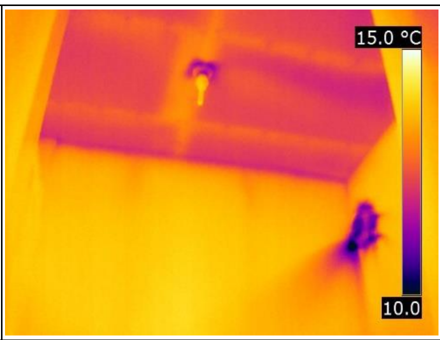




No significant issues with the thermal imaging on a 5° span and the loft un-insulated.
However, the crossed timbers seen through the ceiling plasterboard may explain why some of the cooler patches of ceiling were observed in plot 268; as these would likely allow air gaps between the ceiling plasterboard and insulation, impairing the performance of the insulation

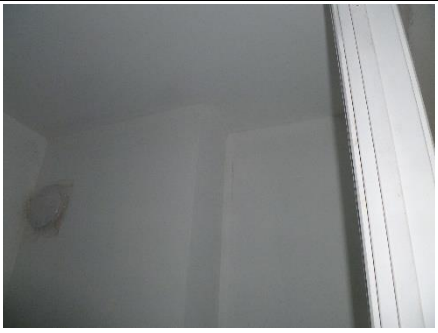
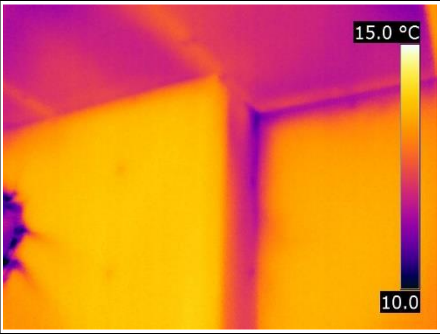
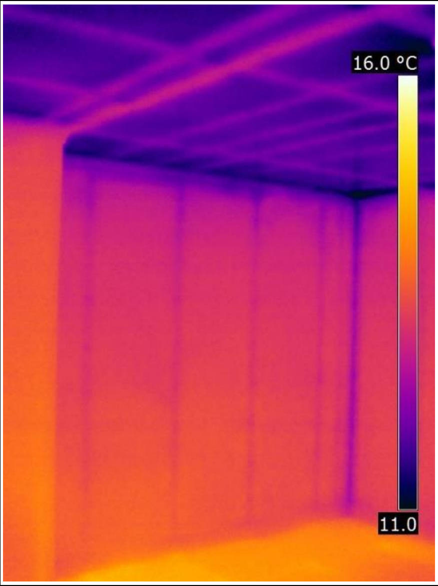
En-Suite – Under depressurisation



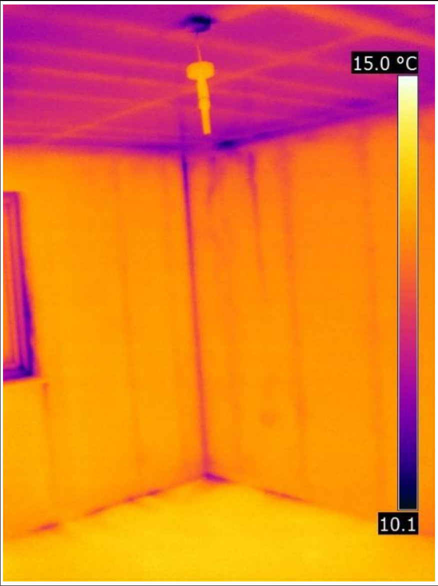
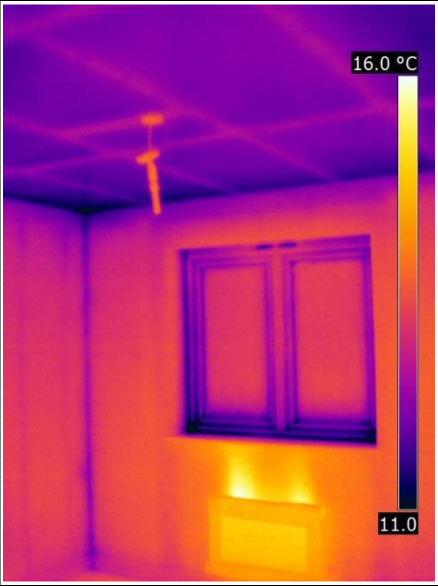


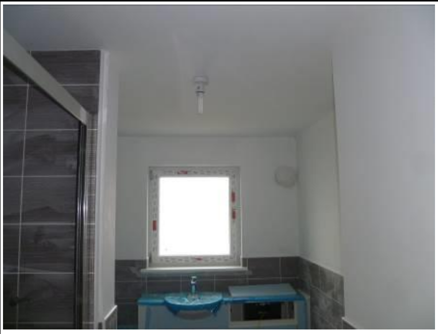
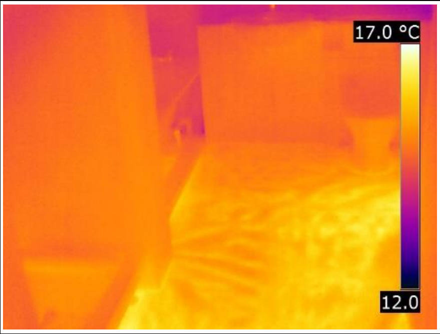
As above, but with cooler air entering around the temporarily sealed extract fan and perhaps down the partition walls and boxed-in services.

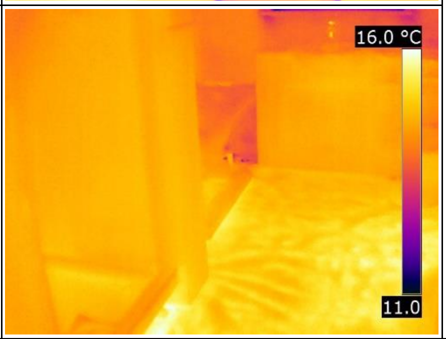
Without loft insulation the air being drawn in from the loft is not that much cooler than the room

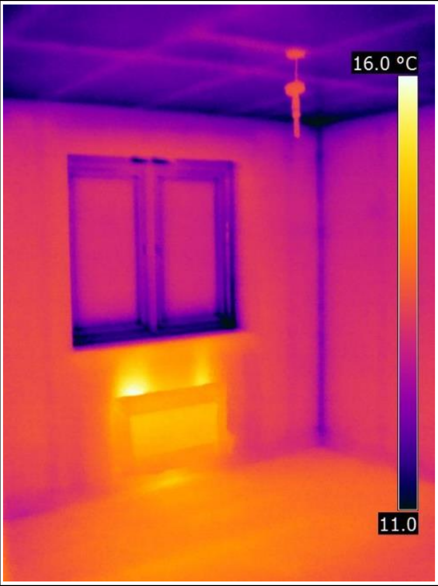
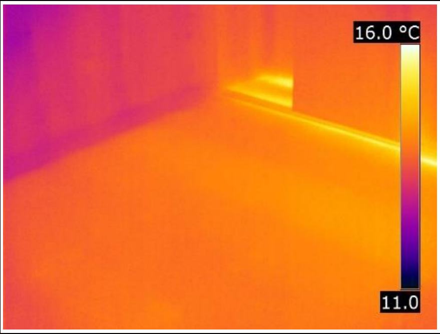
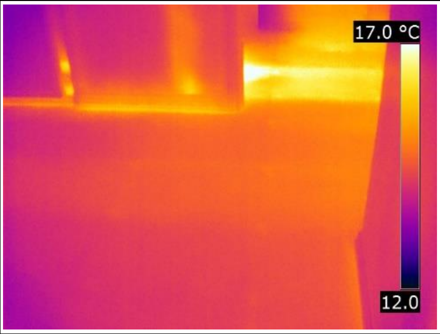
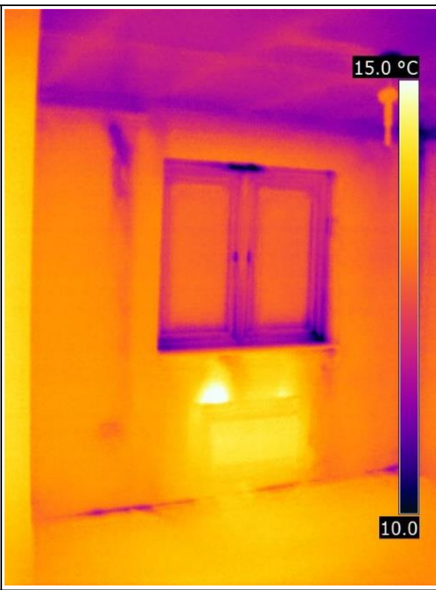
<table>
<tr><td></td><td></td><td>temperature so is difficult to determine with certainty, air infiltration from outside is still clearly visible.</td></tr>
<tr><td colspan="3">Bedroom 1 – Under natural conditions</td></tr>
<tr><td></td><td></td><td rowspan="2">No significant issues with the thermal imaging on a 5° span.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="3">Bedroom 1 – Under depressurisation</td></tr>
<tr><td></td><td></td><td>Infiltration at the ceiling penetration, window jamb were now perceptible.

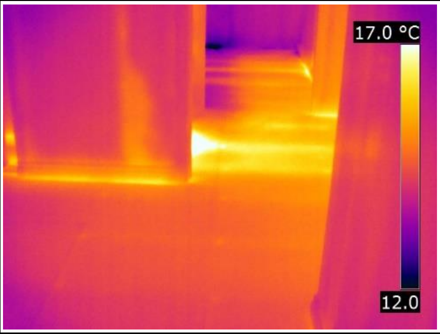
Air could also be seen being drawn into the wall panel at the side of the gable window where issues had been seen in plot 268.</td></tr>
</table>

		
Bedroom 3 – Under natural conditions		
		As Bedroom 1.
Bedroom 3 – Under depressurisation		
		As Bedroom 1; again some air was observed being drawn into the wall panels, but was difficult to detect entering the actual room as it was emerging at the intermediate floor perimeter at room temperature (so not showing up on the thermal camera).

<table>
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Bathroom – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td rowspan="2">No significant issues with the thermal imaging on a 5° span.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="3">Bathroom – Under depressurisation</td></tr>
<tr><td></td><td>
</td><td rowspan="2">The direct infiltration from outside around the extract fan was clearly visible, as was some air movement at the window head.

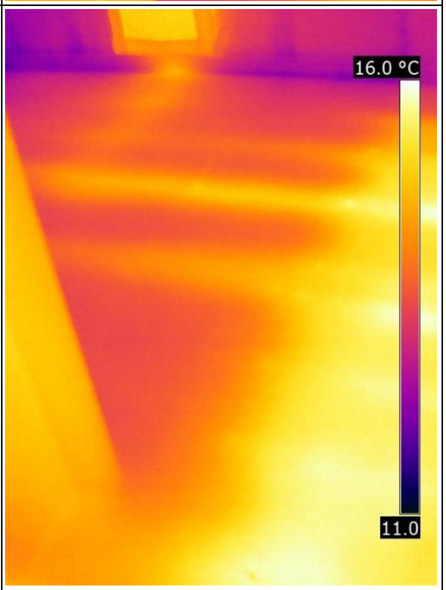
As in Bedroom 3, some air was detected emerging from beneath the shower tray but did not show on the thermal image as it was at room temperature.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="3">Bedroom 4 – Under natural conditions</td></tr>
</table>

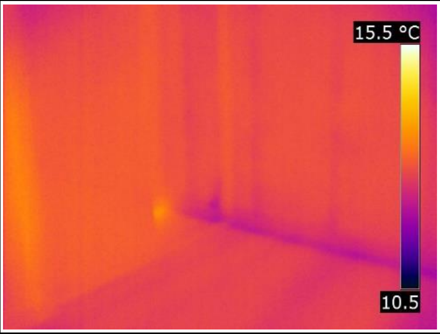
		As seen in previous bedrooms. The pipework from the boiler to the cylinder cupboard retained heat much better than the rest of the upstairs without loft insulation installed.
		
		
Bedroom 4 – Under depressurisation		
		As in Bedroom 1, cooler air was seen tracking down the wall the external wall along the cabling route for an electrical socket. Cooler air could be seen infiltrating around the window and at the intermediate floor perimeter.

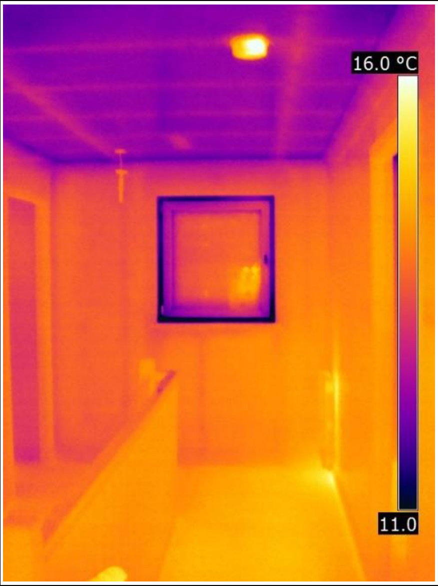
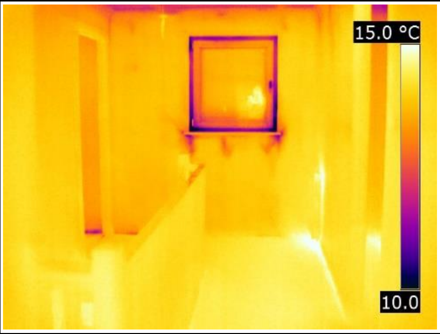


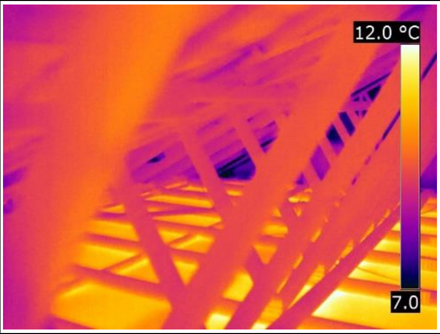
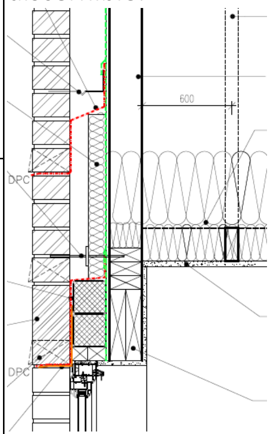
Bedroom 2 – Under natural conditions

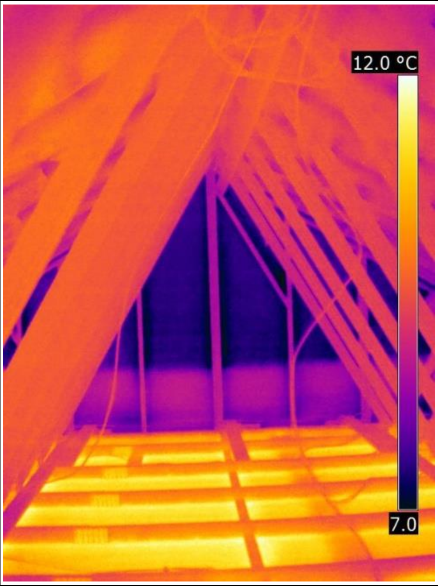
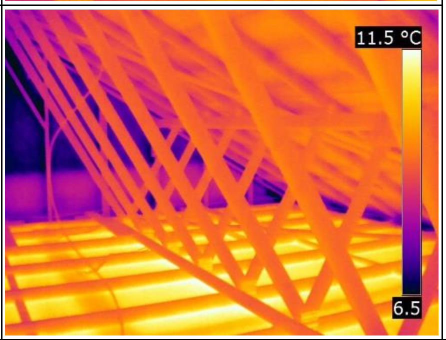
The heating pipework routes were clearly visible in the intermediate floor void but otherwise there were no significant issues with the thermal imaging on a 5° span.



	 	
	 	
Bedroom 2 – Under depressurisation		
	 	As in previous bedrooms: infiltration at ceiling penetrations, around the window, at the intermediate floor perimeter and tracking the cabling down the wall towards the electrical socket.
	 	
Landing – Under natural conditions		

<table>
<tr><td></td><td></td><td rowspan="3">No significant issues with the thermal imaging on a 5° span.</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="3">Landing – Under depressurisation</td></tr>
<tr><td></td><td></td><td>Under depressurisation the usual issues at the window and around ceiling penetrations became apparent</td></tr>
</table>

<table>
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Loft – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td rowspan="3">Looking towards the gable wall above garage the additional rigid board insulation on the outside of the timber frame is easily discernible:


Without insulation the loft itself is around 9~10°C, compared to ~4°C in plot 268.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td></td><td>
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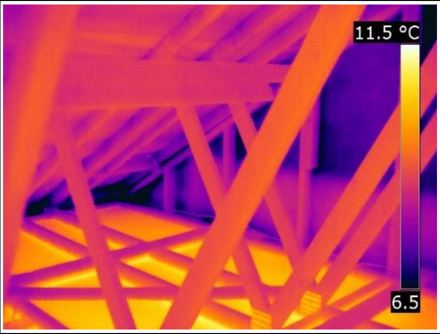
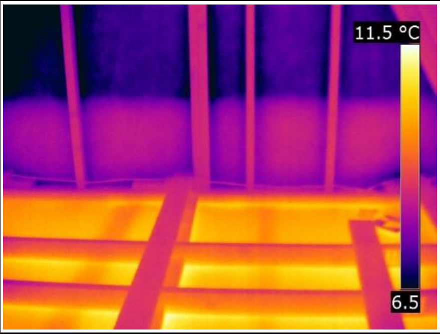
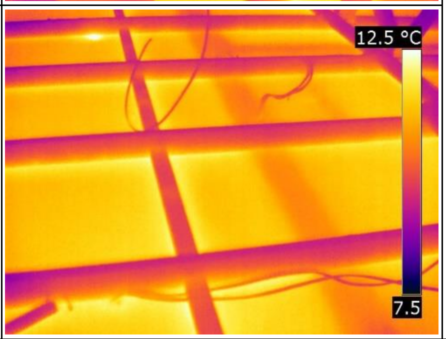






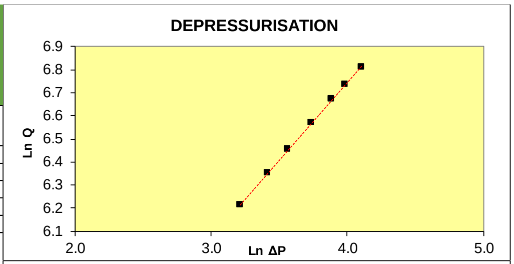
Looking towards the opposing gable wall it is quite easy to see how some of the cold areas of ceiling observed in plot 268 came about. With so many nogs, braces and additional timbers, as well as electrical cabling, it is understandable that gaps between loft insulation and the ceiling will result, compromising the performance of the loft insulation.

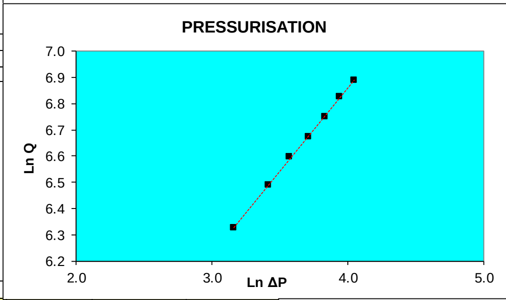
Pressure Test Spreadsheet: 268

LEEDS BECKETT UNIVERSITY | Leeds Sustainability Institute

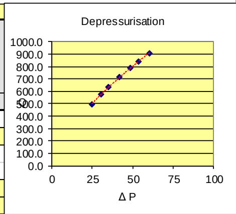
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	13/11/2017		Version 16d	19 June 2017
test house address:	Plot 268 - 49 Thistledown Dv. Cambuslang, G72 6AF			
company:	Knauf Insulation - Taylor Wimpey			
house type:	Fairbairn 2			
tester:	DMS			
test reference number:			Blower Door & Gauge Used	Model 3 with DG700
outdoor temp (°C)	3.8	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN m3/h - When using the DG700 gauge run baseline pressure adjustment for minimum 60s with fan switched on but not rotating	
indoor temp (°C)	19.8	°C		
outdoor humidity (%rh)	73	%RH		
indoor humidity (%rh)	51.4	%RH		
outdoor barometric pressure	1018	mbar or hPa	Calculated Outdoor Air Density	1.28 kg/m^3
indoor barometric pressure	1018	mbar or hPa	Calculated Indoor Air Density	1.21 kg/m^3
temperature corr. fact. depress.	0.945	WARNING!!	description of main construction details:	
temperature corr. fact. press.	1.058	Extreme Test	New build, timber frame, detached, integral garage	
wind speed (m/s):	0	Conditions		
baseline pressure diff (Pa) (+/-)		Pa		
house width:	7.265	m		
house depth:	9.29	m		
house height:	4.923	m		
floor area:	114.5	m^2		
volume:	280.17	m^3		
envelope area including floor:	290.26	m^2		
Pressure Difference for ELA	10	Pa		
RESULTS:				
Q50 Mean Flow at 50Pa =	860.51	m^3/h		
Mean Air Leakage at 50Pa =	3.07	h^{-1}		
Mean Air Permeability at 50 Pa =	2.96	m/h or m^{3}h/m^2		
Equivalent Leakage Area =	0.034	m^2 at	10	Pa

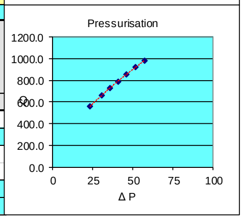




DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa) Max. 90 Pa	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only (m^3/(h.m^2))	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	b	60.5	964	909.3	OK	60.5	4.103	6.813	818.68	2.82	2.92
Approx 57 Pa	b	53.8	892	841.4	OK	53.8	3.985	6.735	r^2	1.000	
Approx 49 Pa	b	48.6	838	790.5	OK	48.6	3.884	6.673	C_{env}	57.375	m^3/h.Pa*n*
Approx 41 Pa	b	42	757	714.1	OK	42	3.738	6.571	n	0.674	
Approx 33 Pa	b	35.3	673	634.8	OK	35.3	3.564	6.453			
Approx 25 Pa	b	30.4	608	573.5	OK	30.4	3.414	6.352	C_L (corrected)	58.560	m^3/h.Pa*n*
Approx 20 Pa	b	24.8	529	499.0	OK	24.8	3.211	6.213			



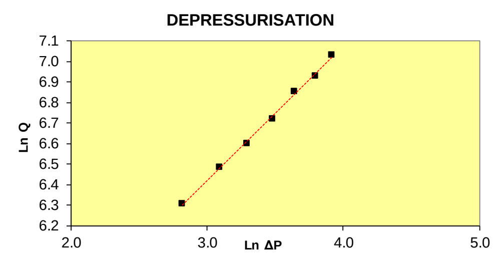
PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa) Max. 90 Pa	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only (m^3/(h.m^2))	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	b	57.4	925	980.6	OK	57.4	4.050	6.888	902.33	3.11	3.22
Approx 57 Pa	b	51.6	870	922.3	OK	51.6	3.944	6.827	r^2	1.000	
Approx 49 Pa	b	46.1	806	854.5	OK	46.1	3.831	6.750	C_{env}	75.895	m^3/h.Pa*n*
Approx 41 Pa	b	40.9	746	790.9	OK	40.9	3.711	6.673	n	0.632	
Approx 33 Pa	b	35.7	691	732.6	OK	35.7	3.575	6.597			
Approx 25 Pa	b	30.6	622	659.4	OK	30.6	3.421	6.491	C_L (corrected)	76.016	m^3/h.Pa*n*
Approx 20 Pa	b	23.6	528	559.8	OK	23.6	3.161	6.328			

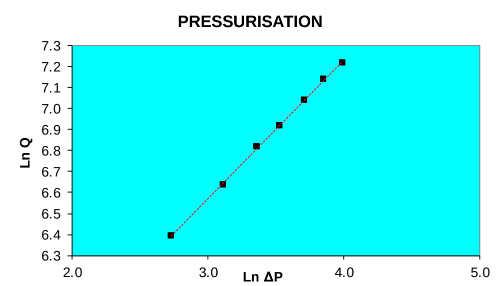


Pressure Test Spreadsheet: 267

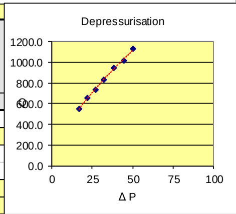
MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION

date:	13/11/2017		Version 16d	19 June 2017	
test house address:	Plot 267 - 51 Thistledown Dv. Cambuslang, G72 6AF				
company:	Knauf Insulation - Taylor Wimpey				
house type:	Maxwell 2				
tester:	DMS				
test reference number:			Blower Door & Gauge Used	Model 3 with DG700	
outdoor temp (°C)	3.4	°C	Note: ENSURE THAT FLOW SETTINGS ARE IN m3/h - When using the DG700 gauge run baseline pressure adjustment for minimum 60s with fan switched on but not rotating		
indoor temp (°C)	18	°C			
outdoor humidity (%rh)	72	%RH			
indoor humidity (%rh)	51	%RH			
outdoor barometric pressure	1019	mbar or hPa	Calculated Outdoor Air Density	1.28	kg/m^3
indoor barometric pressure	1019	mbar or hPa	Calculated Indoor Air Density	1.21	kg/m^3
temperature corr. fact. depress.	0.950	WARNING!!	description of main construction details:		
temperature corr. fact. press.	1.053	Extreme Test	New build, timber frame, detached, integral garage		
wind speed (m/s):	0	Conditions			
baseline pressure diff (Pa) (+/-)		Pa			
house width:	8.728	m			
house depth:	9.963	m			
house height:	4.927	m			
floor area:	137.95	m^2			
volume:	338.34	m^3			
envelope area including floor:	333.8	m^2			
Pressure Difference for ELA	10	Pa			
RESULTS:					
Q50 Mean Flow at 50Pa =	1222.74	m^3/h			
Mean Air Leakage at 50Pa =	3.61	h^{-1}			
Mean Air Permeability at 50 Pa =	3.66	m/h or m^3h/m^2			
Equivalent Leakage Area =	0.048	m^2 at	10	Pa	





DEPRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa) Max. 90 Pa	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Depressurisation Only ($m^3/(h.m^2)$)	Air Leakage Depressurisation Only (h^{-1})
Approx 65 Pa	b	50.3	1195	1133.0	OK	50.3	3.918	7.033	1139.54	3.41	3.37
Approx 57 Pa	b	44.5	1075	1019.2	OK	44.5	3.795	6.927	r^2	0.998	
Approx 49 Pa	b	38.3	999	947.2	OK	38.3	3.645	6.853	C_{env}	85.241	$m^3/h.Pa^n$
Approx 41 Pa	b	32.5	874	828.7	OK	32.5	3.481	6.720	n	0.657	
Approx 33 Pa	b	27	776	735.7	OK	27	3.296	6.601			
Approx 25 Pa	b	22	689	653.3	OK	22	3.091	6.482	C_L (corrected)	87.171	$m^3/h.Pa^n$
Approx 20 Pa	b	16.8	577	547.1	OK	16.8	2.821	6.305			



PRESSURISATION	RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB	MEASURED FAN PRESSURE (Pa) Max. 90 Pa	MEASURED FLOW (m^3/h)	ADJUSTED FLOW (m^3/h)	FLOW RANGE OK FOR SELECTED RING?	Adjusted Pressure (Pa)	Ln delta P	Ln Q	Q50 Calculated Flow at 50Pa (m^3/h)	Permeability Pressurisation Only ($m^3/(h.m^2)$)	Air Leakage Pressurisation Only (h^{-1})
Approx 65 Pa	b	54.3	1291	1361.6	OK	54.3	3.995	7.216	1305.94	3.91	3.86
Approx 57 Pa	b	47.1	1195	1260.4	OK	47.1	3.852	7.139	r^2	0.999	
Approx 49 Pa	b	41.1	1084	1143.3	OK	41.1	3.716	7.042	C_{env}	98.442	$m^3/h.Pa^n$
Approx 41 Pa	b	34.1	958	1010.4	OK	34.1	3.529	6.918	n	0.660	
Approx 33 Pa	b	29	868	915.5	OK	29	3.367	6.819			
Approx 25 Pa	b	22.6	723	762.6	OK	22.6	3.118	6.637	C_L (corrected)	98.845	$m^3/h.Pa^n$
Approx 20 Pa	b	15.4	568	599.1	OK	15.4	2.734	6.395