# Taylor Wimpey – Thermal Imaging Project

Leeds Beckett University
Leeds Sustainability Institute

Site: Hele Park
Newton Abbot
TQ12 6JN

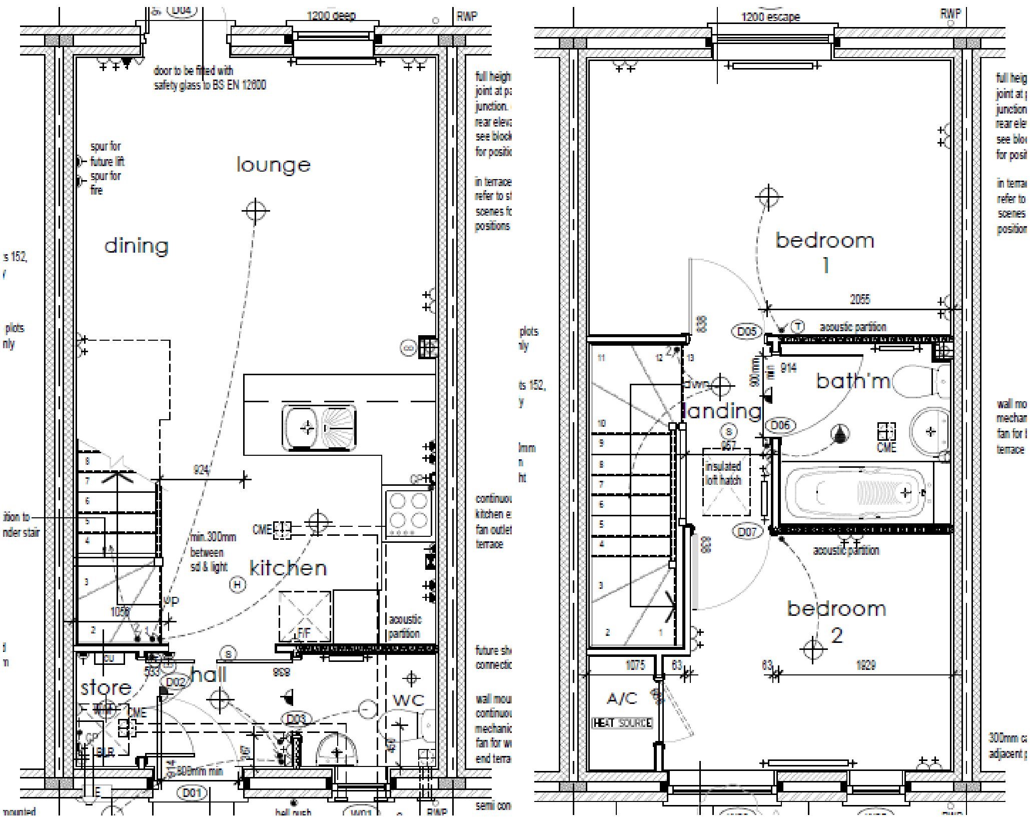
Visit Date: 18th December 2017

Plot(s): 294 & 297

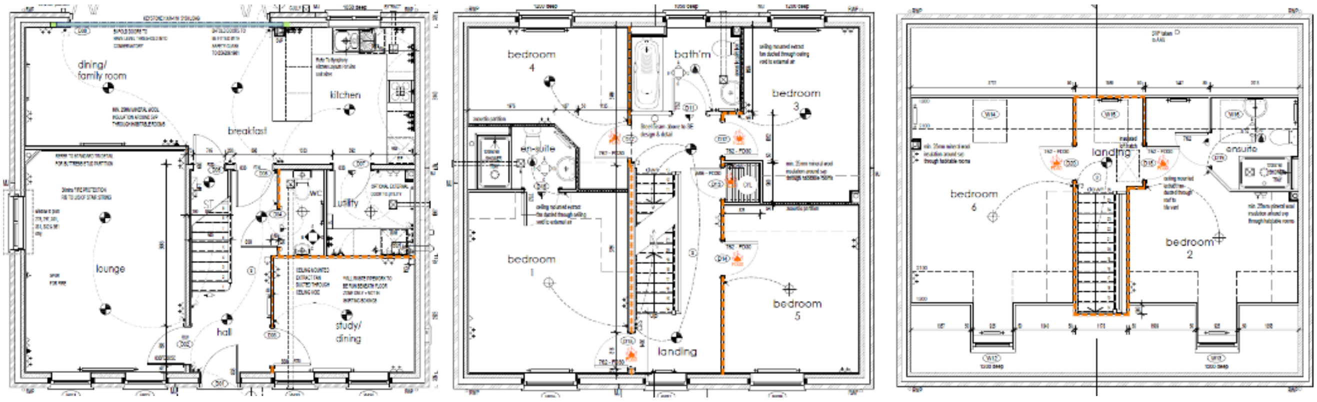
House Type: 294 AA21
Masonry, Partial-fill, 2-Storey, End-terrace
297 D2000
Masonry, Partial-fill, 2½-Storey, Detached

Floor Plans:

294 AA21



297 D2000 (handed)




Environmental Conditions:

| | | | |
|---|---|---|---|
| Internal Temperature | 19.3 / 22.3 °C | External Temperature | 6.9 / 8.6 °C |
| Internal RH | 51.8 / 47.6 % | External RH | 77.3 / 73.4 % |
| Mean Wind Speed | 0.3 $ms^{-1}$ (max. gust 0.9 $ms^{-1}$) | Wind Direction | NNW |

Clear skies, no rain in preceding 24 hours.

Pressure Test Results:

| 294 AA21 | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 | $ach^{-1}$ |
| 6.48 | 7.50 | 1.000 | 6.48 | 7.50 | 1.000 | 6.48 | 7.50 |
| 297 D2000 | | | | | | | |
| 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 | $ach^{-1}$ |
| 6.86 | 5.71 | 1.000 | 7.39 | 6.15 | 0.999 | 7.13 | 5.93 |

Observations:

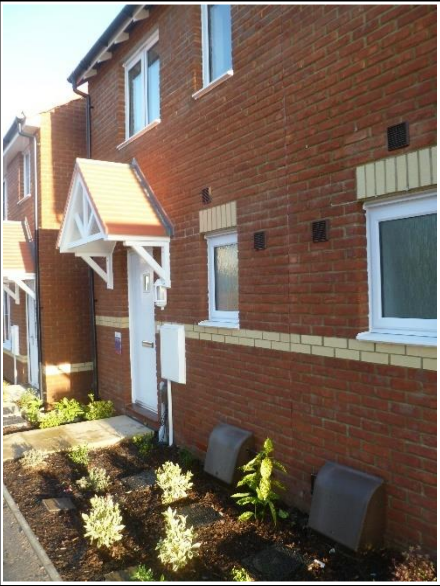
The thermal images below are shown on varying temperature scales to highlight what was being observed, please take into account these different image spans when directly comparing images. The minimum span used is 5° so as not to over-exaggerate any thermal anomalies observed.

## Plot 294

Thermal images under depressurisation were captured at an average pressure of -51.2 Pa.

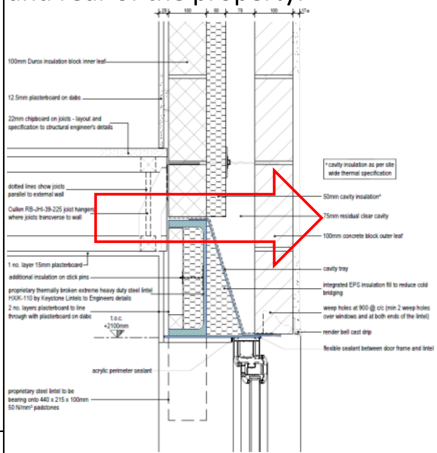
External - Under natural conditions





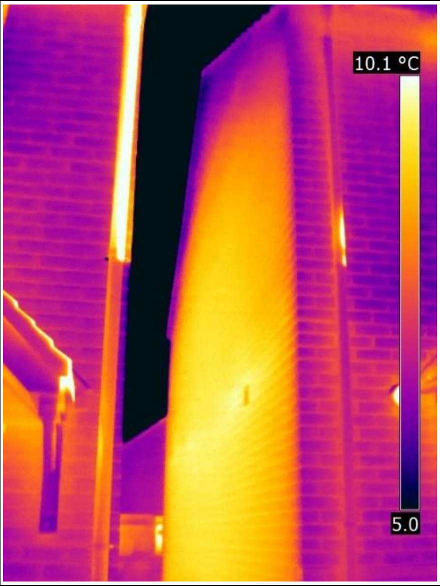
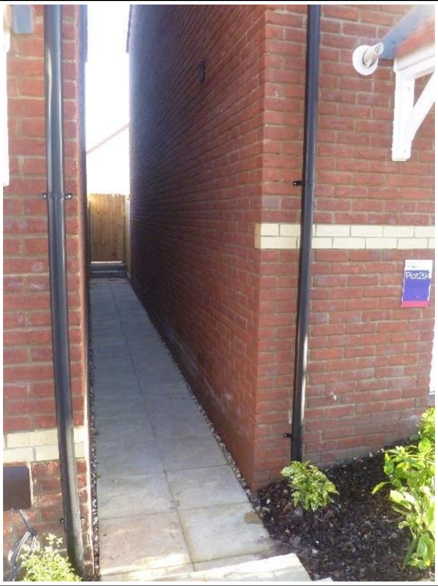
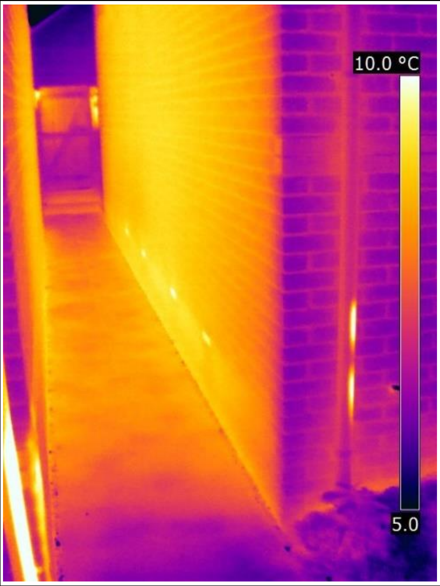
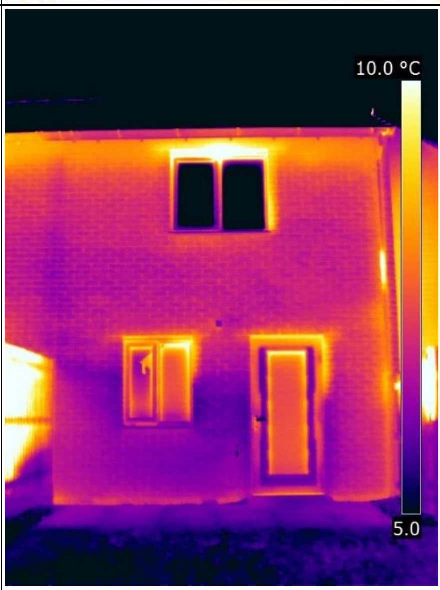


On the South West facing front façade the eaves junction appeared warmer than the rest of the wall. This is exaggerated in the thermal image as the area above the 1st floor windows reflects the warmer overhang whereas the wall beneath is reflecting the much cooler clear sky; however there is still a clear distinction of brickwork in front of lintels and the rest of the eaves junction. Without access to the detailed designs it is dangerous to deduce why this should be the case, but if the lintel detail is similar to the door head section supplied below (Dwg no. 20957-D2000-62) then a thermal bridge looks likely to exist, although raises the question of why it is so much more apparent on the 1st floor heads than the ground floor ones, on both front and rear of the property.

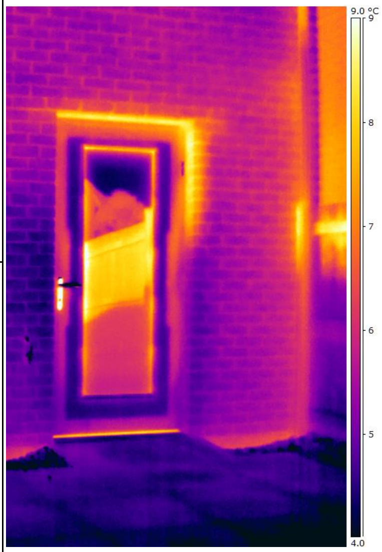


The internal thermal images of the eaves also show a discontinuity of insulation between loft and front/rear walls which will also affect heat loss at this junction.

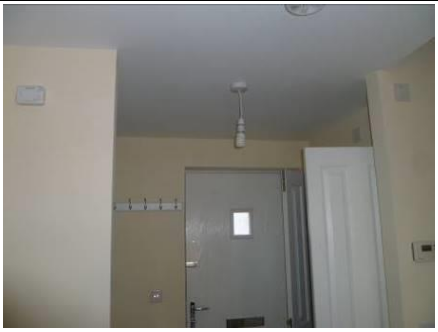
A warmer strip is also obvious at the ground floor perimeter.

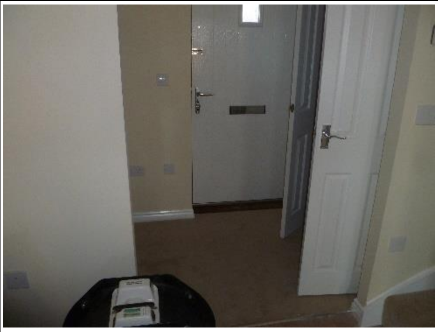
| | | |
|---|---|---|
|  |  | The North West facing gable wall was not exposed to solar, but is reflecting the adjacent heated property’s gable wall rather than the clear sky so appears warmer in the thermal image.<br><br>Warmer strips are again visible at the ground floor perimeter and also at the intermediate floor level adjacent to the staircase. |
|  |  | |
|  |  | The North East facing rear façade displayed similar characteristics to those observed on the other 2 elevations.<br><br>The thermal performance of the rear door and threshold also raised questions. The threshold revealed a significantly warmer strip when viewed from the outside, coinciding with a significantly cooler strip when viewed from the inside; whilst the opaque sections of door varied in temperature by >2° from the better performing areas around the glazing panel to worse performing |


areas around the perimeter of the door leaf:




Hall – Under natural conditions




The perimeter of the front door and the threshold displayed similar issues to those seen with the rear door.

Colder spots can be seen to the left of the door backing onto the base of the electric meter box and gas pipe penetration, and also where the penetrations for the doorbell and outside light are likely to be.

Under natural condition the ground floor is likely to be an infiltration zone where cooler external air enters and the 1$^{st}$ floor an exfiltration zone where warmed air leaves the inhabited space.

Hall – Under depressurisation

<table>
<tr>
<td></td>
<td>
</td>
<td rowspan="3">Under depressurisation air is blown out of the property through the blower door fan, allowing cooler air to enter the dwelling through uncontrolled ventilation paths (controlled ventilation such as extract vents and trickle vents are either closed or temporarily sealed for the purposes of this test).<br><br>The penetrations through the inner leaf blockwork observed previously are now more obvious as the internal/external pressure difference is held at around -50 Pascal. Cooler air can also be seen moving into the void behind the dry lining plasterboard around the door head and at the base of the door jamb.<br><br>Under depressurisation air was also getting beneath the hall carpet and lifting it slightly, although it was not clear where this air was entering it seemed to be from around the door jamb junctions with the threshold.</td>
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<tr>
<td></td>
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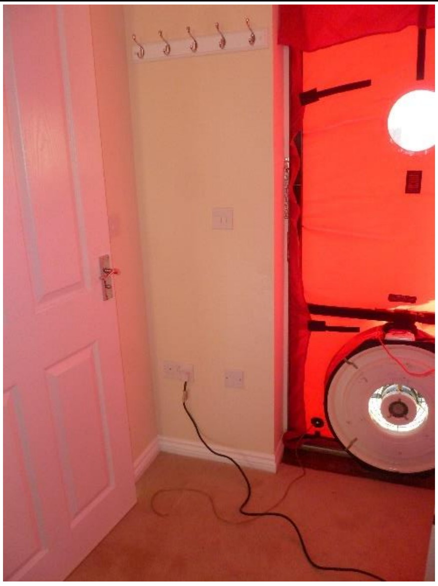
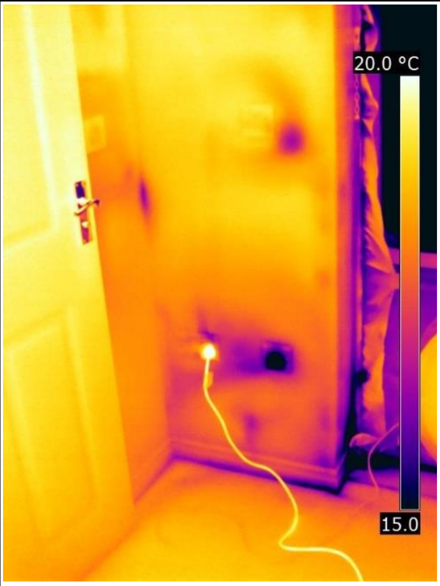
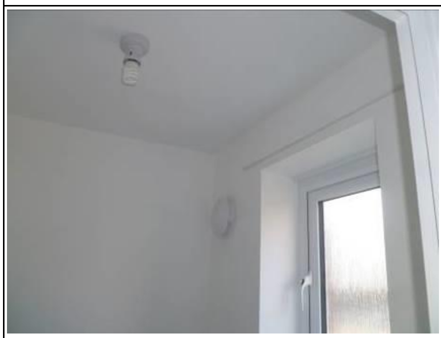
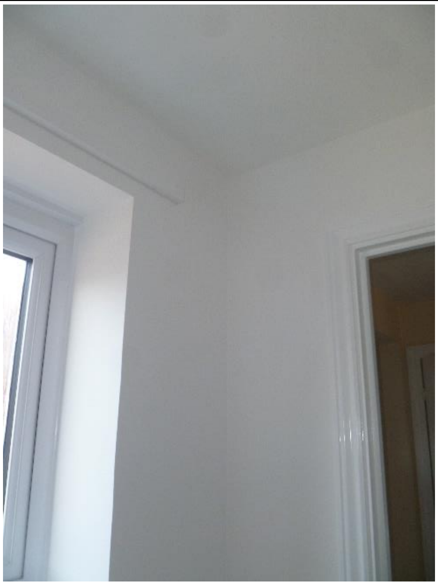
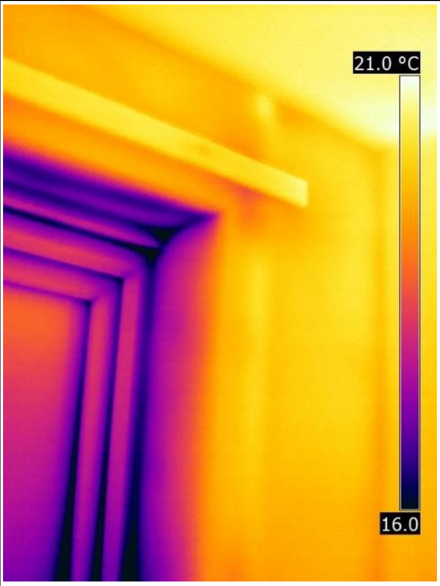
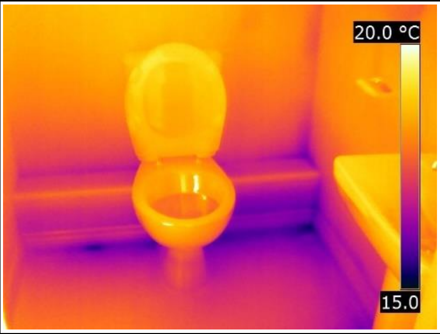
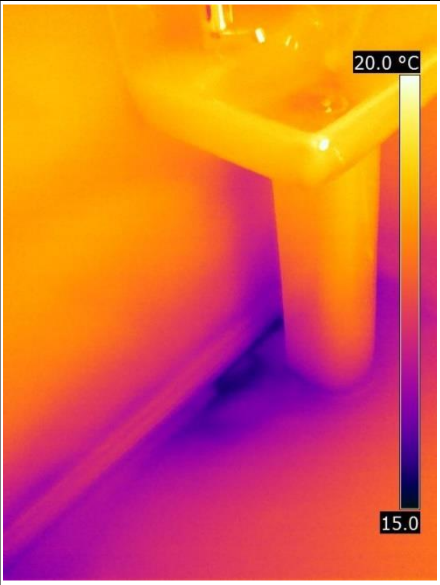
<tr>
<td></td>
<td>
</td>
</tr>
<tr>
<td colspan="3">Ground Floor WC – Under natural conditions</td>
</tr>
<tr>
<td></td>
<td>
</td>
<td>The window reveals varied between jamb and head, with the thermal bridge at the head continuing further than that at the jamb. Possibly there is just plasterboard and no insulation beneath the base plate of the lintel?</td>
</tr>
</table>



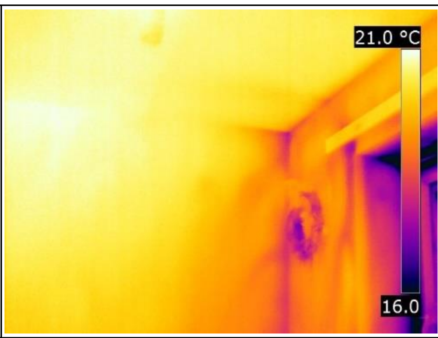



The service penetrations for the WC and basin are not obvious under natural conditions.

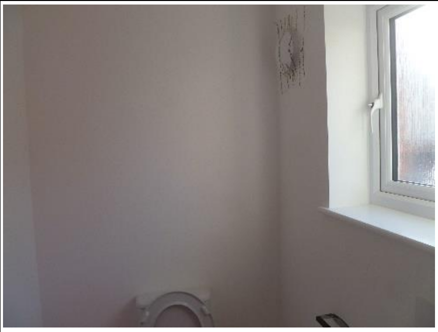


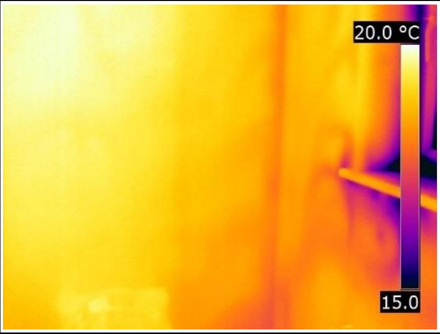



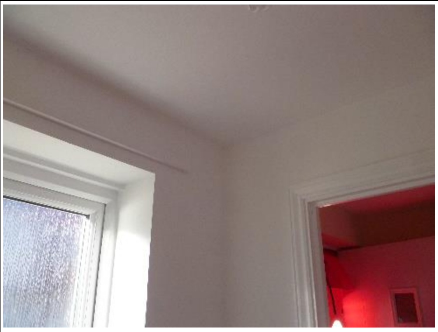

Ground Floor WC – Under depressurisation

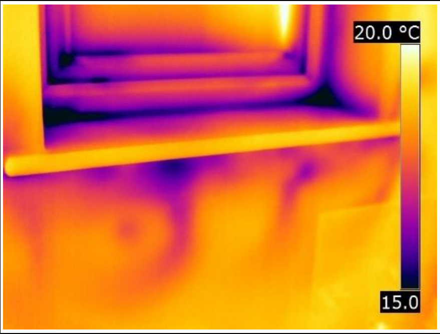


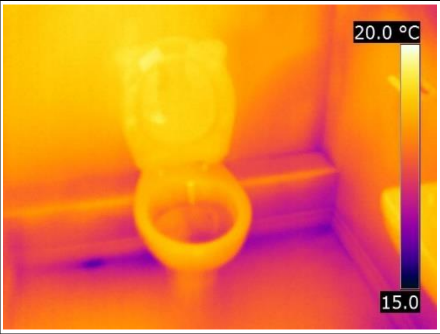

Under depressurisation air can be seen entering the void behind the dry lining and moving around the external wall and into the adjacent void on the party wall.
The main points of entry appear to be around the window opening and particularly around the sill board.



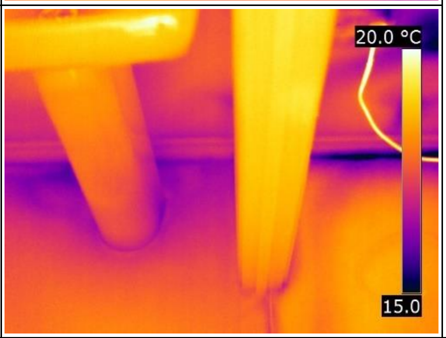



The service penetrations for the WC and basin are not obvious under depressurisation, as under natural conditions, showing them to be effectively sealed.
The floor/wall junction in the ground floor WC also appeared to be better sealed than in the hall.




Ground Floor Store – Under natural conditions

<table>
<tr>
<td></td>
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<td rowspan="3">As the boiler had not long been switched off it was still very warm and difficult to see anything around it thermally; however it was very cold in the corner beneath the worktop by the penetrations for the condensate pipe and washing machine outlet.<br><br>Small cooler spots above the consumer unit were visible, there appeared to be nothing externally on the gable wall that would cause this.</td>
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<tr>
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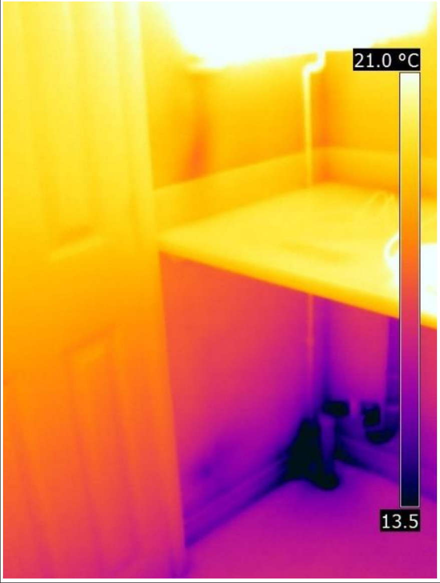
<td>
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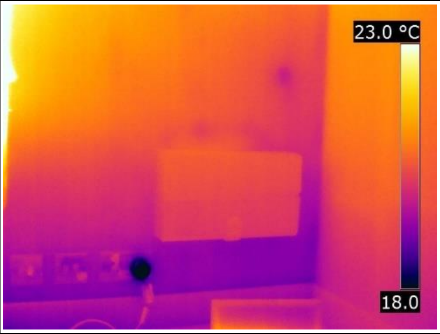
<td>
</td>
</tr>
<tr>
<td colspan="3">Ground Floor Store – Under depressurisation</td>
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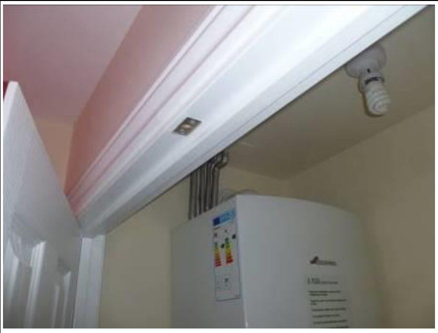
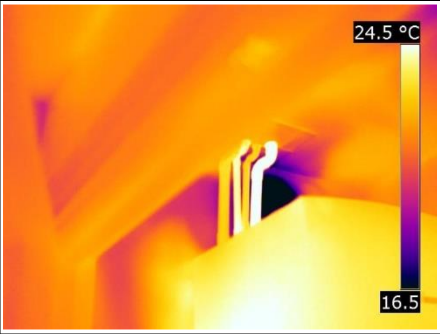
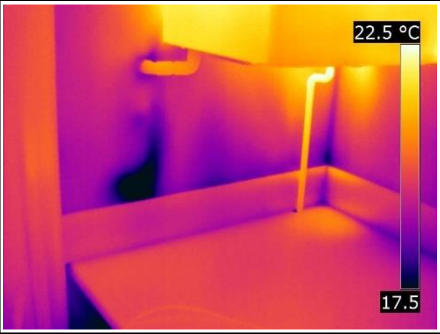
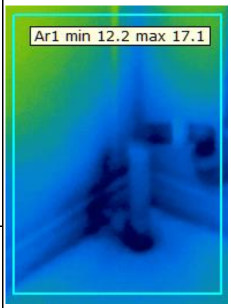
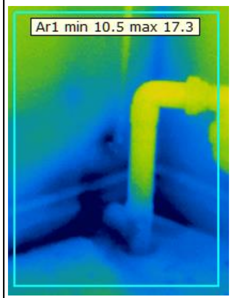
<td></td>
<td>
</td>
<td>Under depressurisation cold external air could be seen entering around the boiler flue and other external wall penetrations and again moving around through the void behind the dry lining.<br>The cold area in the external corner did drop in temperature under depressurisation, indicating that</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td rowspan="2">infiltration is playing a part in making this junction cooler:<br><br>Natural Conditions, min T = 12.2 °C<br><br>Under Depressurisation, min T = 10.5 °C</td>
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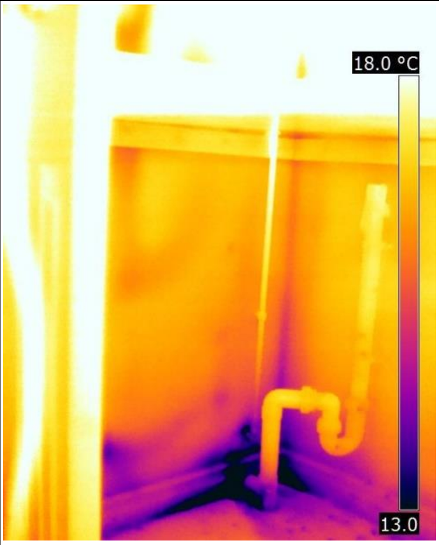
<td></td>
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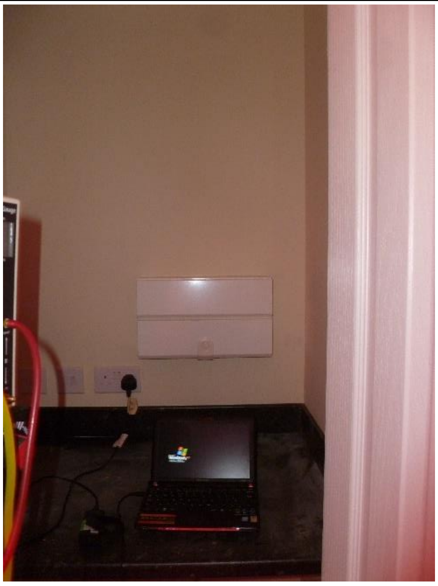
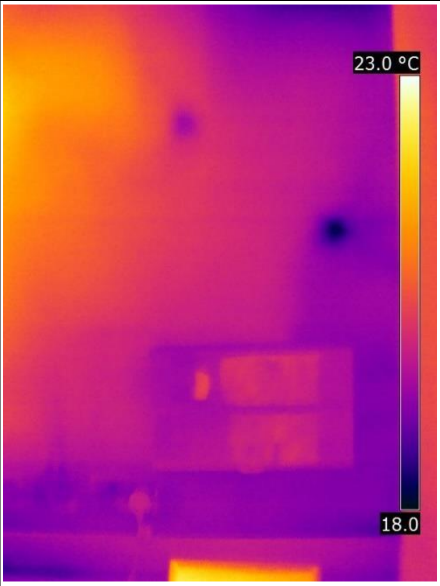
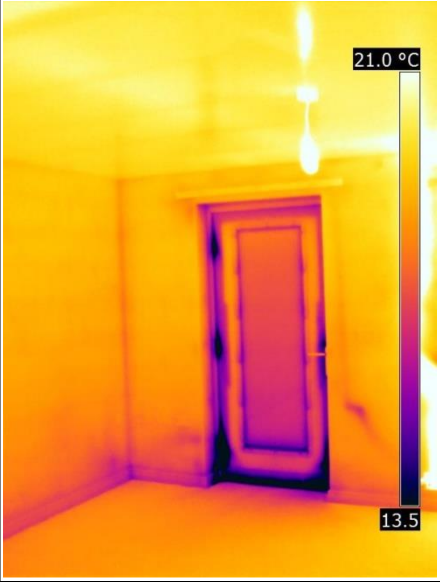
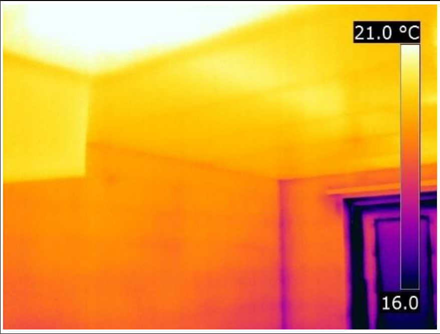
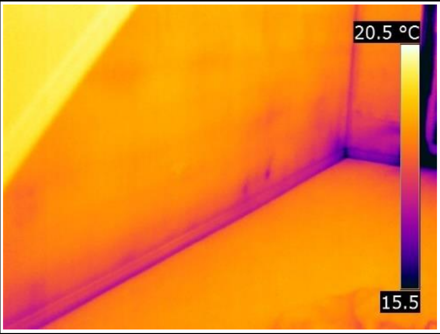
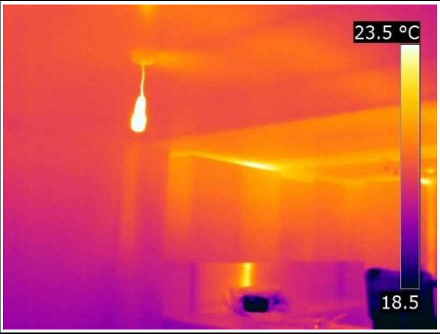
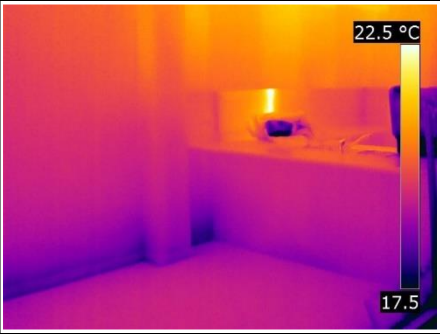
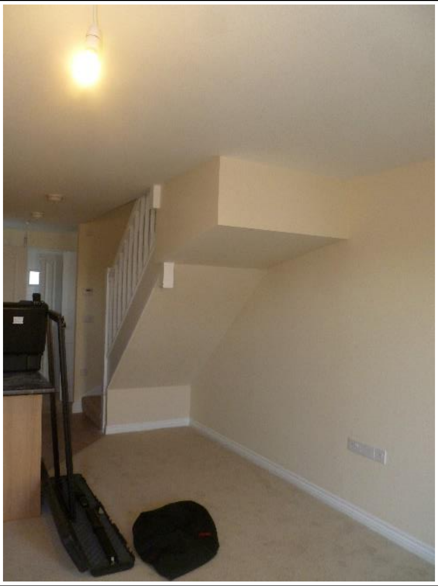
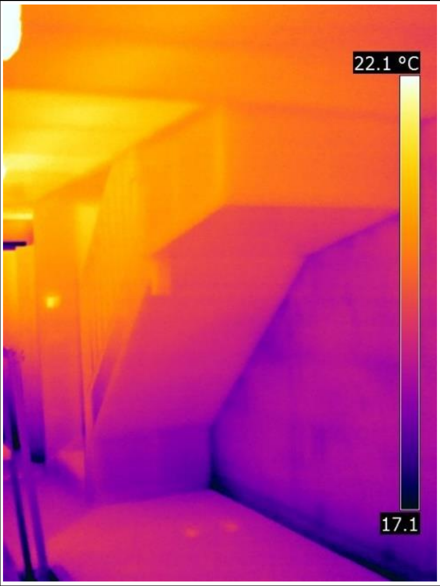
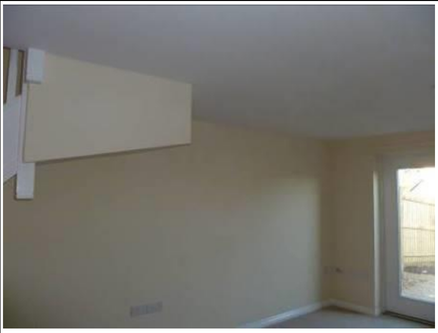
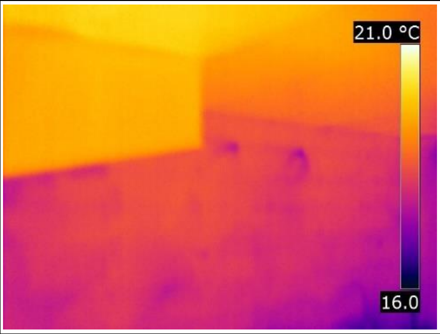
<td></td>
<td></td>
<td>The spots above the consumer unit appeared to worsen under depressurisation, possibly due to gaps in mortar joints in the inner leaf blockwork that were not repaired prior to dry lining.</td>
</tr>
<tr>
<td colspan="3">Dining/Lounge/Kitchen – Under natural conditions</td>
</tr>
</table>

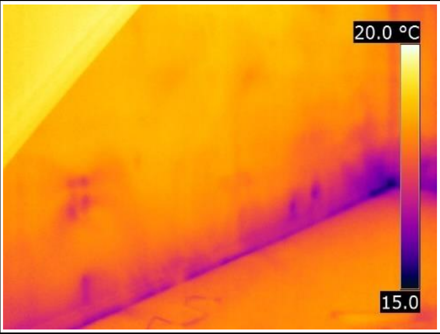
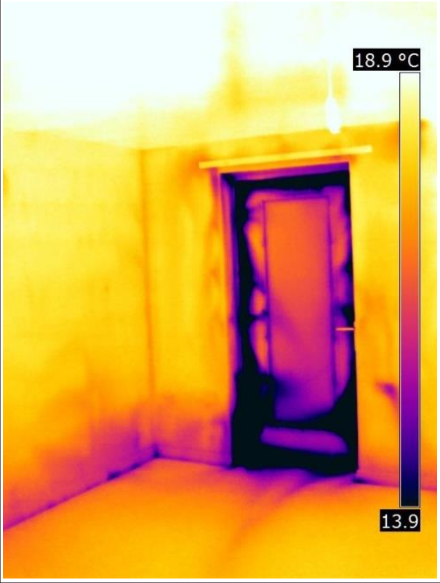
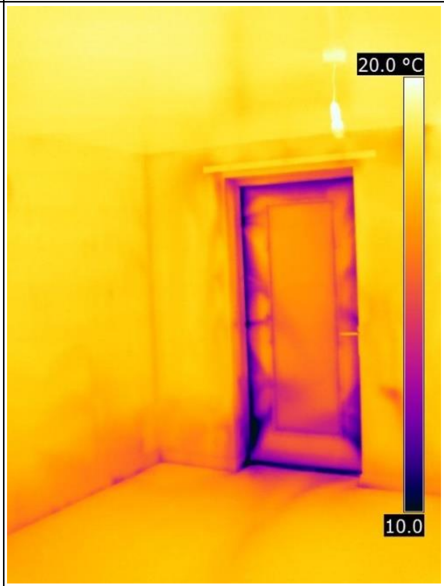
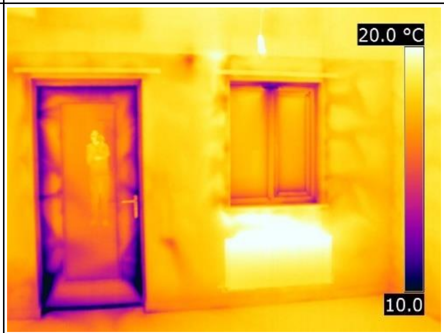
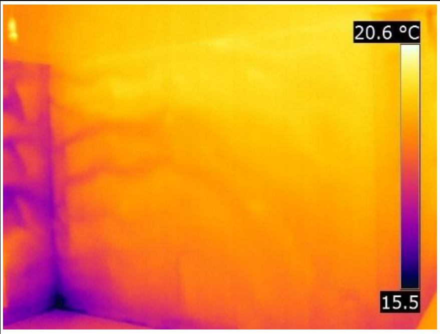


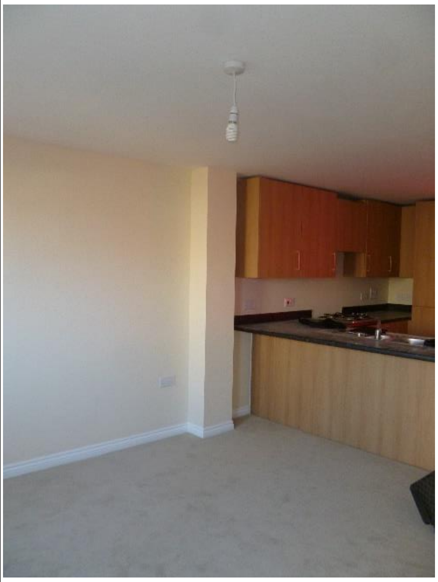
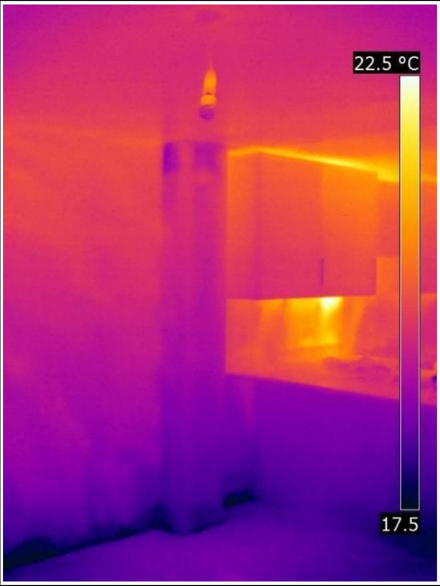

Under natural conditions there is a slight cooler area at the ground floor perimeter, a cold spot on the rear wall where the outside tap is sited, indications of air leakage around the back door (particularly around the 3 door hinges) and a very cold threshold.




| | | |
|---|---|---|
|  |   | |
|  |   | |
|  |   | |
| Dining/Lounge/Kitchen – Under depressurisation | | |
|  |   | Under depressurisation there again appear to be cooler spots appearing in the gable wall with no apparent reason visible externally, this could again be due to gaps in the perpends and bedding layers of the inner leaf blockwork allowing air to enter the void behind the dry lining |

| | | |
|---|---|---|
|  |  | directly from the external wall cavity. |
|  |  |  |
|  |  |  |
|  |  | Air leakage at the outside tap, external security light and around the window and door opening were clearly visible under depressurisation. Infiltration at the window jambs was observed spreading throughout the external wall and party wall behind the dry lining. There was also significant |

<table>
<tr>
<td></td>
<td>
</td>
<td rowspan="2">lifting of the lounge carpet under depressurisation, with air appearing to enter at the back door threshold.<br><br>The service riser at the edge of the kitchen units appeared cooler under depressurisation, the direction of airflow through it was not obvious.</td>
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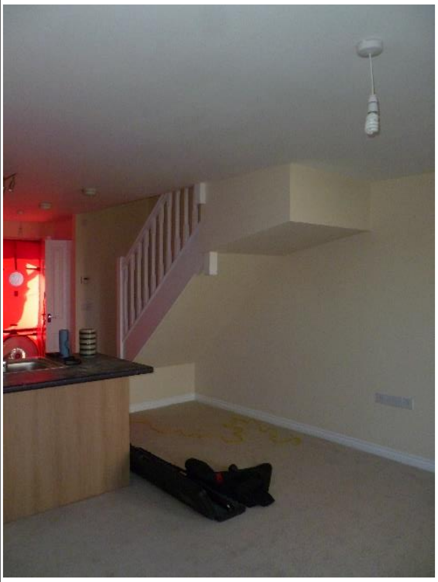
<tr>
<td></td>
<td>
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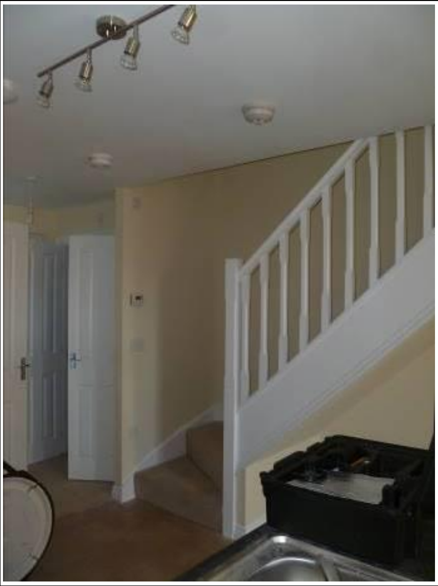
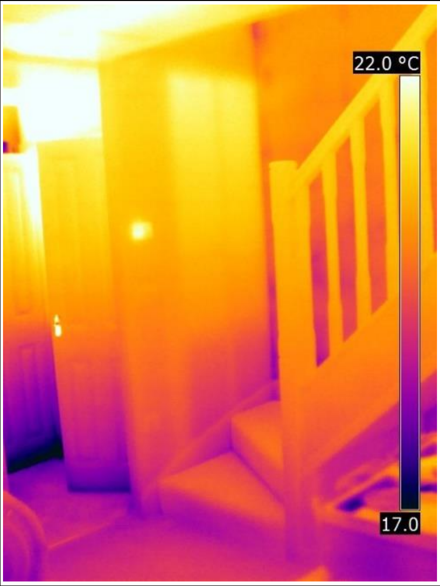
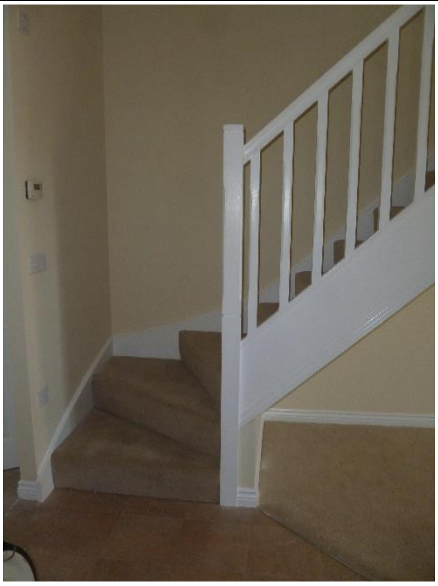
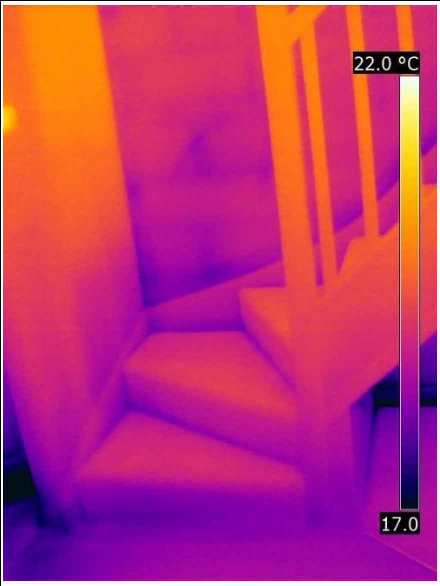
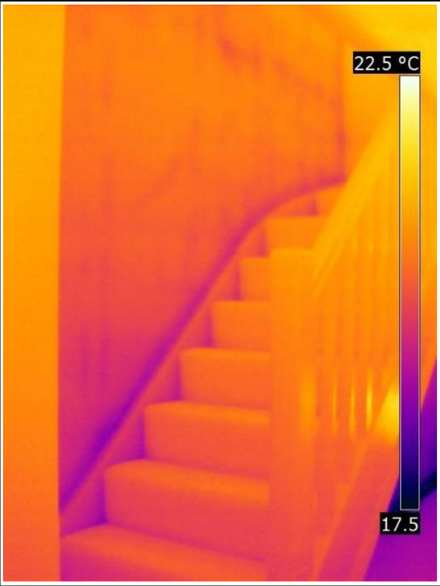
</tr>
<tr>
<td colspan="3">Stairs & Landing – Under natural conditions</td>
</tr>
<tr>
<td></td>
<td>
</td>
<td>The boiler in the store could be seen to make the internal partition wall to the stairs much warmer, as is to be expected.<br><br>The pattern of the inner leaf blockwork was clearly visible along the gable wall, but there was nothing that coincided with the warmer strip at intermediate floor level observed from outside.<br><br>There was a colder strip at the 1st floor ceiling junction with the gable wall, suggesting a lack of insulation</td>
</tr>
</table>

| | | |
|---|---|---|
|  |  | between the gable wall and end trussed rafter.<br><br>Cooler spots could be seen around the loft hatch, this is quite unusual under natural conditions as this is an exfiltration zone, with warmer air leaving the property. |
|  |  | |
|  |  | |
|  |  | |

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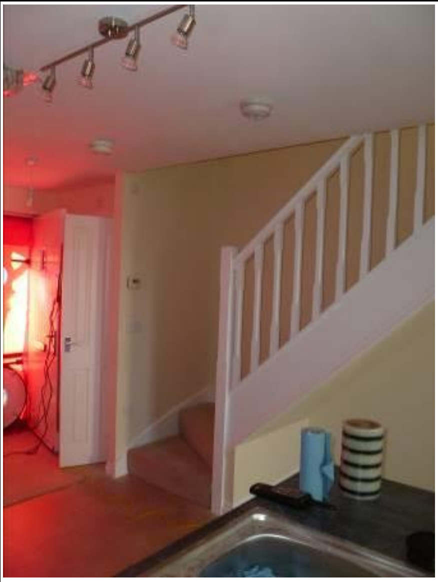
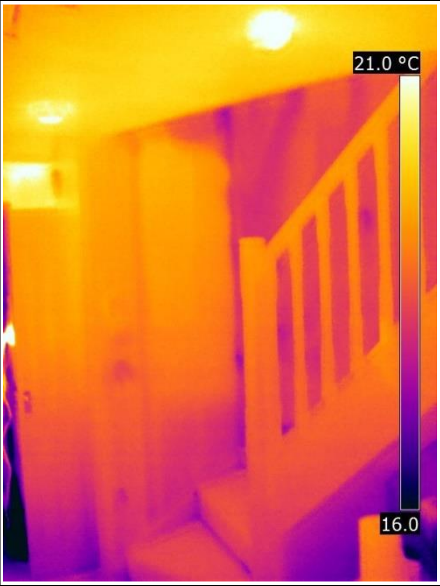
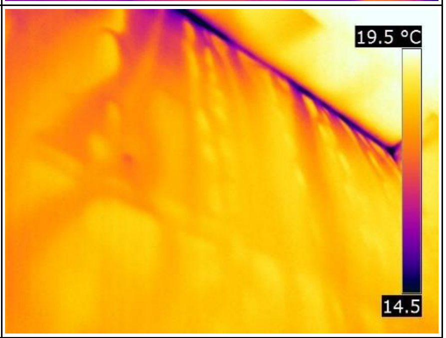
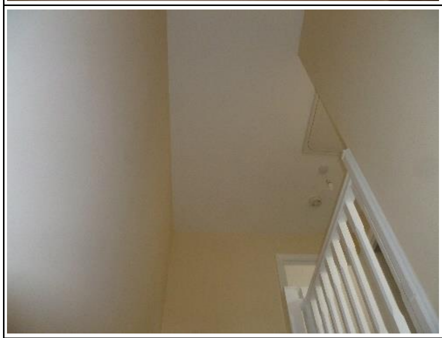
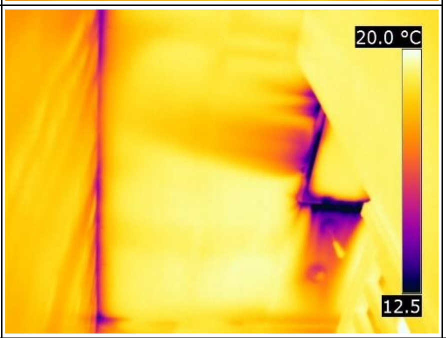
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Stairs & Landing – Under depressurisation</td></tr>
<tr><td></td><td>
</td><td rowspan="3">Under depressurisation cold air from the loft was observed being drawn down behind the dry lining on the gable wall, around the plasterboard adhesive dabs. Although nothing appeared to be being drawn down the internal partition voids.<br><br>Significant air leakage could now be seen around the loft hatch, both between the door and surround and between the surround and the ceiling.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td></td><td>
</td></tr>
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| | | |
|---|---|---|
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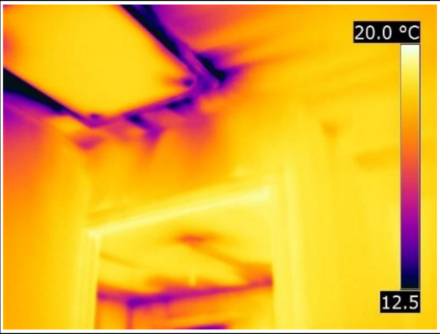
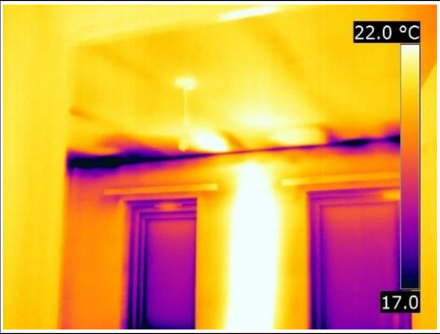
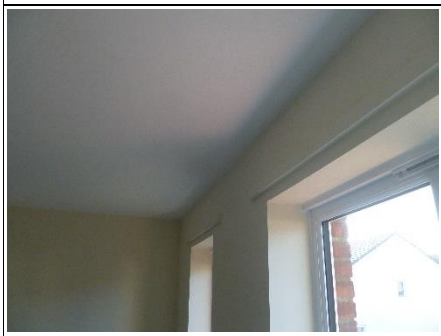
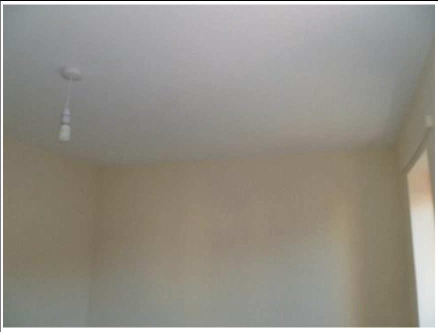
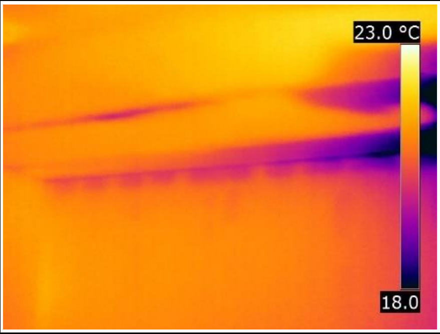
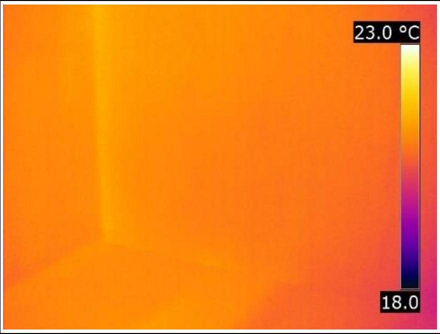
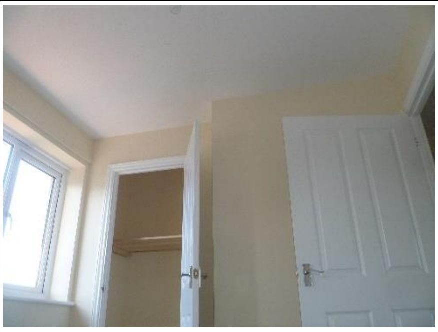
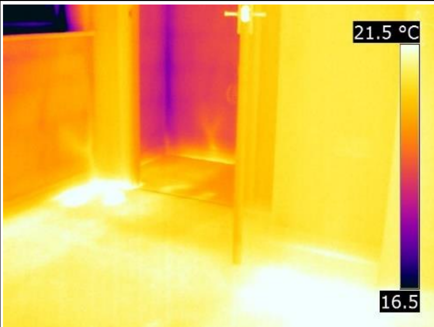
|  |  | |
| Bedroom 2 – Under natural conditions | | |
|  |  | Under natural conditions it could be seen that the loft insulation did not always meet up fully with the external wall insulation at the eaves, this may have been a factor in what was seen at the eaves junction from outside the front of the house. |
|  |  | |
|  |  | |

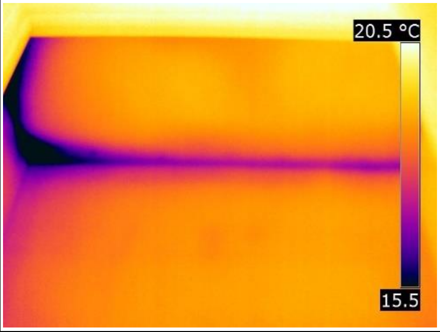




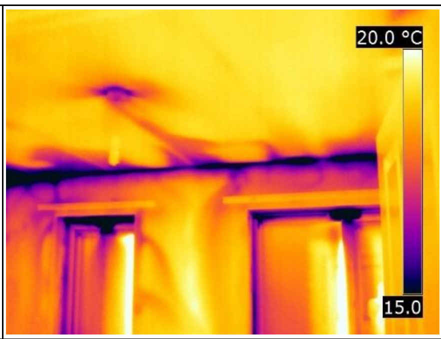



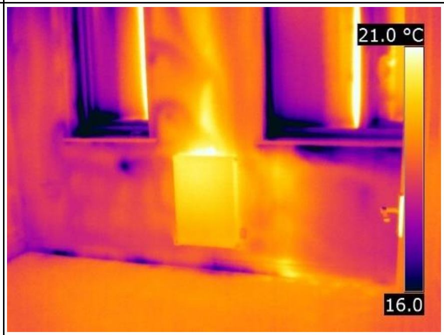



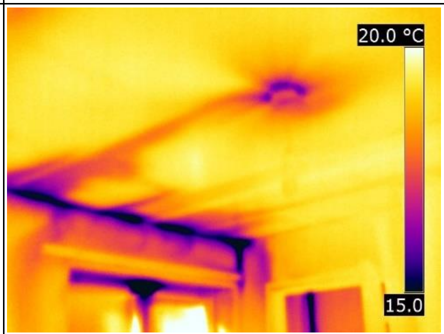

The party wall appeared to be fairly isothermal, with a consistent temperature across the whole wall apart from some of the plasterboard adhesive dabs being visible at the party wall junction with the ceiling.

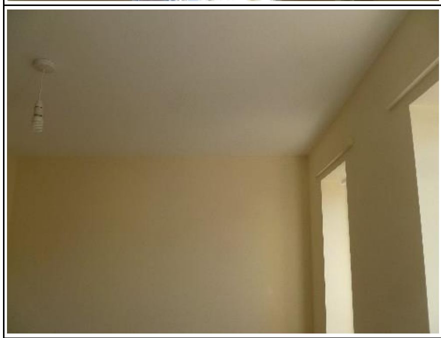
The airing cupboard above the boiler/store was unheated for this test and understandably cooler than the rest of bedroom 2, warmer air could be seen moving up behind the plasterboard dry lining from the room below. The external wall corner junction with ceiling also appeared to display a particularly cool surface temperature.

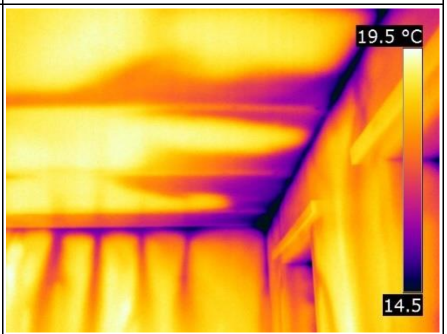
Bedroom 2 – Under depressurisation

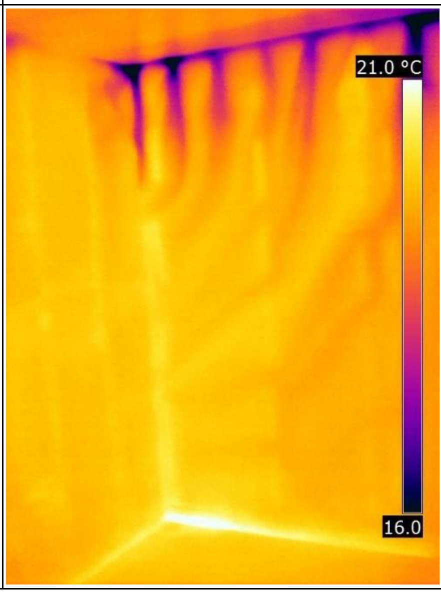


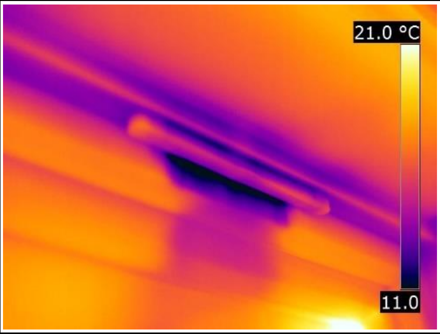
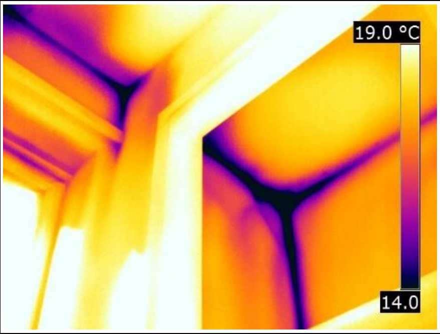
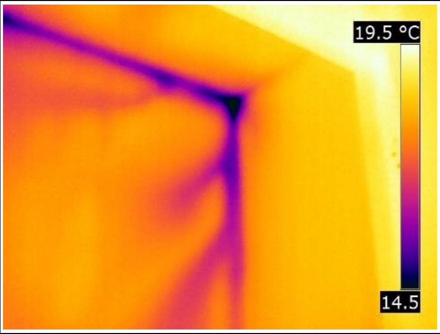
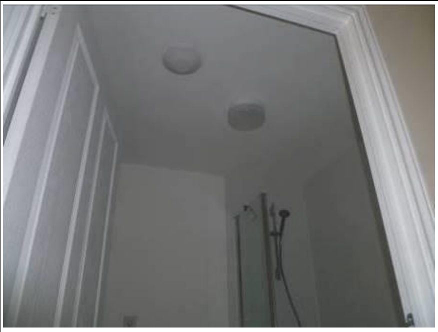



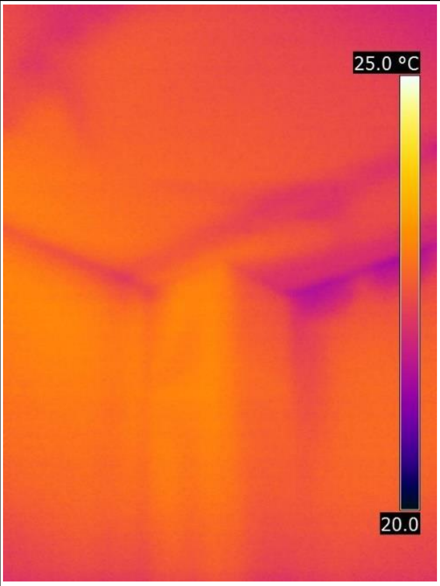


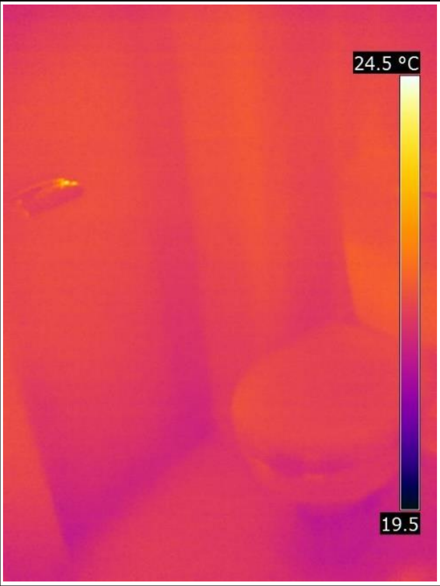




Under depressurisation there was extensive indirect infiltration into the dry lining void from around the windows, with lesser direct infiltration into the habitable space at the intermediate floor junction and around the central light fitting.

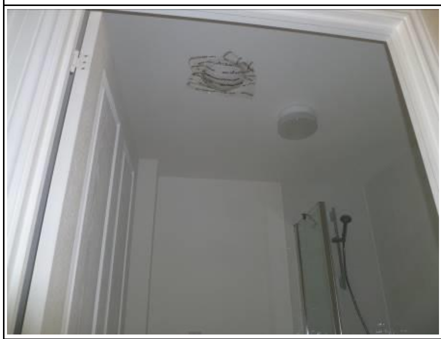
Cold air was also seen being drawn down from the loft space on both the external and party walls.

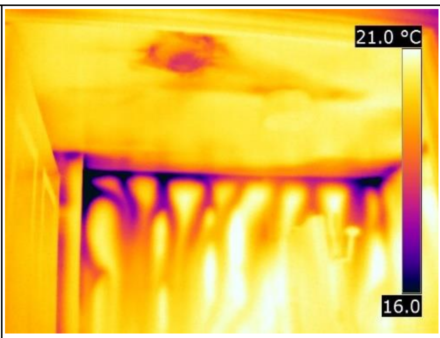
| | | |
|---|---|---|
|  |  | Air leakage was observed around most trickle vents under depressurisation. Generally the vents closed quite well, but infiltration occurred between the vents themselves and the window frames which they were only push-fitted against and not sealed. |
|  |  | The ceiling in the airing cupboard was again the coolest surface (apart from where external air was entering around the trickle vents) and highlights the need to keep this cupboard heated. |
|  |  | |
| Bathroom – Under natural conditions | | |
|  |  | Much like the party wall in bedroom 2, the bathroom was pretty much isothermal throughout under natural conditions. |
|  |  | |

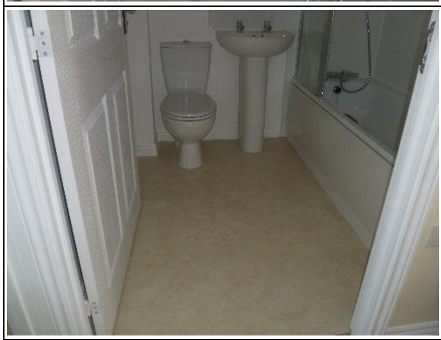



Bathroom – Under depressurisation



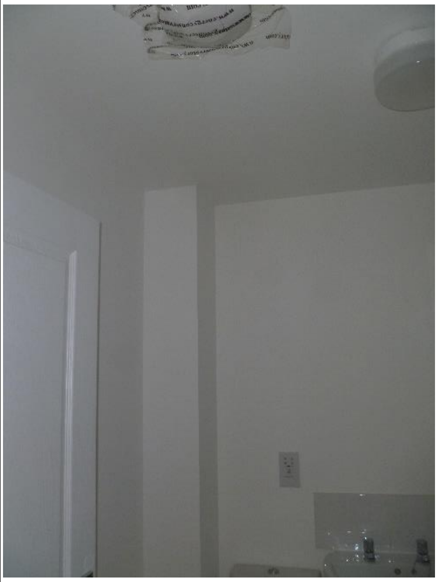
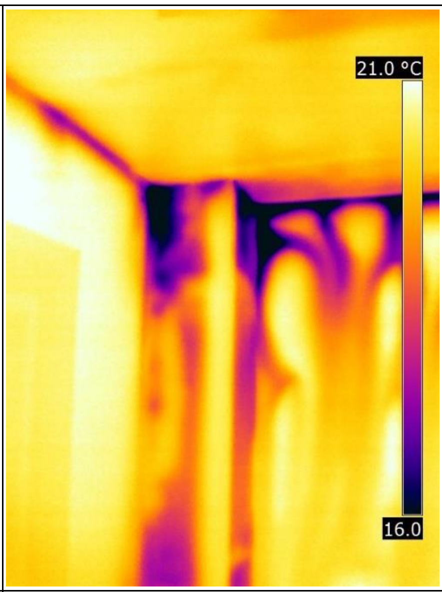


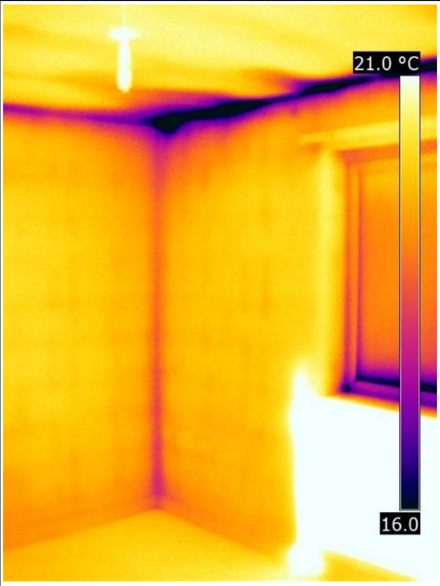




Under depressurisation the bathroom looked very different thermally, with cold air being drawn down from the loft space down the void behind the dry lining on the party wall and down the service riser.

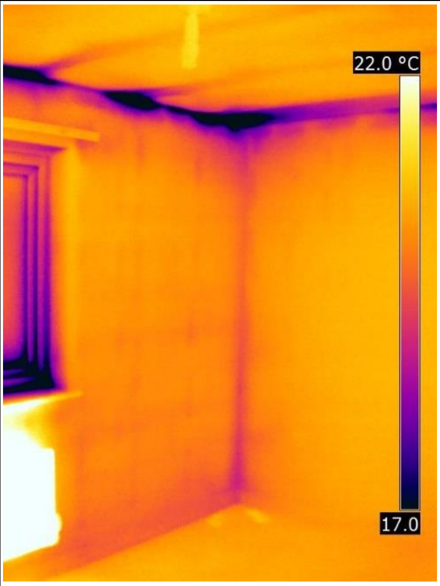
There was some air emerging at the floor wall junction backing on to bedroom 1, possibly tracking along from the stack.

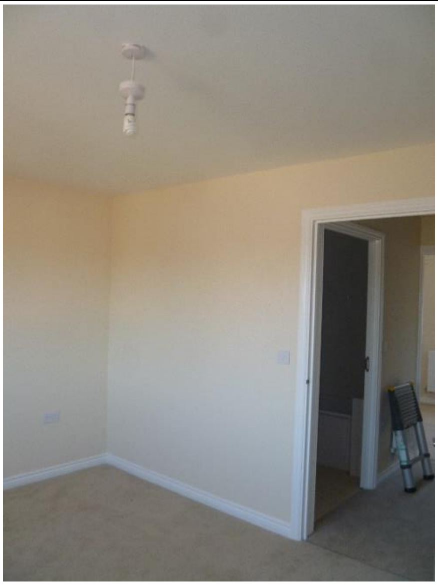
Service penetrations for the bathroom furniture appeared to perform very well.

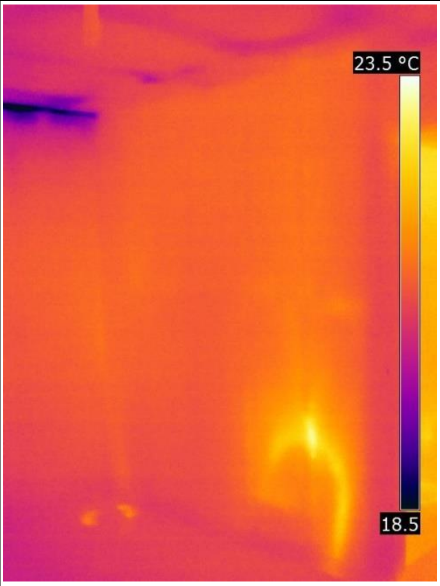
<table>
<tr><td></td><td><br></td><td></td></tr>
<tr><td></td><td><br></td><td></td></tr>
<tr><td colspan="3">Bedroom 1 – Under natural conditions</td></tr>
<tr><td></td><td><br></td><td>As observed in bedroom 2.</td></tr>
</table>

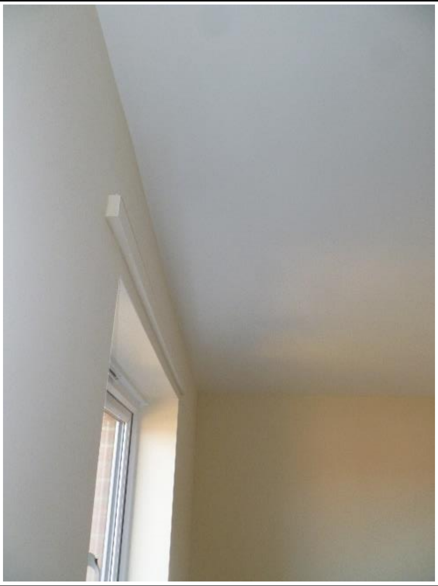

21.0 °C
16.0

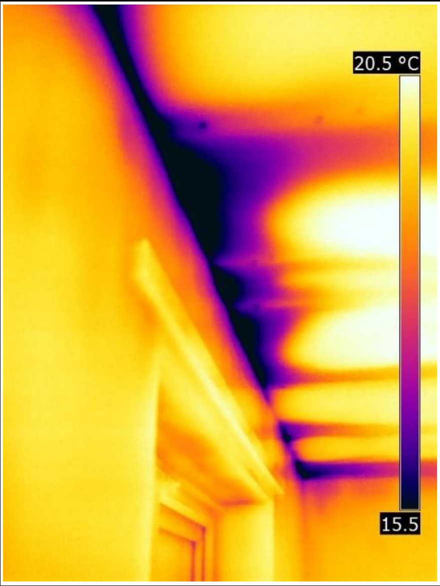

21.5 °C
16.5


22.0 °C
17.0

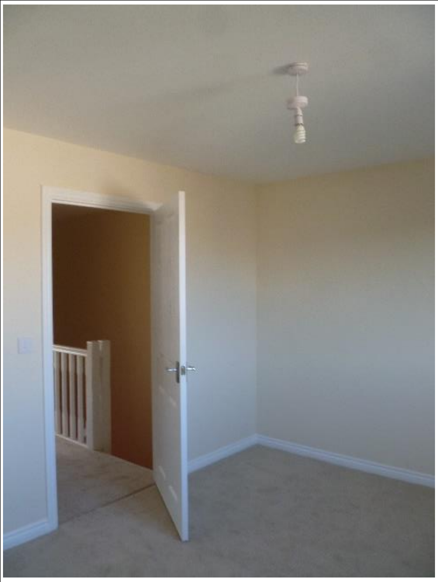


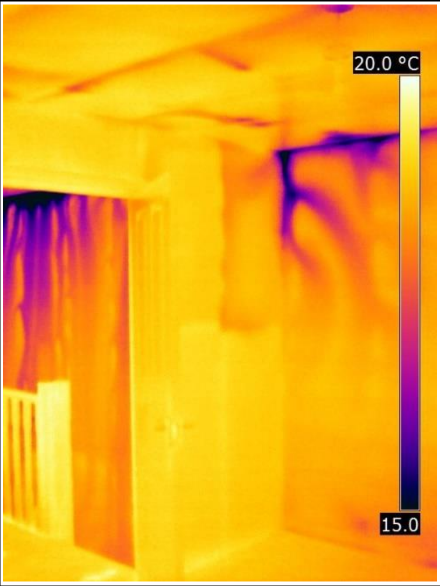





Bedroom 1 – Under depressurisation

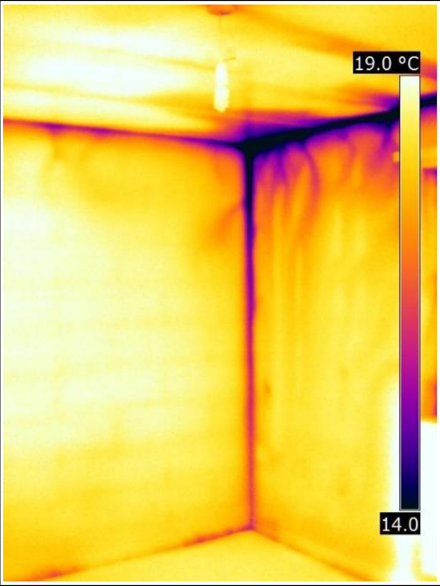
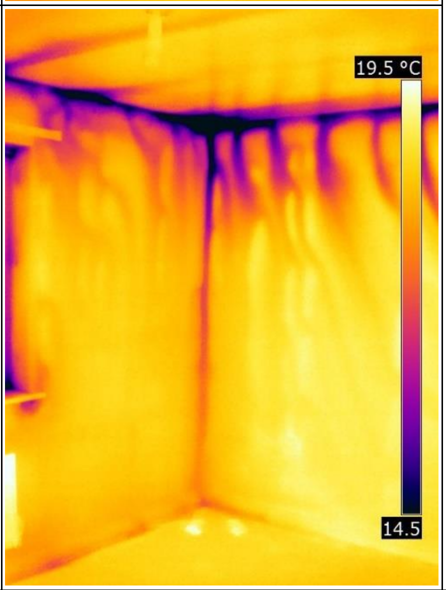





Under depressurisation air could be seen being drawn in from the loft space on both external walls and on the party wall.

On the gable wall, cooler air could also be seen entering the internal partition wall adjacent to the stairs/landing.

On the party wall, cooler air could also be seen entering the internal partition wall adjacent to the bathroom there the soil stack was positioned.

| | | |
|---|---|---|
|  |   | The external corner junction with the ceiling was again very cold, as seen in the airing cupboard in bedroom 2. |
|  |   | |
|  |   | |
|  |   | |

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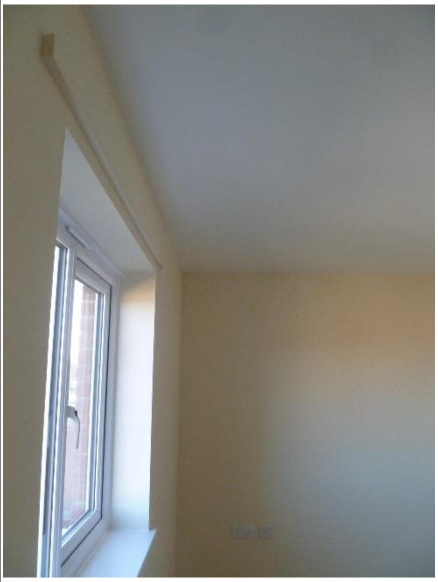
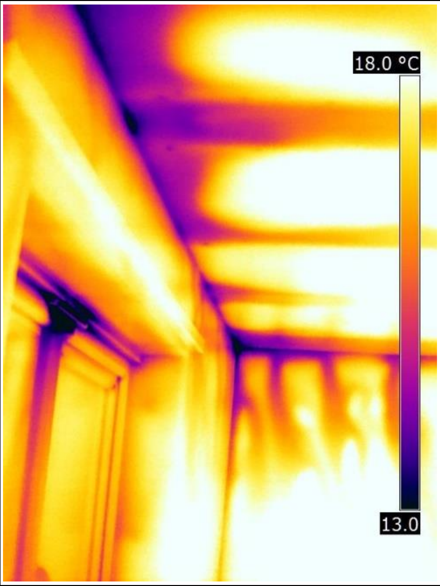
<tr><td></td><td>
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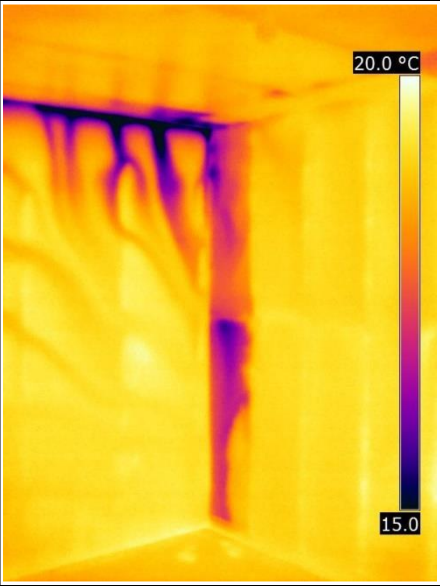
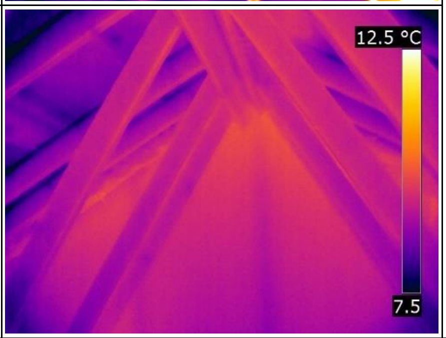
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Loft – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td rowspan="2">Around the loft hatch the insulation was not completely continuous, which may account for some of the observations made from the landing.</td></tr>
<tr><td></td><td>
</td></tr>
</table>

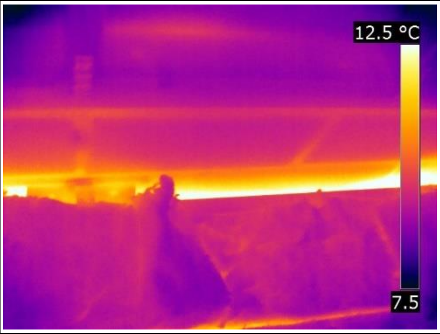

Along the party wall there was significant heat loss at the ceiling perimeter. This is likely to be due to the combined effect of thermal bridging and exfiltration of air from behind the plasterboard dry lining void. As there appears to be the warmest section of wall below the spandrel panel around the soil vent, it could well be that air movement is the most significant contributor to this heat loss.







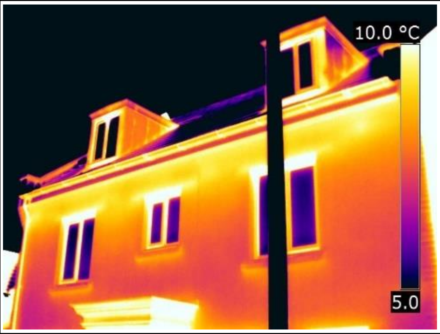
North East facing rear eaves, above bedroom 1, the insulation looks well laid from inside the loft; observations from below suggest that it might just be the top layer that is well-laid.

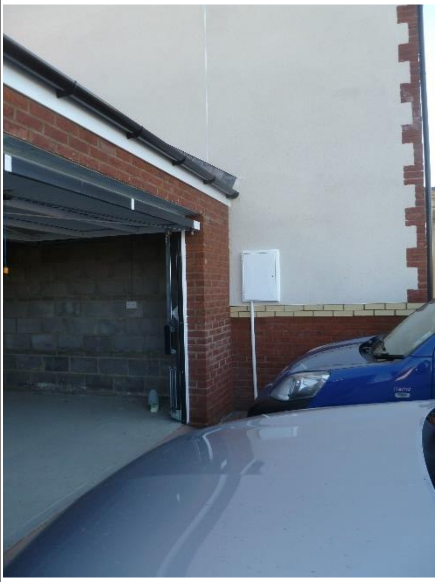
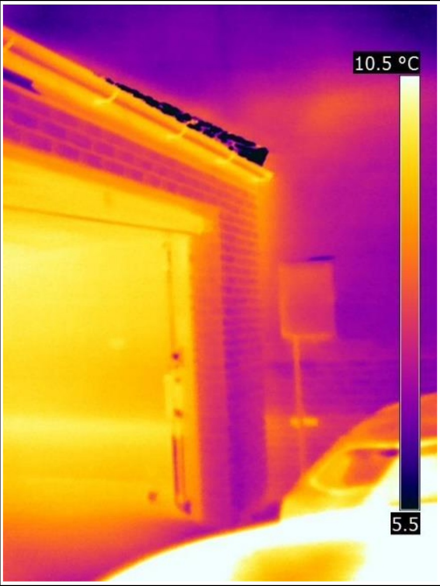
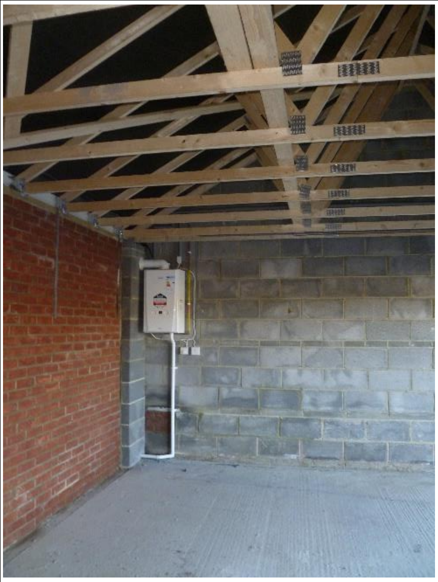
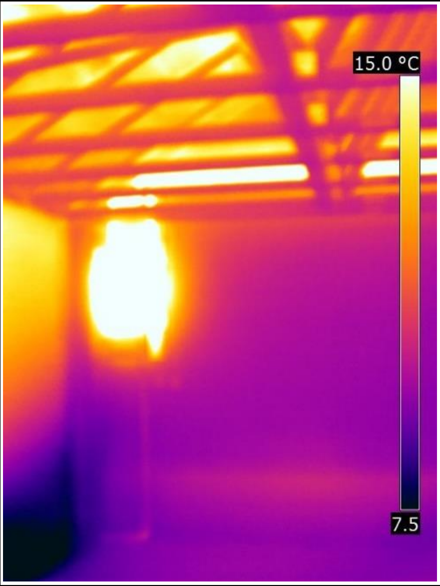
| | | |
|---|---|---|
|  |   | The North West facing gable wall showed a similar pattern of heat loss to the party wall. Here it was possible to see that there was no insulation between the end trussed rafter and the wall, with the non-continuous ribbon of plasterboard adhesive dabs clearly visible from above. |
|  |   | |
|  |   | |
|  |   | |
|  |   | The South West facing front eaves, above bedroom 2, looks similar to the other eaves junction. |

Plot 297

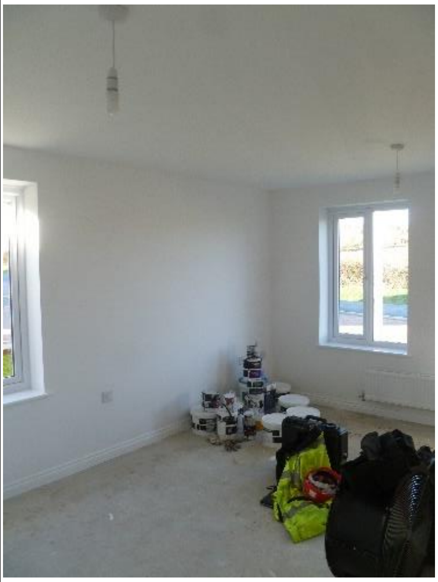
It was not possible to access the loft space as the loft hatch was too far from a suitable wall to safely site a telescopic ladder and reach the loft door.

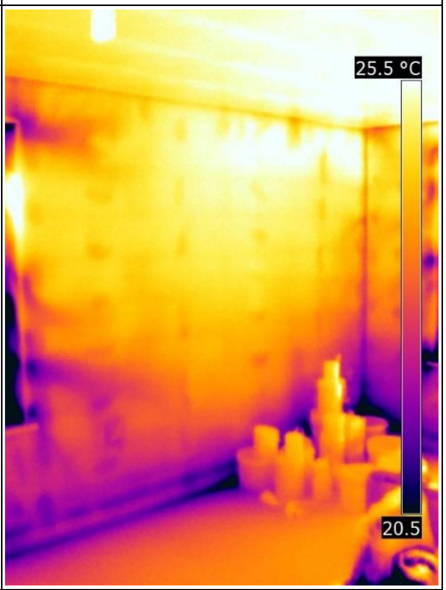
Thermal images under depressurisation were captured at an average pressure of -50.3Pa.

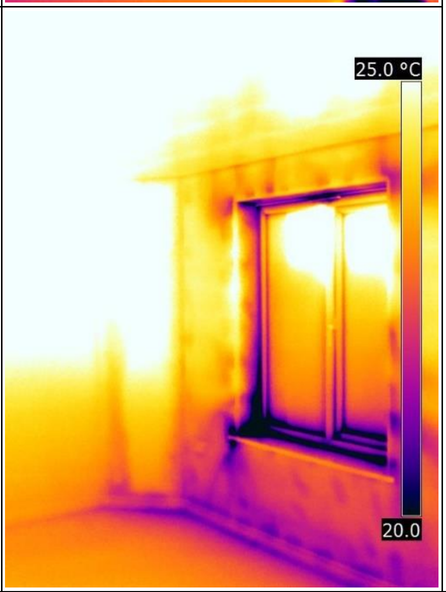
| External - Under natural conditions | | |
|---|---|---|
|  |  | The South West facing gable wall had been exposed to direct solar radiation for over an hour prior to the survey, but the North West facing front façade had not.<br><br>The gable wall still showed warmer strips at intermediate floor levels, although this was compromised by the direct solar.<br><br>The eaves junction looks warmer but with the same caveats as with plot 294, and the ground floor perimeter looks slightly warmer than the rest of the external façade. |
|  |  | |
|  |  | |
|  |  | Neither the front façade nor North East gable wall had been exposed to direct solar. Here the warmer strips at intermediate floor levels are more apparent, as is a warmer section at the ridge. |
|  |  | |

| | | |
|---|---|---|
|  |   | |
|  |   | The attached garage on the North East gable wall sheltered most of the ground floor and some of the 1st floor. The boiler itself was providing heat to the garage, as was the insulated pipework. Even so, the warmer strip at the ground floor perimeter was still visible from within the garage. |
|  |   | |
|  |   | |


Lounge – Under natural conditions

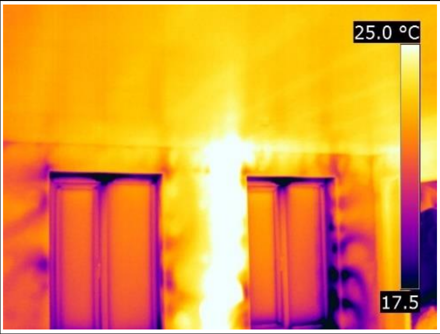


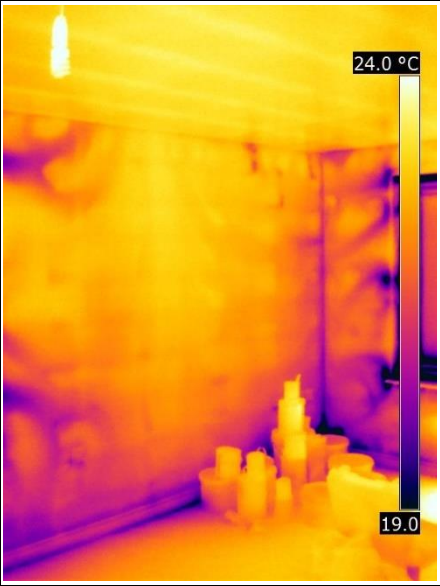

With the wind blowing directly on to the front façade of the property the combined wind-driven effects and natural stack made the rooms on the ground floor at the front of the house significant infiltration zones even under natural conditions. Infiltrations cooler air could be seen entering the void behind the dry lining without any induces negative pressure.

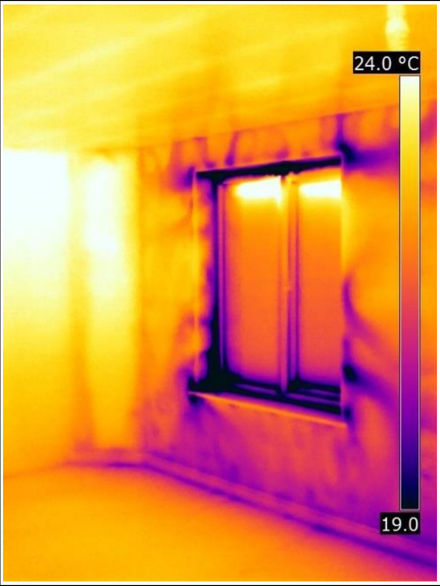
The ground floor perimeter did appear markedly cooler than the walls above, more so than would be expected due to just natural internal temperature stratification.

Lounge – Under depressurisation

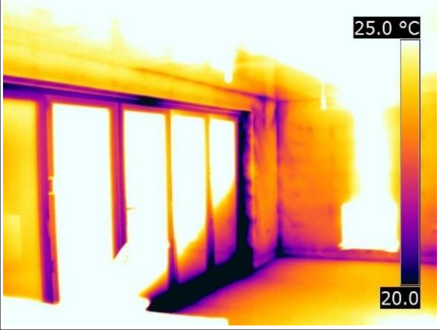



The infiltration observed under natural conditions was exacerbated under depressurisation on both the front elevation and on the South West facing gable wall.

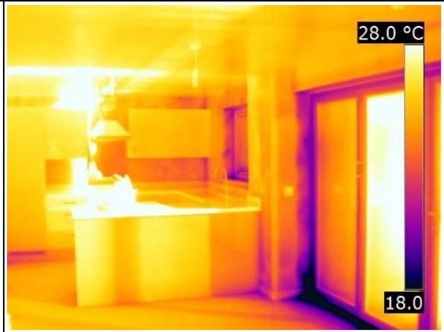




Dining/Kitchen – Under natural conditions







The Dining/Kitchen extended across the entire rear elevation at the ground floor; unlike the Lounge and Study this was on the leeward side of the dwelling and infiltration around the windows under natural conditions was much reduced. However the patio door jambs and threshold appeared particularly cool. The jamb adjacent to the kitchen was even colder than the window head, but this was partially due to shading by the frame. The threshold also appeared very cool.

Dining/Kitchen – Under depressurisation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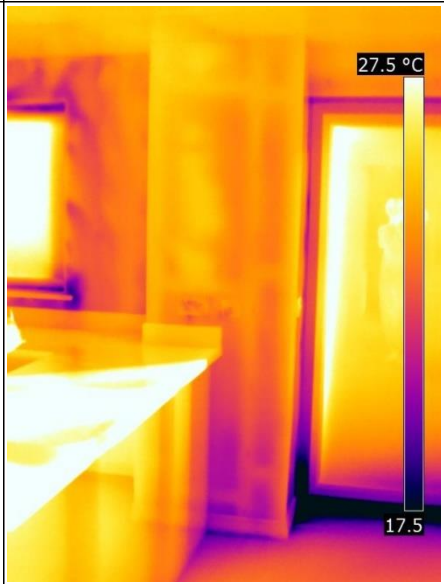
<td></td>
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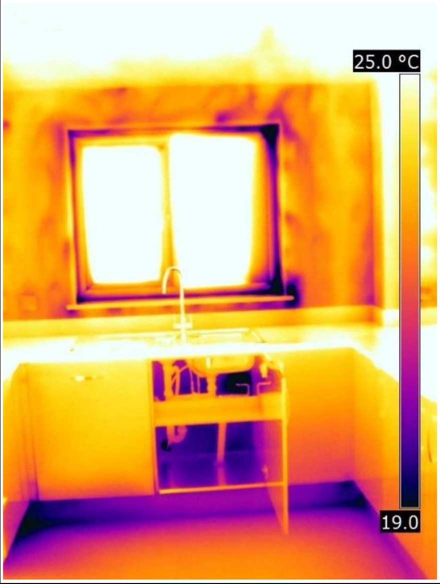
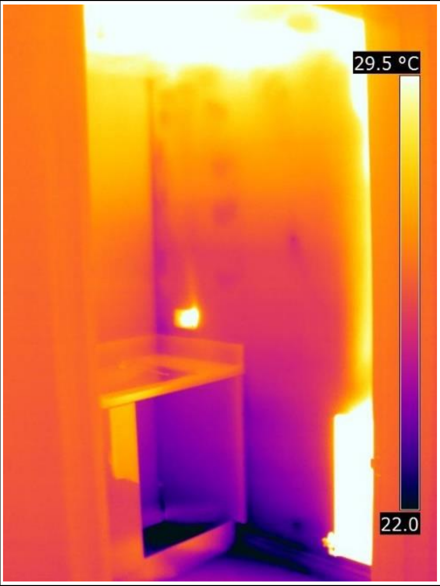
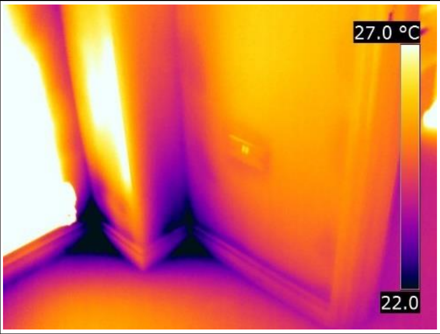
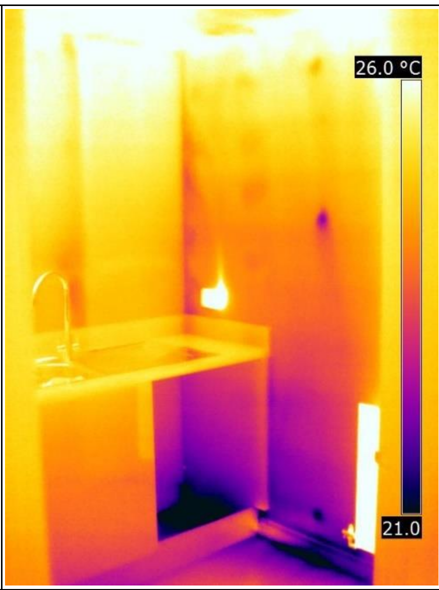
<td></td>
<td>The actual doors and windows performed reasonably well, but infiltration into the dry lining void appeared to occur at all jambs, heads and threshold/sills. Possibly a sign that the external wall cavity is not being closed off fully?<br><br>The service riser appeared to show air being drawn in from beneath, but this may possibly be from the threshold/jamb junction rather than around the floor penetration.<br><br>Service penetrations below the sink showed only minor infiltration.</td>
</tr>
<tr>
<td colspan="3">Utility – Under natural conditions</td>
</tr>
</table>




The floor wall junction backing on to the garage looked cooler, but as this room was warmer than the rest of the house it was hard to tell if this was significant.

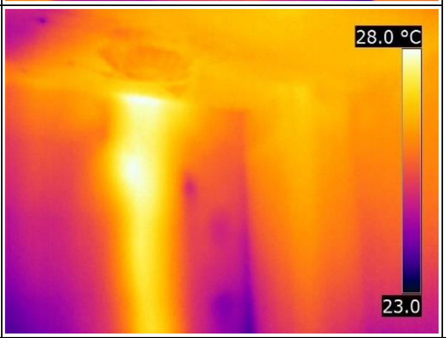


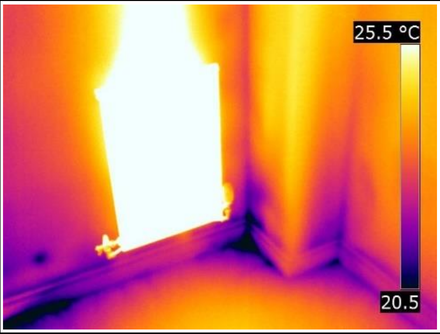

Utility – Under depressurisation



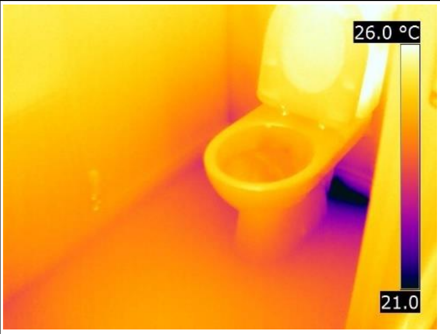

Cold spots on the external wall again suggest (as in the previous plot) that there may be gaps in the inner leaf blockwork that allow air to infiltrated directly from the external wall cavity into the void behind the dry lining.

The service riser looks a little cooler nearer the base, but it is still fairly warm.

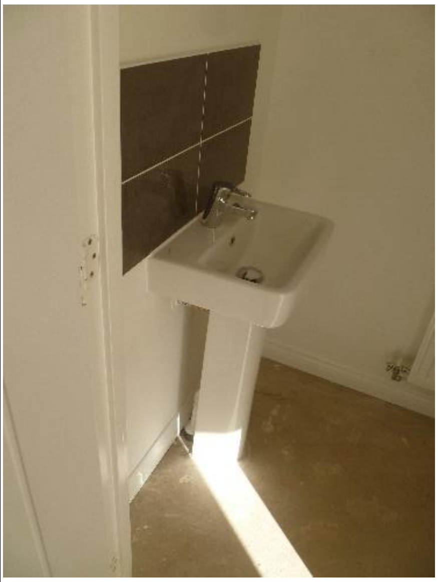


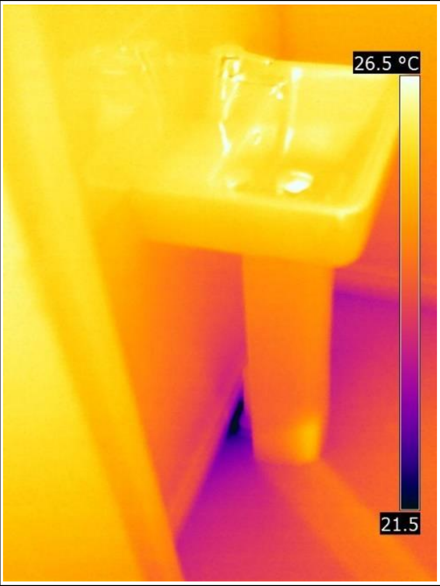



Ground Floor WC – Under natural conditions

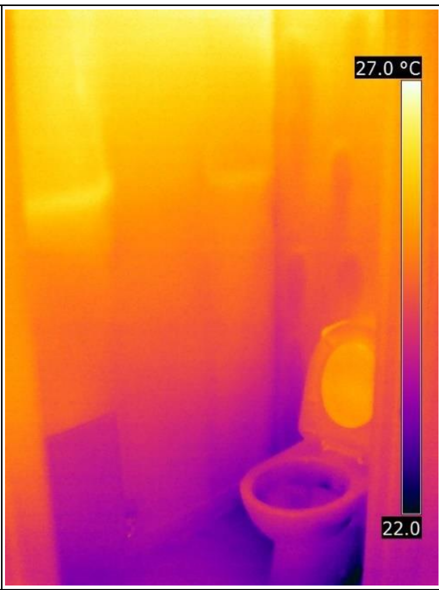



The ground floor WC has no external walls so it would be unlikely to exhibit any strange behaviour, cooler patches around the service penetrations through the floor can be explained by the different filling materials around the penetrations.

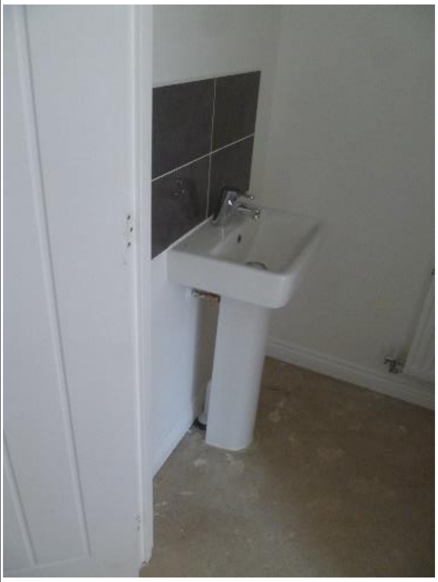


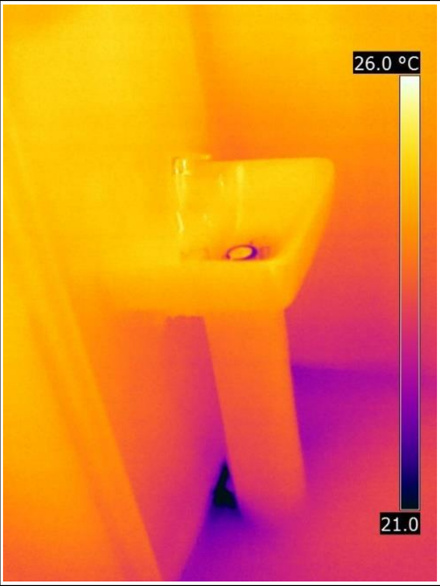



Ground Floor WC – Under depressurisation

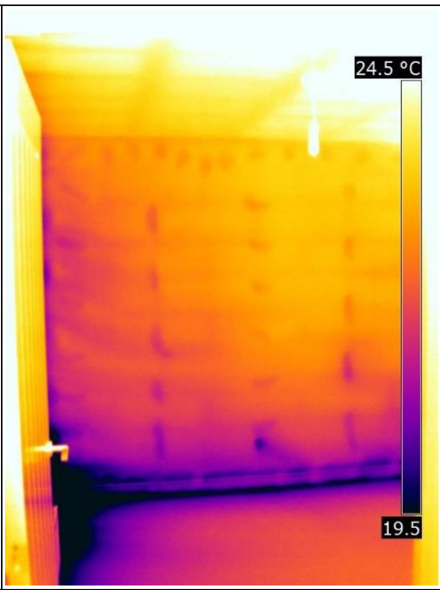



Under depressurisation air can be seen moving upwards through the partition wall adjacent to the utility.



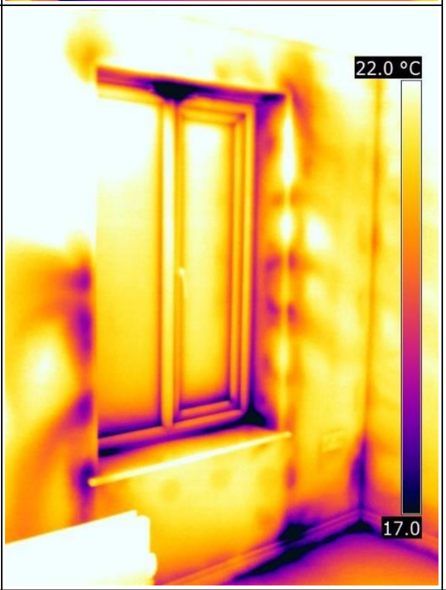



Study – Under natural conditions




The gable wall was party covered by the garage and contained the electricity meter box, but neither of these were obvious under natural conditions. The ground floor perimeter was again coole and the pattern of the blockwork visible through the dry lining.

As in the Lounge, the front-facing windows were on the windward side of the house making it an infiltration zone. There appears to be infiltration below the window adjacent to where the gas meter box is positioned.



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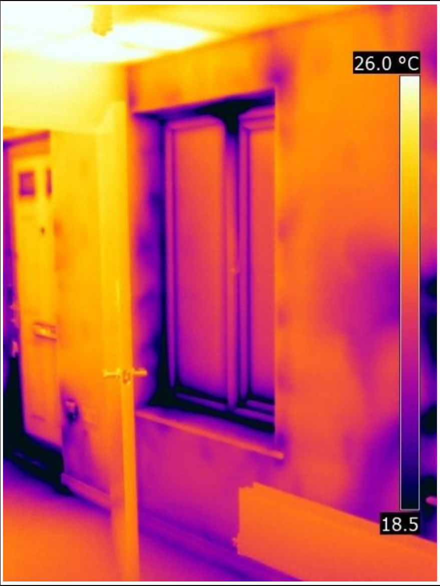
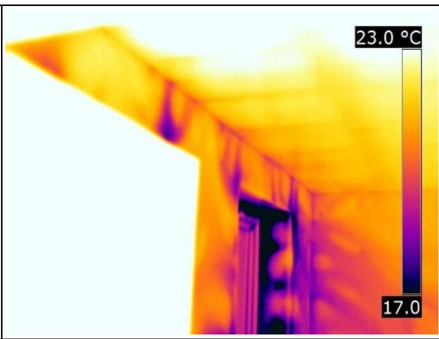
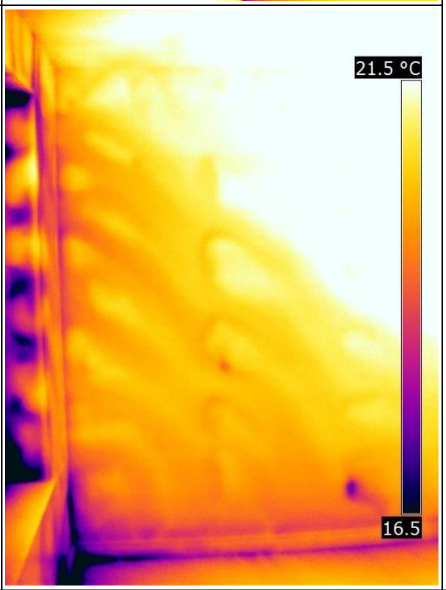
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Study – Under depressurisation</td></tr>
<tr><td></td><td></td><td rowspan="3">Again, under depressurisation the infiltration paths appear significantly worse, with infiltrating air entering the dry lining void all around the windows.<br><br>Adjacent to the gas meter box more air is entering, some of which appears to emerge below the skirting.<br><br>On the gable wall there are a couple of spots that again appear to line up with the inner leaf mortar courses. However, the position of the electricity meter box is not visible internally under pressurisation, unlike what was observed with fully filled walls behind meter boxes.</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
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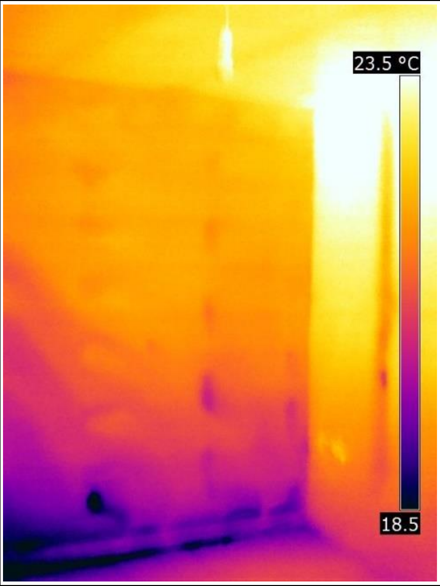
<tr><td></td><td>
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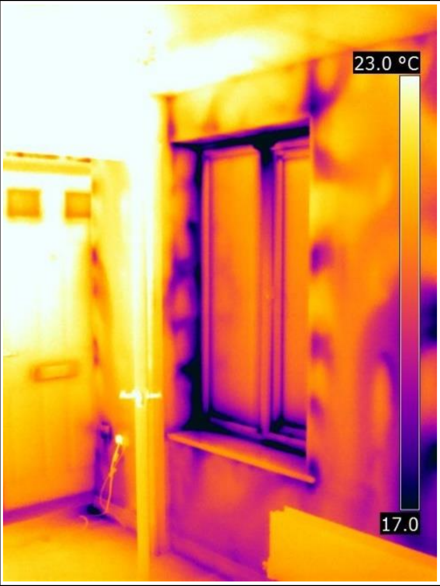
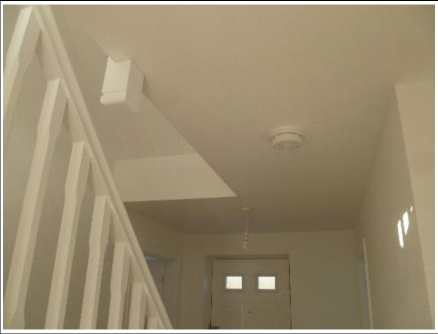
<tr><td></td><td>
</td><td rowspan="2">As with most windows and trickle vents observed on this site; the windows function well but allow significant air exchange between the void behind the dry lining and the external wall cavity, and the trickle vents close effectively but are not actually sealed to the window frames.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="3">Hall & Stairs – Under natural conditions</td></tr>
</table>







The door perimeter is again significantly cooler than the centre of the door, as seen in plot 294.

The threshold is also very cold, although the door having been opened a number of times may have made this look worse.

The external wall in the hall showed numerous cooler spots and air leakage paths, but this did not appear to affect the intermediate floor void directly above.

Hall & Stairs – Under depressurisation


Again, under depressurisation the observations made under natural conditions were the same, just more extreme.

<table>
<tr><td></td><td>
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<tr><td></td><td>
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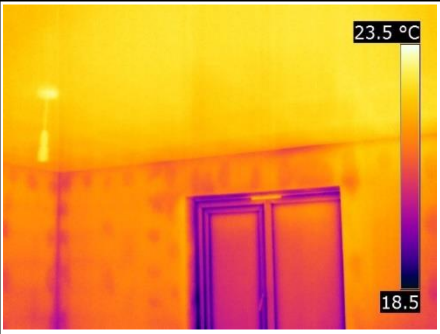
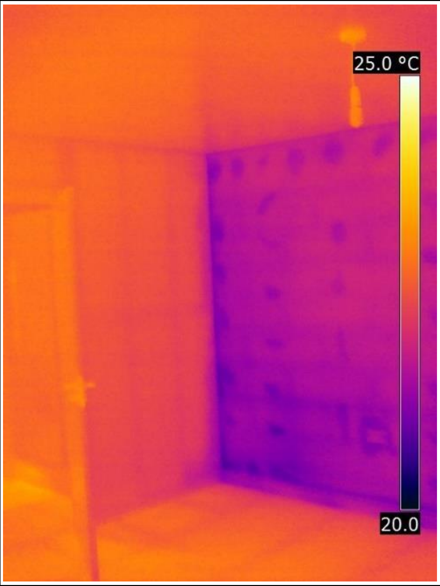
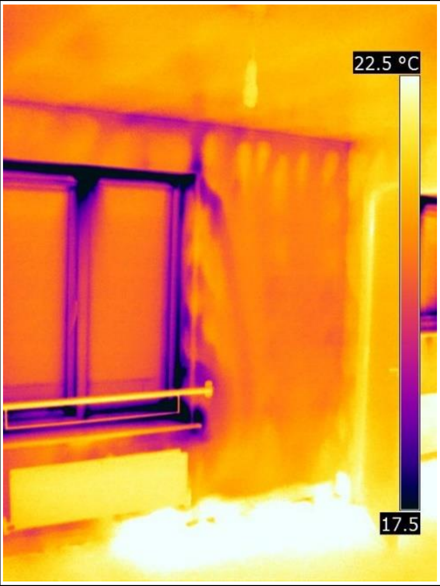
<tr><td colspan="3">Bedroom 1 – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td rowspan="2">Above the lounge on the 1st floor it no longer appears to be an infiltration zone under natural conditions. The external walls show the blockwork pattern and the adhesive dabs, but no air movement around them or significant thermal anomalies.</td></tr>
<tr><td></td><td>
</td></tr>
</table>

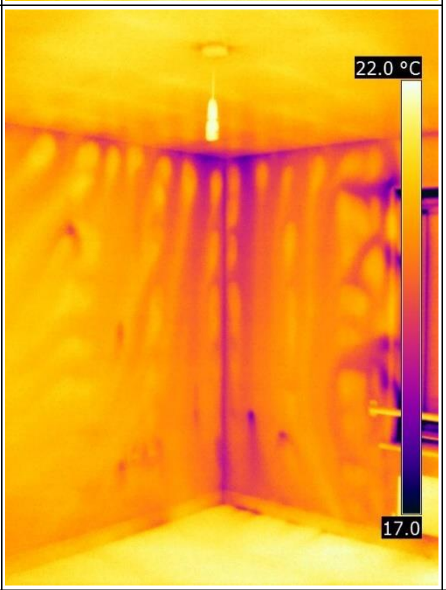


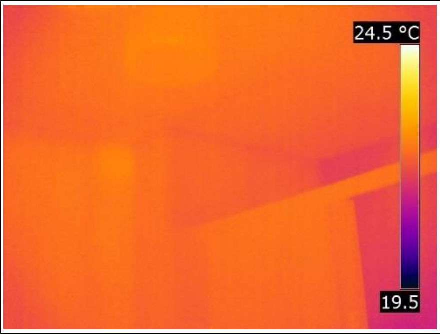
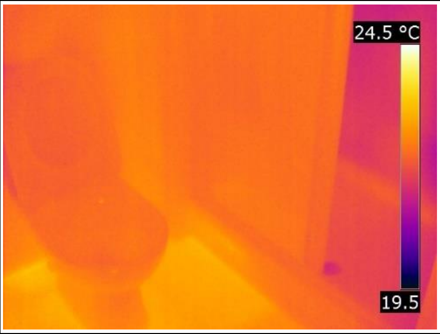

Bedroom 1 – Under depressurisation

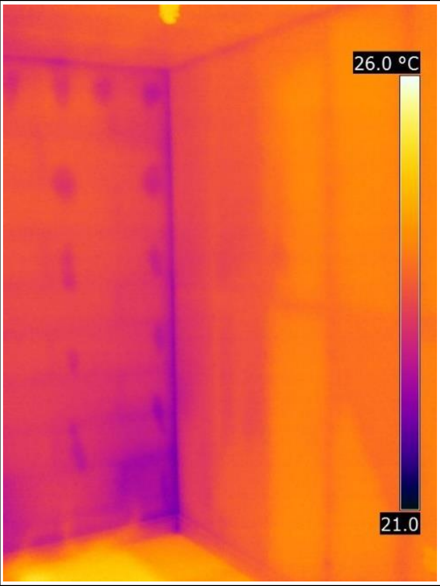


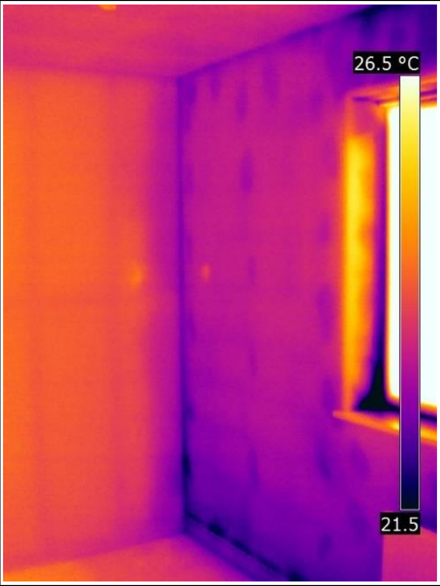

Under depressurisation air is again drawn into the dry lining void from around the windows, and also downwards from the eaves more so than from the gable. The gable wall appears to show air moving across through this void rather than downwards.

Again cold spots are seen where air appears to be coming through the blockwork.

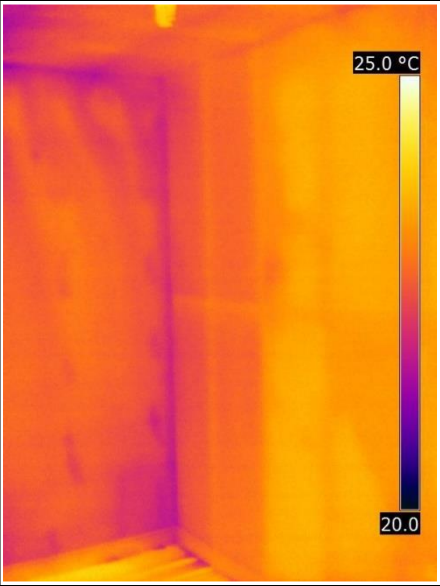


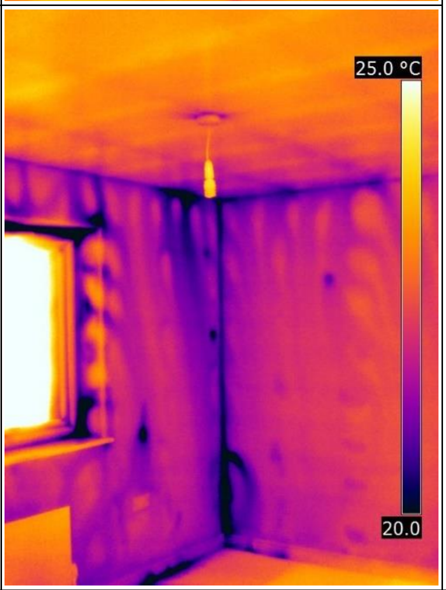
| | | |
|---|---|---|
|  |  | |
|  |  | |
| 1st Floor En-Suite – Under natural conditions | | |
|  |  | This looks fairly isothermal under natural conditions. |
|  |  | |
| 1st Floor En-Suite – Under depressurisation | | |
|  |  | Under depressurisation the 1st floor en-suite looks similar to under natural conditions, with no significant air movement around the service penetrations (apart from a poorly temporarily sealed extract grille). |

<table>
<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">The internal partition walls backing onto the en-suite shower and service void in the bathroom look slightly cooler than the rest of the partition walls, but otherwise the room appears very similar to the observations made for bedroom 1.</td></tr>
<tr><td></td><td></td></tr>
</table>




Bedroom 4 – Under depressurisation

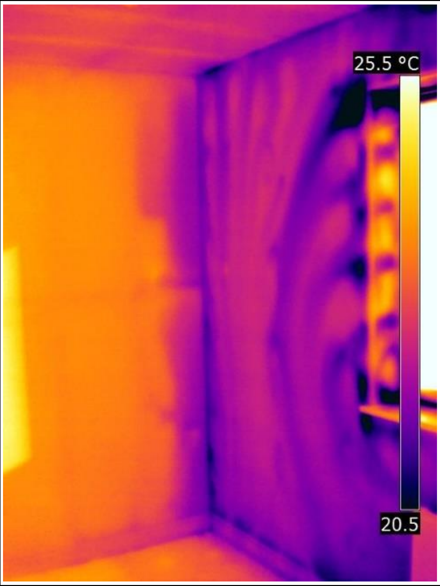


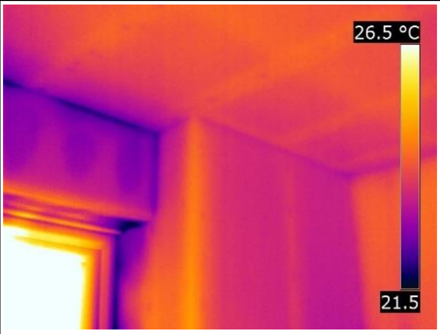

The partition wall backing onto the en-suite looks the same under depressurisation as it did under natural conditions so does no appear to be affected by air movement, the same cannot be said of the one backing onto the service void in the bathroom.

As in bedroom 1 the gable wall appears to be less affected by air movement than the other external wall under depressurisation.

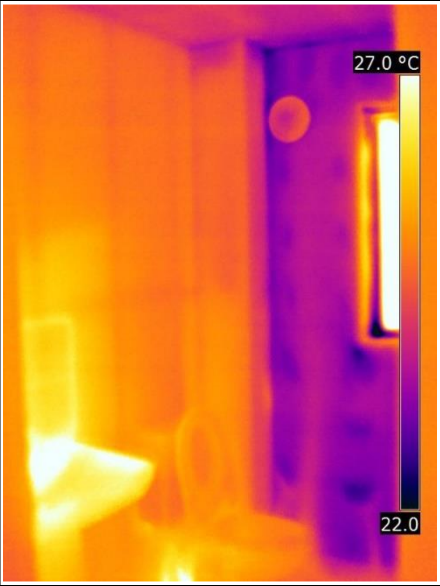
Again cold spots appear under depressurisation which coincide with mortar joins in the inner leaf blockwork.



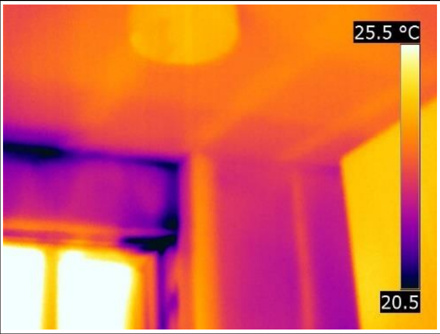

Bathroom – Under natural conditions




The external wall is unsurprisingly cooler than the boxed in voids, but otherwise there's not much happening in the bathroom under natural conditions.


Bathroom – Under depressurisation







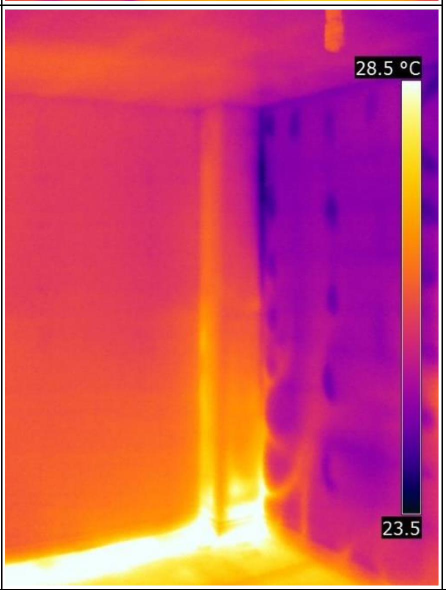
Under depressurisation the boxed in void adjacent to bedroom 4 appears cooler at the top, implying that air is being drawn down from above into the void.

There is a great deal of air movement in the void behind the plasterboard, particularly around the extract grille. It would appear that the grille is sealed nicely to the plasterboard where it is visible, but not sealed behind the plasterboard where it penetrated the blockwork.

Some infiltrations is also detected coming into the bathroom at the junction of the floor with the external wall.

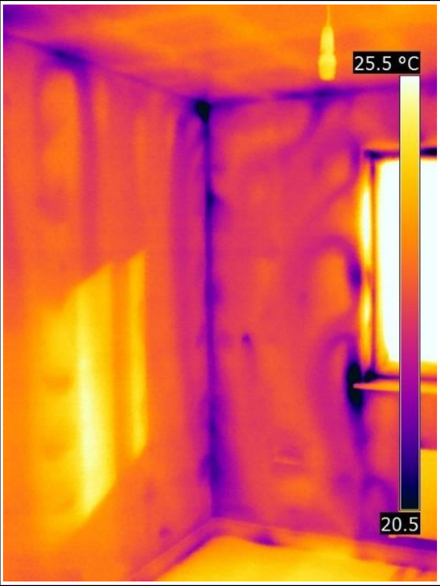
Bedroom 3 – Under natural conditions

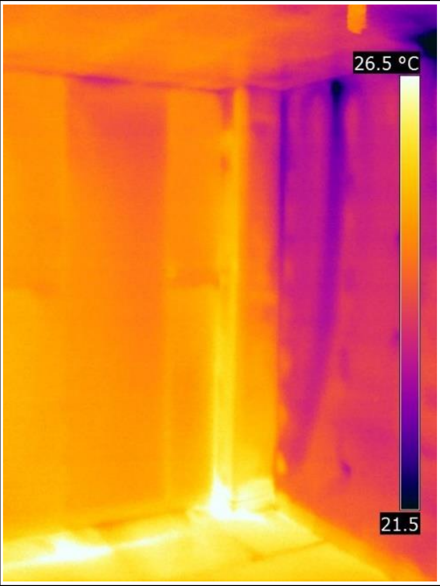

Warm air can be seen being drawn up from the intermediate floor void into the dry lining void under natural conditions on both external walls above the kitchen and utility.

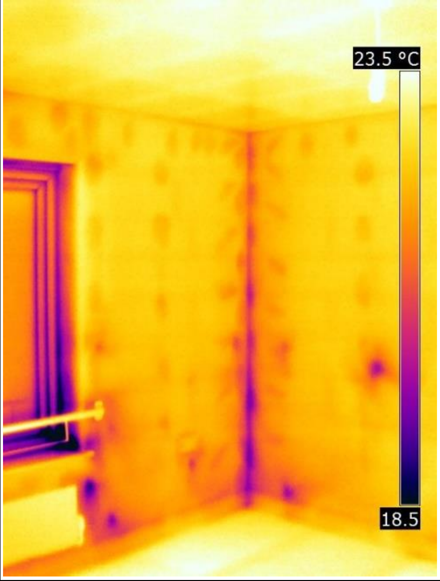

Bedroom 3 – Under depressurisation


Under depressurisation the warm air moving up the wall void has been replaced by colder air entering from around the window on the rear elevation and being drawn down from above on the gable wall.



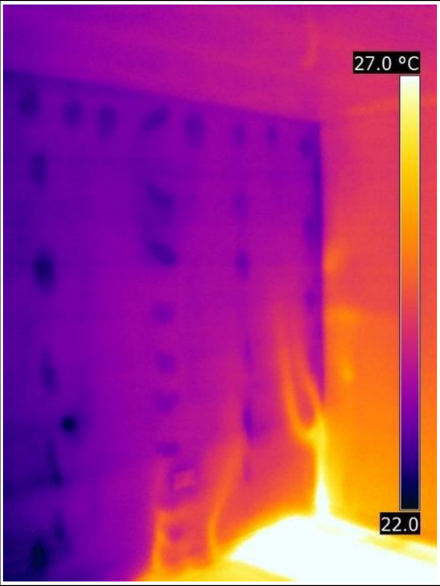



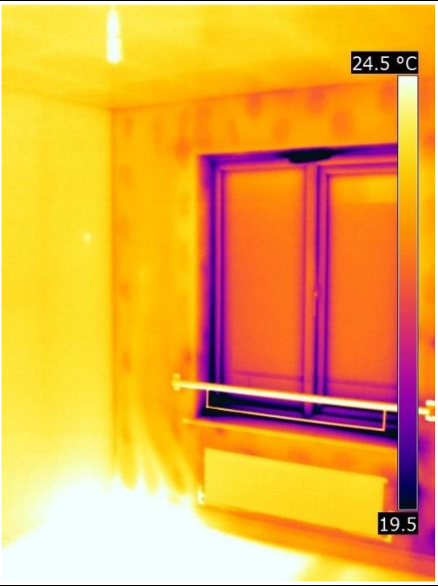

Bedroom 5 – Under natural conditions




The cooler North corner shows some cold spots possibly due to gaps in the inner leaf blockwork.

As in bedroom 3 warm air can be seen being drawn up from the intermediate floor void into the dry lining void under natural conditions on both external walls above




Bedroom 5 – Under depressurisation

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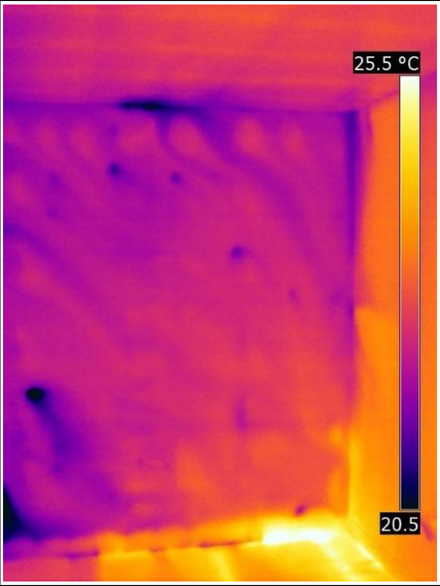
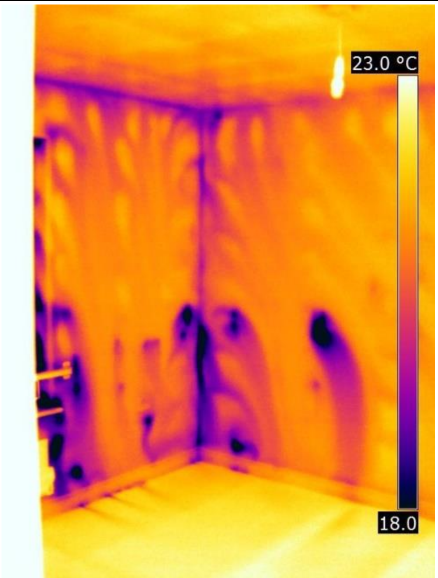
|---|---|---|
|  |  | As in bedroom 3 the warm air moving up the wall voids under natural conditions has been replaced by colder air entering from around the window on the front elevation and being drawn down from above on the gable wall.<br><br>The cold spots on the wall presumably due to leaky blockwork are more extreme under depressurisation, with some infiltrating air emerging at the floor perimeter. |
|  |  | |
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|  |  | |
| 1st Floor Landing & Stairs – Under natural conditions | | |

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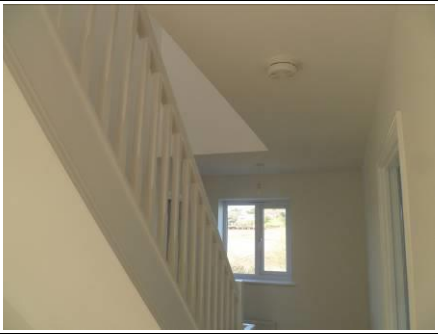
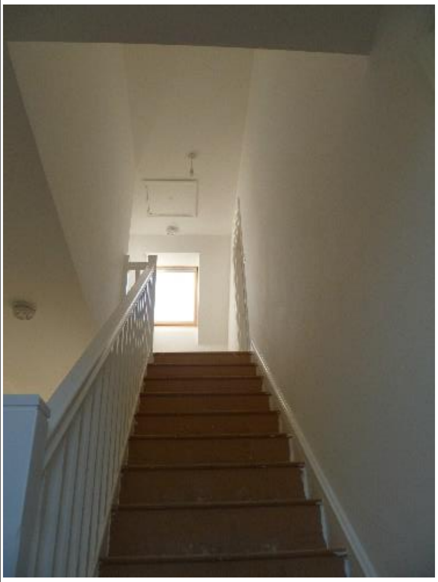
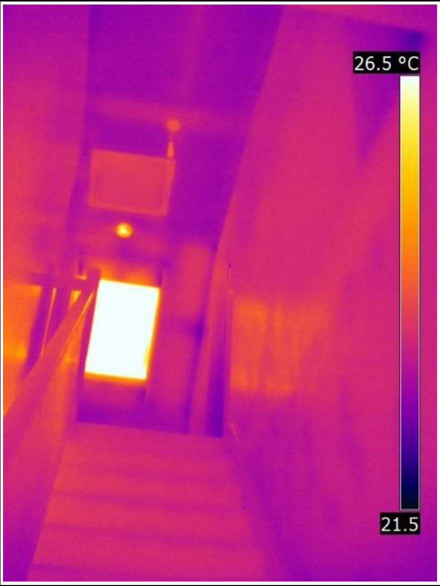
<tr><td></td><td>
</td><td rowspan="3">As in bedrooms 3 & 5, warmer air can be seen moving up the void behind the plasterboard under natural conditions.<br><br>Looking upwards to the 2nd floor there appears to be only small deviations in surface temperatures.</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="3">1st Floor Landing & Stairs – Under depressurisation</td></tr>
<tr><td></td><td>
</td><td>Once again, air being drawn in around the window opening under depressurisation moves around the dry lining void.<br><br>Air can also be seen being drawn in around the loft hatch.</td></tr>
</table>

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<tr><td></td><td>
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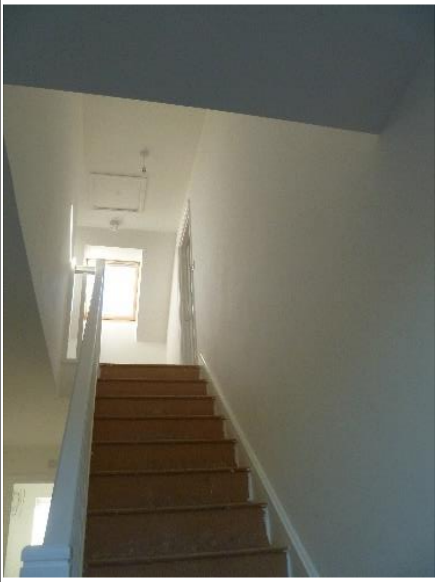
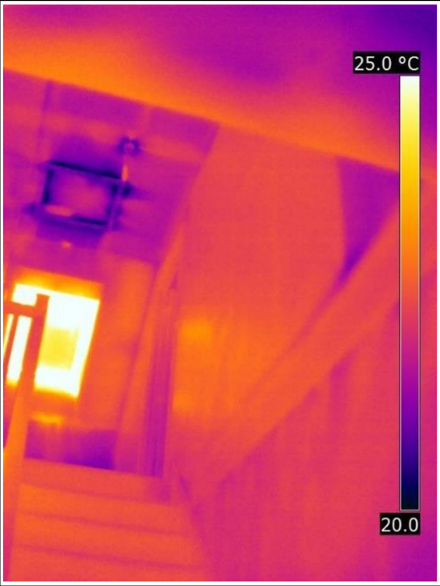
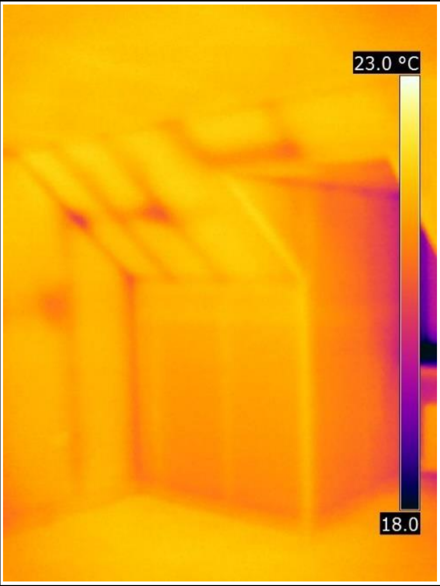
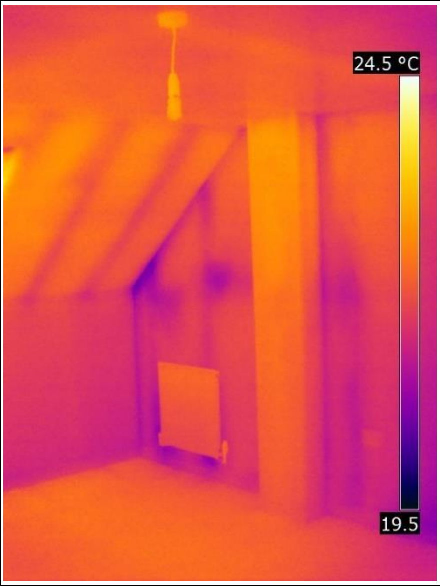
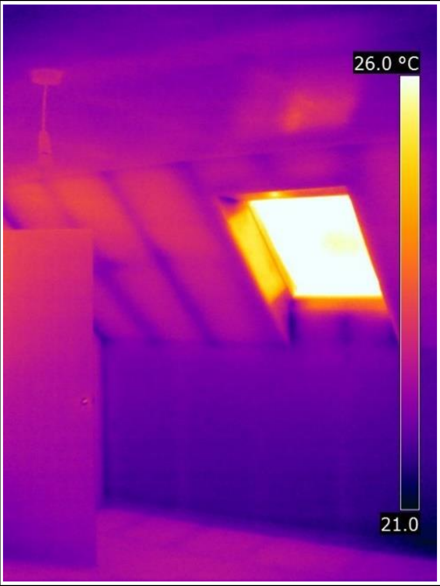
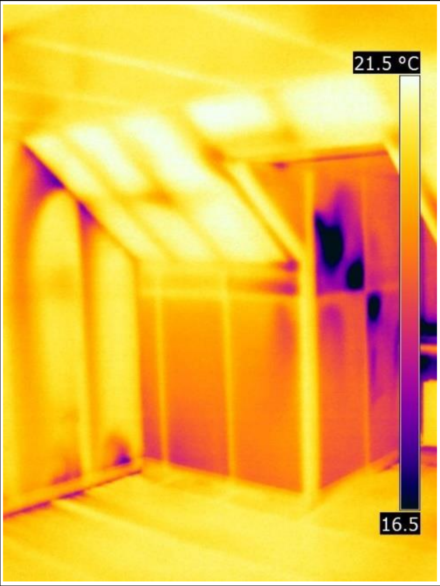
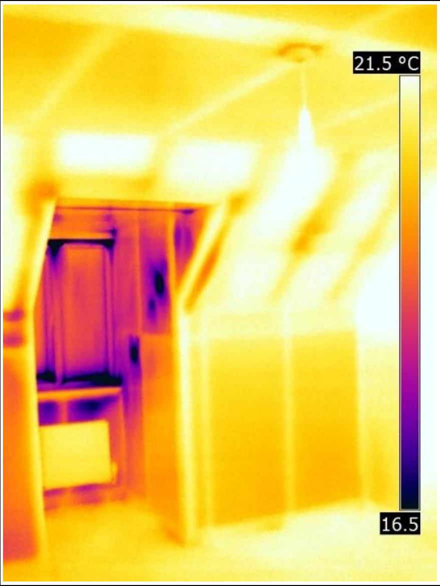
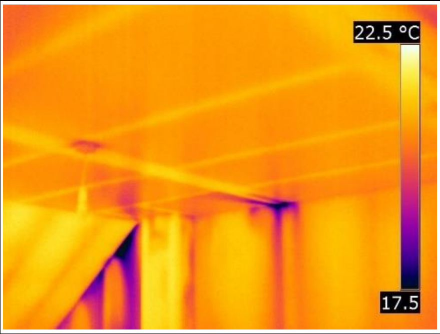
<tr><td></td><td>
</td><td></td></tr>
<tr><td colspan="3">Bedroom 6 – Under natural conditions</td></tr>
<tr><td></td><td>
</td><td>Under natural conditions there is not much variation in surface temperatures as the 2nd floor is an exfiltration zone and warmer air is more likely to be escaping the house.<br><br>The cooler timber and warmer insulated areas of the sloping sections and spandrel show areas without voids behind, the areas with voids behind show warmer timbers and cooler uninsulated sections.</td></tr>
</table>

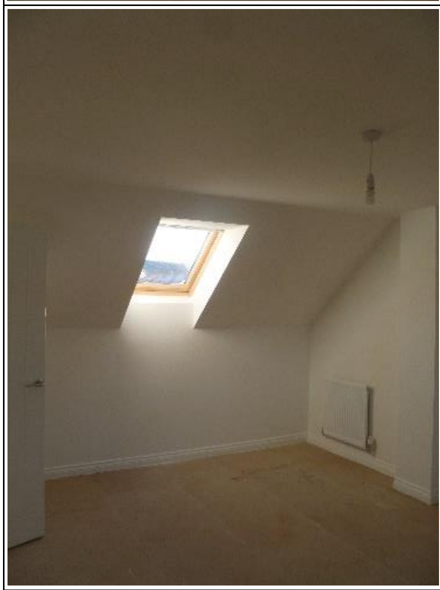
| | | |
|---|---|---|
|  |  | |
|  |  | |
| Bedroom 6 – Under depressurisation | | |
|  |  | The areas with voids behind have become much cooler as cold air is drawn into those voids under depressurisation. This cooler air can be seen being drawn down the gable wall and emerging at the floor/wall junction.<br><br>The dormer cheeks appear to be an issue when the direction of air movement in reversed. Cold air appears to be bypassing any insulation in the cheeks.<br><br>Air infiltrations around the dormer window appears to still be of |

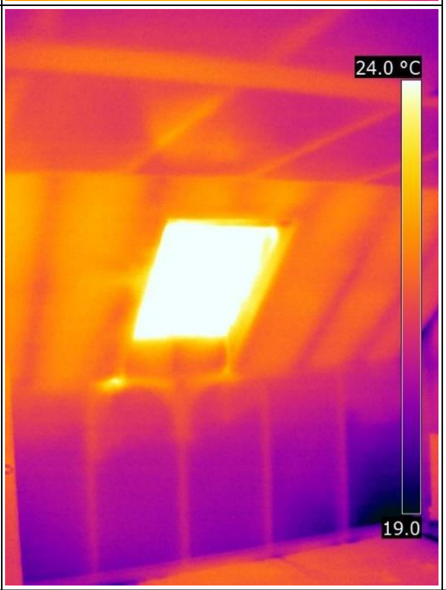
concern; the roof-light however appeared to perform very well.









<table>
<tr>
<td></td>
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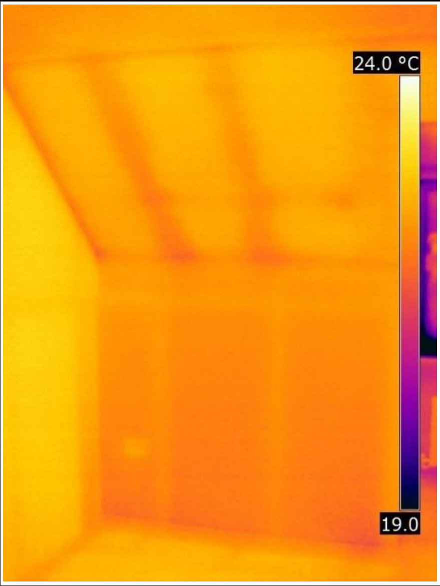
<tr>
<td colspan="3">Bedroom 2 – Under natural conditions</td>
</tr>
<tr>
<td></td>
<td>
</td>
<td rowspan="2">Observations as bedroom 6.</td>
</tr>
<tr>
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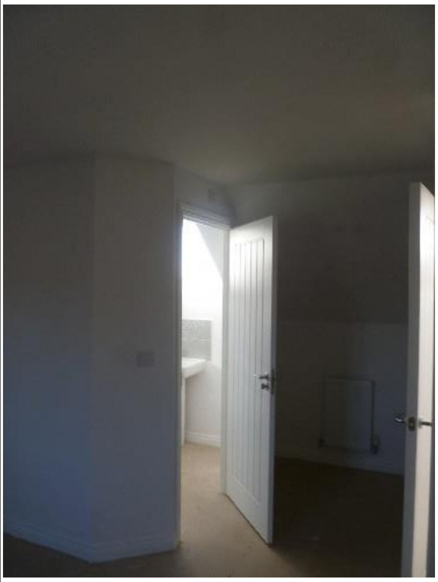
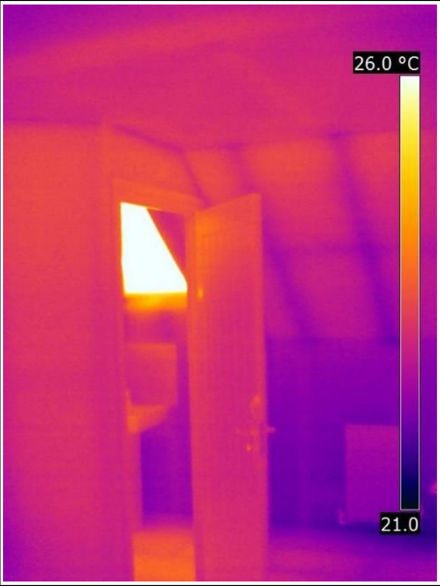
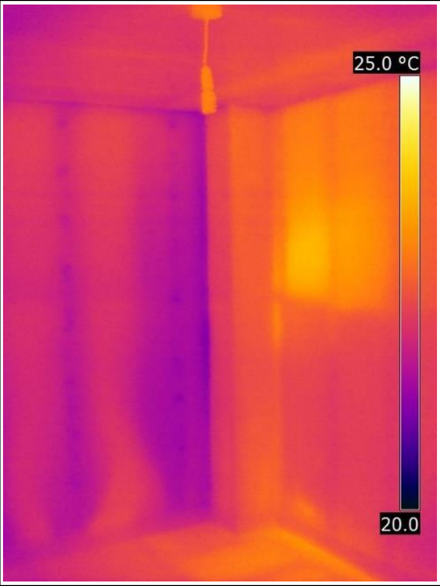
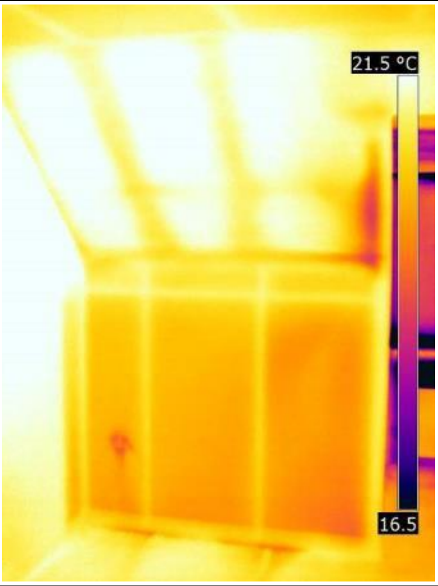
</tr>
</table>





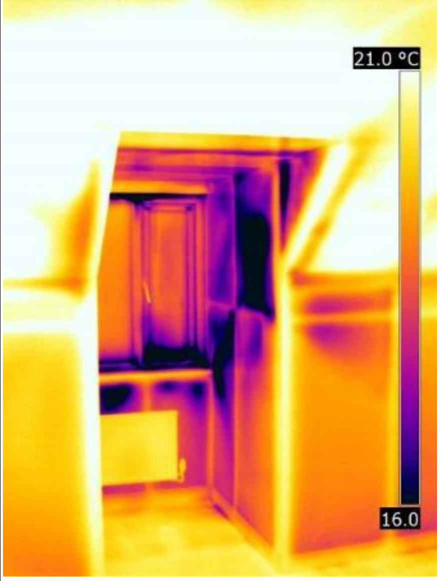

Bedroom 2 – Under depressurisation

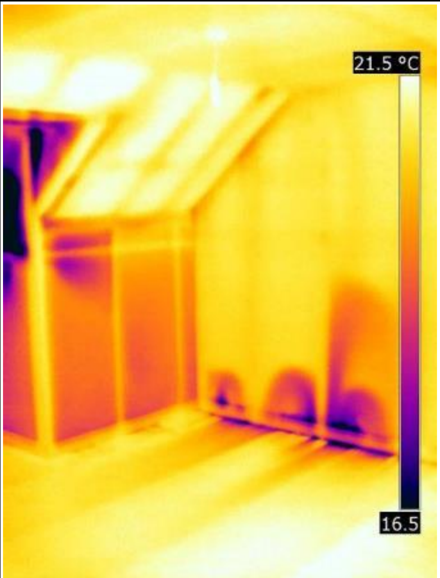


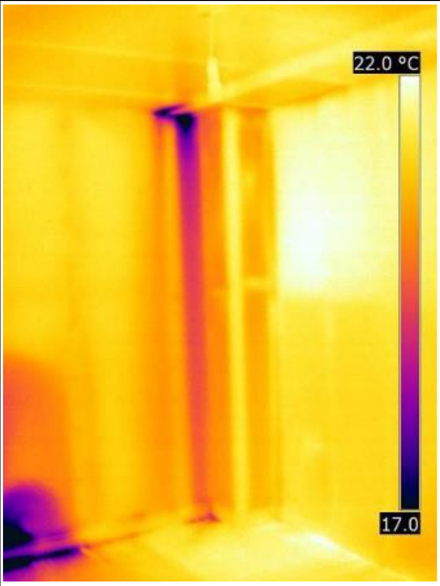

Under depressurisation similar observations were made as bedroom 6 only slightly more severe.

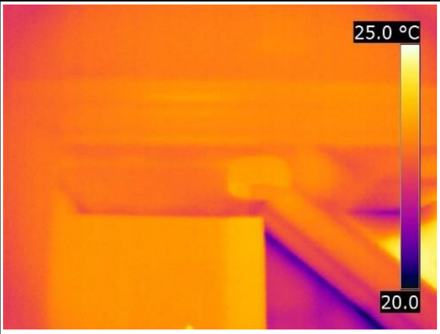
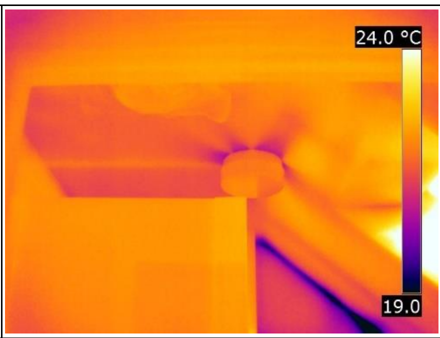
Air leakage was also detected around electrical services into the eaves void, and significant infiltration was observed at the floor wall junction on the gable wall.

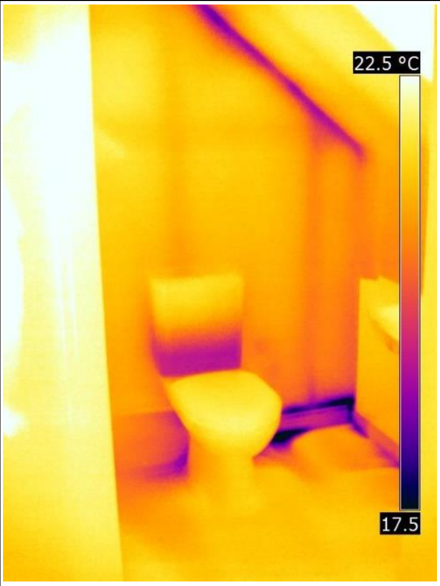
Also on the gable wall, the service riser adjacent to the en-suite showed cooler air being drawn down from above.

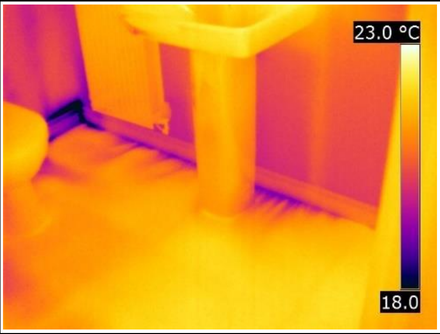

21.0 °C
16.0


21.5 °C
16.5

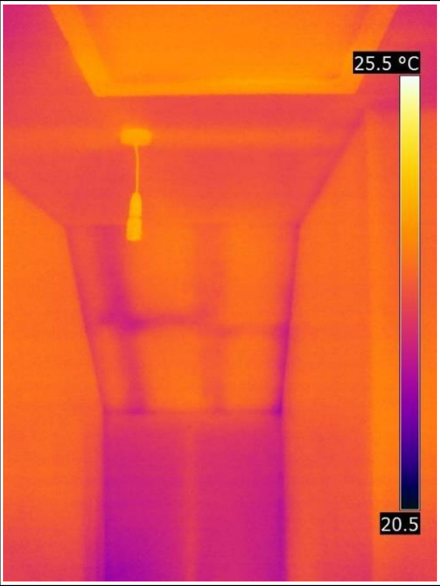

22.0 °C
17.0

| | | |
|---|---|---|
|  |  | |
| 2nd Floor En-Suite – Under natural conditions | | |
|  |  | The gable wall looks slightly cooler, but with all the direct sunlight and reflection it's difficult to assess. |
|  |  | |
| 2nd Floor En-Suite – Under depressurisation | | |
|  |  | Under depressurisation air can be seen drawn in from above around the central light, and at the floor/wall junctions on both external facades. Again, there was too much direct solar to view most of the room. |

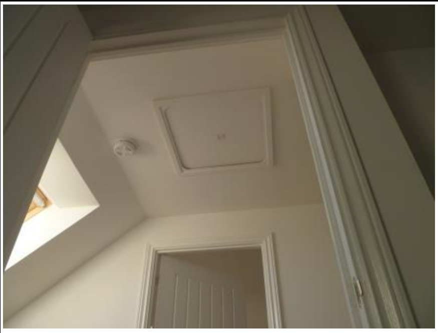
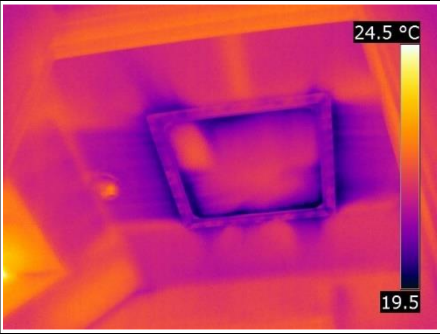
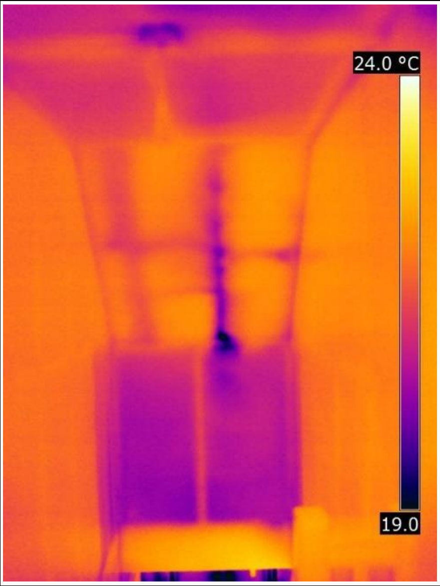
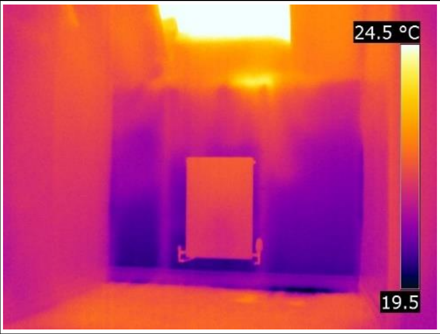



2nd Floor Landing – Under natural conditions



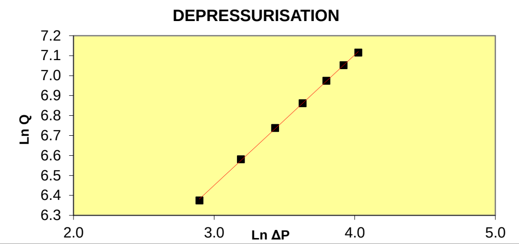

As in bedrooms 6 & 2, the panels backing onto voids appeared cooler than those backing directly on to panels.

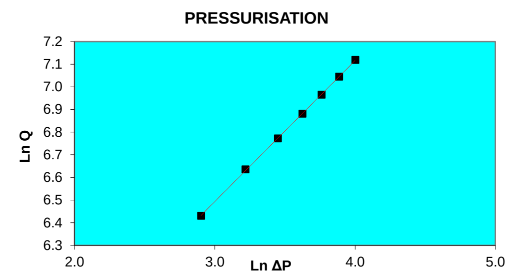
| | | |
|---|---|---|
|  | <br> | |
| 2nd Floor Landing – Under depressurisation | | |
|  | <br> | Under depressurisation air leakage was detected around the loft hatch.<br><br>Again the areas backing onto voids appeared to cool more under depressurisation than those backing directly onto panels.<br><br>The cold strip along the sloping ceiling section towards the front of the house may indicate the type of place where the cooler air is getting into these voids. |
|  | <br> | |
|  | <br> | |

# Pressure Test Spreadsheet: 294

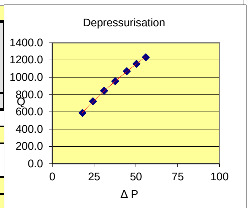
**MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION**

| | | | | |
|---|---|---|---|---|
| date: | 18/12/2017 | | Version 16d | 19 June 2017 |
| test house address: | Plot 294 - Hele Park, TQ12 6JN | | | |
| company: | Knauf Insulation - Taylor Wimpey | | | |
| house type: | AA21 | | | |
| tester: | DMS | | | |
| test reference number: | | | Blower Door & Gauge Used | Model 3 with DG700 |
| outdoor temp (°C) | 6.9 | °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) | 19.3 | °C | | |
| outdoor humidity (%rh) | 77.3 | %RH | | |
| indoor humidity (%rh) | 51.8 | %RH | | |
| outdoor barometric pressure | 1019 | mbar or hPa | Calculated Outdoor Air Density | 1.26 kg/m$^3$ |
| indoor barometric pressure | 1019 | mbar or hPa | Calculated Indoor Air Density | 1.21 kg/m$^3$ |
| temperature corr. fact. depress. | 0.958 | WARNING!! | description of main construction details: | |
| temperature corr. fact. press. | 1.044 | Extreme Test | New build, partial-fill, 2-storey, 2-bed | |
| wind speed (m/s): | 0.3 | Conditions | | |
| baseline pressure diff (Pa) (+/-) | | Pa | | |
| house width: | 4.05 | m | | |
| house depth: | 7.9 | m | | |
| house height: | 4.875 | m | | |
| floor area: | 64 | m$^2$ | | |
| volume: | 156 | m$^3$ | | |
| envelope area including floor: | 180.5 | m$^2$ | | |
| Pressure Difference for ELA | 10 | Pa | | |
| RESULTS: | | | | |
| Q50 Mean Flow at 50Pa = | 1169.51 | m$^3$/h | | |
| Mean Air Leakage at 50Pa = | 7.50 | h$^{-1}$ | | |
| Mean Air Permeability at 50 Pa = | 6.48 | m/h or m$^3$h/m$^2$ | | |
| Equivalent Leakage Area = | 0.047 | m$^2$ at | 10 | Pa |

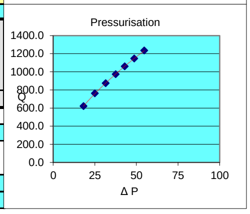



| DEPRESSURISATION | RING - O,A,B,C,D,E for BD3 0,1,2,3 for DuctBB | MEASURED FAN PRESSURE (Pa) Max. 90 Pa | MEASURED FLOW (m$^3$/h) | ADJUSTED FLOW (m$^3$/h) | FLOW RANGE OK FOR SELECTED RING? | Adjusted Pressure (Pa) | Ln delta P | Ln Q | Q50 Calculated Flow at 50Pa (m$^3$/h) | Permeability Depressurisation Only (m$^3$/(h.m$^2$)) | Air Leakage Depressurisation Only (h$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Approx 65 Pa* | b | 56 | 1287 | 1230.6 | OK | 56 | 4.025 | 7.115 | 1169.79 | 6.48 | 7.50 |
| *Approx 57 Pa* | b | 50.4 | 1208 | 1155.1 | OK | 50.4 | 3.920 | 7.052 | $r^2$ | 1.000 | |
| *Approx 49 Pa* | b | 44.6 | 1118 | 1069.0 | OK | 44.6 | 3.798 | 6.975 | $C_{env}$ | 88.927 | m$^3$/h.Pa$n$ |
| *Approx 41 Pa* | b | 37.7 | 999 | 955.3 | OK | 37.7 | 3.630 | 6.862 | n | 0.654 | |
| *Approx 33 Pa* | b | 31 | 882 | 843.4 | OK | 31 | 3.434 | 6.737 | | | |
| *Approx 25 Pa* | b | 24.3 | 754 | 721.0 | OK | 24.3 | 3.190 | 6.581 | $C_L$ (corrected) | 90.538 | m$^3$/h.Pa$n$ |
| *Approx 20 Pa* | b | 18.1 | 614 | 587.1 | OK | 18.1 | 2.896 | 6.375 | | | |




| 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 | 54.7 | 1181 | 1235.1 | OK | 54.7 | 4.002 | 7.119 | 1169.24 | 6.48 | 7.50 |
| *Approx 57 Pa* | b | 48.7 | 1097 | 1147.2 | OK | 48.7 | 3.886 | 7.045 | $r^2$ | 1.000 | |
| *Approx 49 Pa* | b | 43 | 1013 | 1059.4 | OK | 43 | 3.761 | 6.965 | $C_{env}$ | 102.047 | m$^3$/h.Pa$n$ |
| *Approx 41 Pa* | b | 37.5 | 931 | 973.6 | OK | 37.5 | 3.624 | 6.881 | n | 0.623 | |
| *Approx 33 Pa* | b | 31.5 | 835 | 873.2 | OK | 31.5 | 3.450 | 6.772 | | | |
| *Approx 25 Pa* | b | 25 | 728 | 761.3 | OK | 25 | 3.219 | 6.635 | $C_L$ (corrected) | 102.322 | m$^3$/h.Pa$n$ |
| *Approx 20 Pa* | b | 18.2 | 593 | 620.2 | OK | 18.2 | 2.901 | 6.430 | | | |



Pressure Test Spreadsheet: 297

LEEDS BECKETT UNIVERSITY

Leeds Sustainability Institute

**MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION**

| | | | | |
|---|---|---|---|---|
| date: | 18/12/2017 | | Version 16d | 19 June 2017 |
| test house address: | Plot 297 - Hele Park, TQ12 6JN | | | |
| company: | Knauf Insulation - Taylor Wimpey | | | |
| house type: | D2000 | | | |
| tester: | DMS | | | |
| test reference number: | | | Blower Door & Gauge Used | Model 3 with DG700 |
| outdoor temp (°C) | 8.6 | °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) | 22.3 | °C | | |
| outdoor humidity (%rh) | 73.6 | %RH | | |
| indoor humidity (%rh) | 47.6 | %RH | | |
| outdoor barometric pressure | 1019 | mbar or hPa | Calculated Outdoor Air Density | 1.26 $kg/m^3$ |
| indoor barometric pressure | 1019 | mbar or hPa | Calculated Indoor Air Density | 1.20 $kg/m^3$ |
| temperature corr. fact. depress. | 0.954 | WARNING!! | description of main construction details: | |
| temperature corr. fact. press. | 1.049 | Extreme Test | New build, partial-fill, 2.5-storey, 6-bed | |
| wind speed (m/s): | 0.3 | Conditions | | |
| baseline pressure diff (Pa) (+/-) | | Pa | | |
| house width: | 8.89 | m | | |
| house depth: | 7.878 | m | | |
| house height: | 7.24 | m | | |
| floor area: | 186 | $m^2$ | | |
| volume: | 444.8 | $m^3$ | | |
| envelope area including floor: | 370.4 | $m^2$ | | |
| Pressure Difference for ELA | 10 | Pa | | |

RESULTS:

| | | |
|---|---|---|
| Q50 Mean Flow at 50Pa = | 2639.29 | $m^3/h$ |
| Mean Air Leakage at 50Pa = | 5.93 | $h^{-1}$ |
| Mean Air Permeability at 50 Pa = | 7.13 | m/h or $m^3h/m^2$ |
| Equivalent Leakage Area = | 0.113 | $m^2$ 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* | a | 51.9 | 2692 | 2562.8 | OK | 51.9 | 3.949 | 7.849 | 2541.39 | 6.86 | 5.71 |
| *Approx 57 Pa* | a | 47 | 2518 | 2397.1 | OK | 47 | 3.850 | 7.782 | $r^2$ | 1.000 | |
| *Approx 49 Pa* | a | 41.9 | 2345 | 2232.4 | OK | 41.9 | 3.735 | 7.711 | $C_{env}$ | 223.122 | $m^3/h.Pa^n$ |
| *Approx 41 Pa* | a | 36.2 | 2159 | 2055.4 | OK | 36.2 | 3.589 | 7.628 | n | 0.617 | |
| *Approx 33 Pa* | a | 31.1 | 1959 | 1865.0 | OK | 31.1 | 3.437 | 7.531 | | | |
| *Approx 25 Pa* | a | 26.5 | 1763 | 1678.4 | OK | 26.5 | 3.277 | 7.426 | $C_L$ (corrected) | 227.056 | $m^3/h.Pa^n$ |
| *Approx 20 Pa* | a | 21.3 | 1553 | 1478.5 | OK | 21.3 | 3.059 | 7.299 | | | |

| 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* | a | 56.2 | 2783 | 2923.3 | OK | 56.2 | 4.029 | 7.980 | 2737.20 | 7.39 | 6.15 |
| *Approx 57 Pa* | a | 50.2 | 2612 | 2743.7 | OK | 50.2 | 3.916 | 7.917 | $r^2$ | 0.999 | |
| *Approx 49 Pa* | a | 44.9 | 2449 | 2572.5 | OK | 44.9 | 3.804 | 7.853 | $C_{env}$ | 272.277 | $m^3/h.Pa^n$ |
| *Approx 41 Pa* | a | 39.5 | 2277 | 2391.8 | OK | 39.5 | 3.676 | 7.780 | n | 0.590 | |
| *Approx 33 Pa* | a | 33.8 | 2087 | 2192.2 | OK | 33.8 | 3.520 | 7.693 | | | |
| *Approx 25 Pa* | a | 27 | 1822 | 1913.9 | OK | 27 | 3.296 | 7.557 | $C_L$ (corrected) | 271.885 | $m^3/h.Pa^n$ |
| *Approx 20 Pa* | a | 22.8 | 1627 | 1709.0 | OK | 22.8 | 3.127 | 7.444 | | | |