# Taylor Wimpey – Thermal Imaging Project

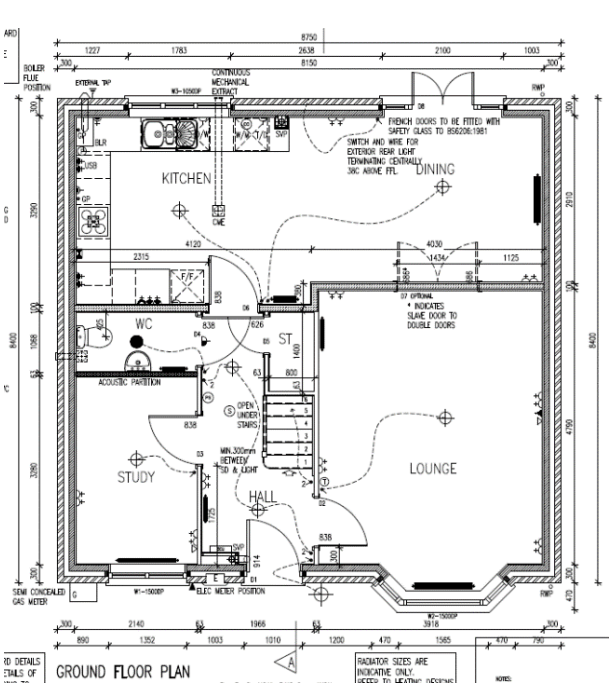
Site: Pipers Green
Crigglestone
WF4 3HY

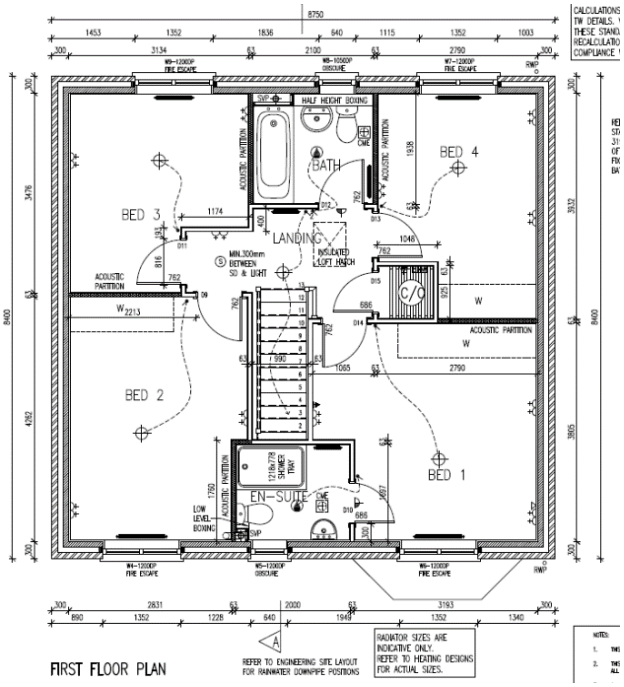
Visit Date: 8th November 2017

Plot(s): 288

House Type: PA48 – Shelford
Full-fill Masonry, 2-Storey, 4-Bed Detached

Floor Plans:




Environmental Conditions:

| | | | |
|---|---|---|---|
| Internal Temperature | 22 °C | External Temperature | 8.2 °C |
| Internal RH | 51 % | External RH | 62% |
| Wind Speed | 0.2 $ms^{-1}$ | Wind Direction | SW |

Clear skies, no rain in preceding 18 hours.

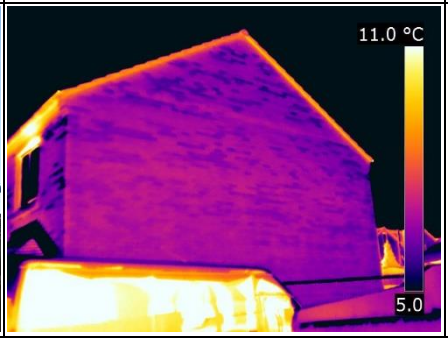
Pressure Test Results:

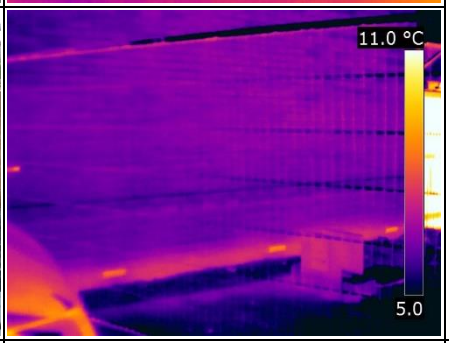
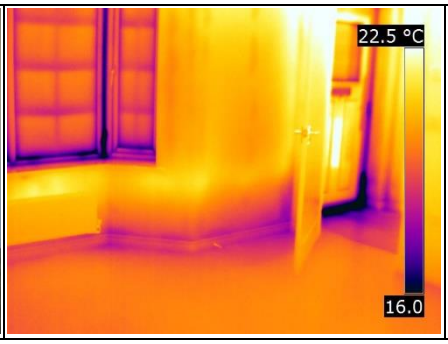
| Depressurisation Only | | | Pressurisation Only | | | Mean | |
|---|---|---|---|---|---|---|---|
| $m^3/(h.m^2)$@50Pa | $ach^{-1}$ | $r^2$ | $m^3/(h.m^2)$@50Pa | $ach^{-1}$ | $r^2$ | $m^3/(h.m^2)$@50Pa | $ach^{-1}$ |
| 4.65 | 4.22 | 0.999 | 4.98 | 4.51 | 1.000 | 4.81 | 4.37 |

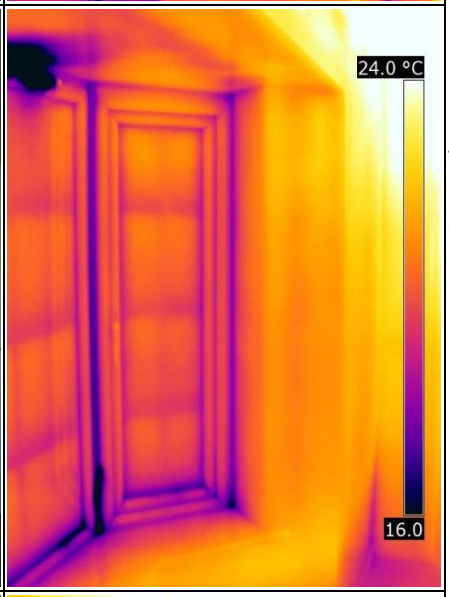
Observations:

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.

Thermal images under depressurisation were captured at an average pressure of -52.4 Pa.

| External - Under natural conditions | | |
|---|---|---|
|  |  | NE Front Façade<br>Some direct sunlight on the East-facing bay wall is apparent.<br>First floor trickle vents had been left open making it difficult to assess whether there is additional unplanned heat loss at the eaves.<br>Warmer area above bay roof possibly due to a radiator directly under the window in Bedroom 1. |
|  |  | Southerly wind resulted in warm air emerging from the underfloor vents.<br>There also appears to be a warmer band around the ground floor perimeter which extends around the whole dwelling, possibly due to a thermal bridge as the internal IR images also show the floor/wall junction to be cooler than expected.<br>I don't know if a cavity tray was fitted preventing the blown insulation getting down below, but this resemble instances where I have observed this previously. |
|  |  | |
|  |  | |
|  |  | NW Gable |

| | | |
|---|---|---|
|  |  | |
|  |  | |
|  |  | SE Gable<br>Direct solar impinging on the SE gable, the front part is shown shaded but had direct solar within the last 2 hours. |
| Lounge – Under natural conditions | | |
|  |  | The warmer strip seen from outside at the ground floor perimeter can be observed as a colder area at the floor/wall junctions from inside the dwelling.<br>Without any mixing of air inside the house there would be some natural temperature stratification internally, but this unlikely to |

| | | |
|---|---|---|
|  |  | account for the significantly cooler surface temperatures at the base of the external walls. The temperature difference between the wall surface on and off the plasterboard adhesive dabs appears to reduce near the base of the wall.<br>The internal surface of the bay roof appears cooler than the external elements around it, but due to cold air ingress at the trickle vents and reflection of the cooler windows it is difficult to analyse.<br>The bay window jambs appear to show no significant issues, an area where problems are commonplace. |
|  |  | |
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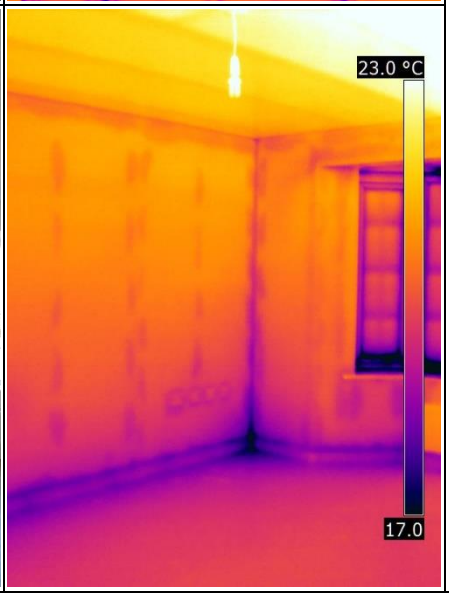
|  |  | |

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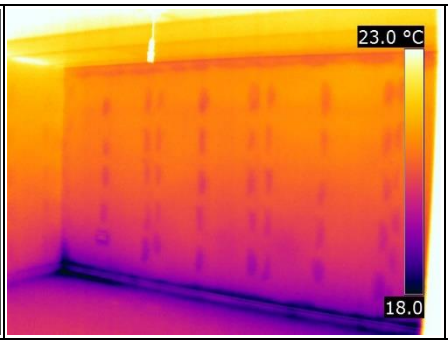
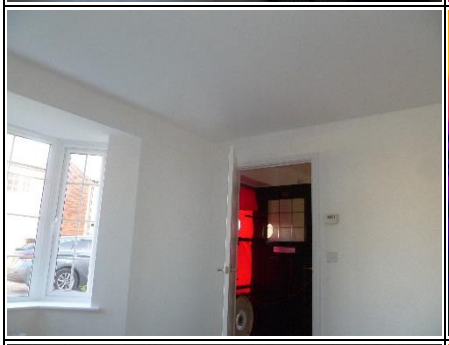
<tr><td>  </td><td> 
</td><td></td></tr>
<tr><td colspan="3">Lounge – Under depressurisation</td></tr>
<tr><td>  </td><td> 
</td><td rowspan="4">Under depressurisation cooler air could be observed infiltration around the windows, with air entering through and around the closed trickle vents, at junctions between the lights and around the sill board.<br>The thermal anomalies on the bay appear to worsen under depressurisation, where air movement is forced from cold external air to inside the structure, with a much clearer cold strip at the junction with the external wall above. This would indicate that gaps at interfaces play a part at this detail, whereas at the floor/wall junction the difference in IR images between natural and depressurised conditions is marginal suggesting that the increased heat loss at this junction is more likely due to conductive heat loss with discontinuities or disruptions of the insulation layer.</td></tr>
<tr><td>  </td><td> 
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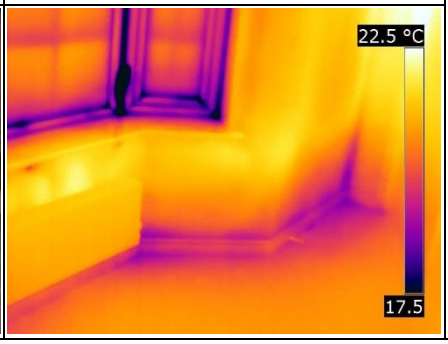
<tr><td>  </td><td> 
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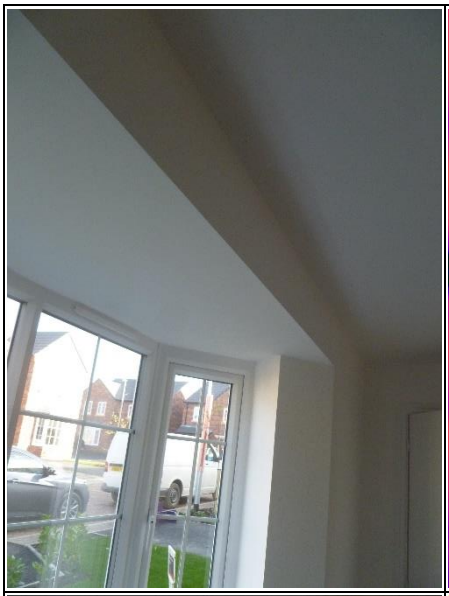



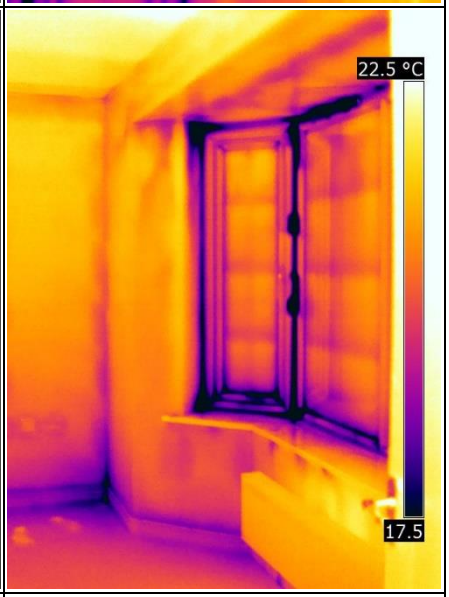


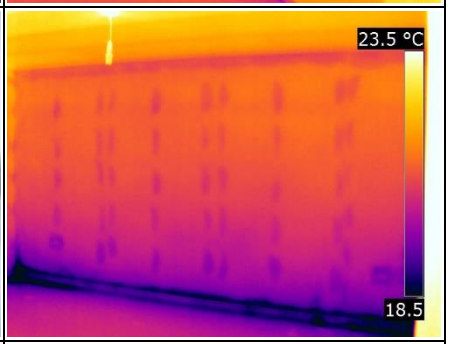

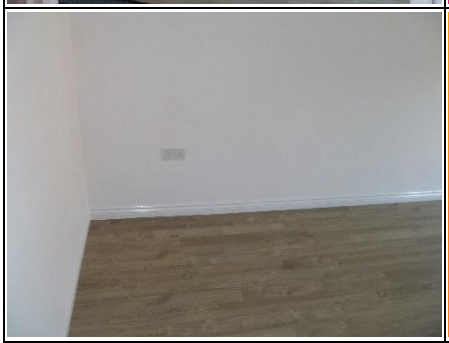
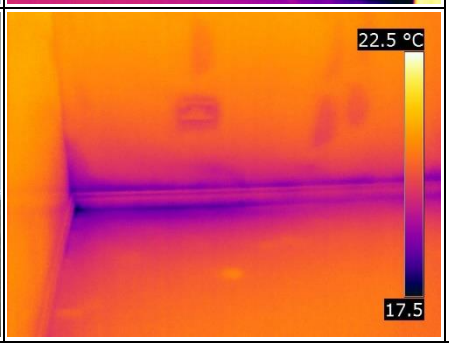


Dining / Kitchen – Under natural conditions

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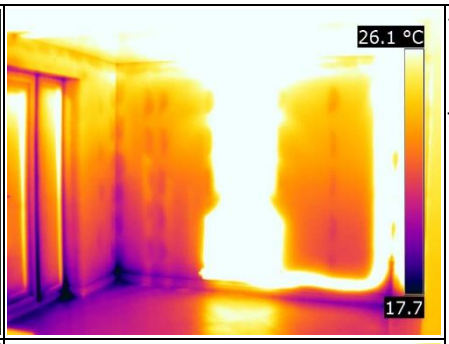
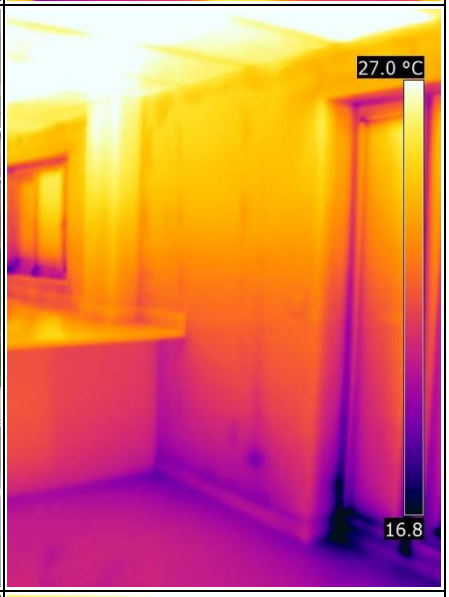
|  |  | The previously observed phenomena at the floor/wall junction was again apparent. Where the patio doors are positioned further out in the external wall the floor surface appears to get noticeably cooler, possibly due to greater thermal bridging. |
|  |  | |
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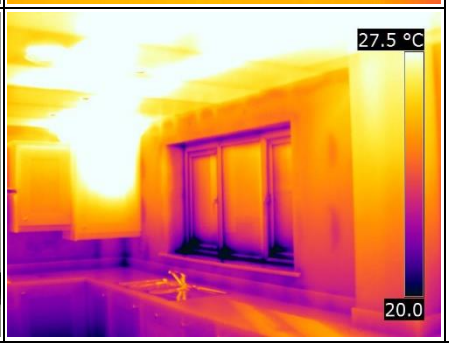
|  |  | |

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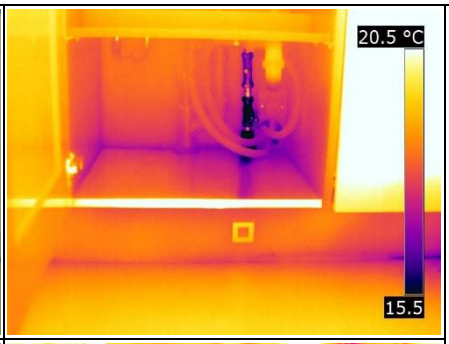
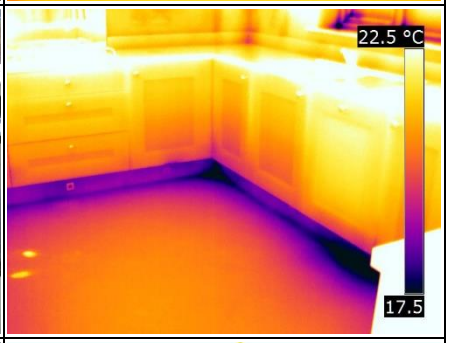
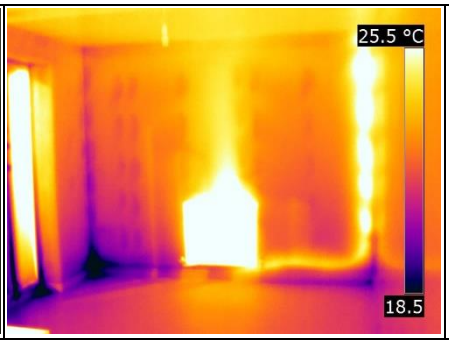
|  |  | |
|  |  | |
|  |  | |
| Dining / Kitchen – Under depressurisation | | |
|  |  | |

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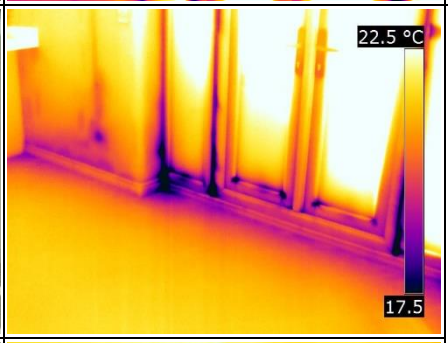
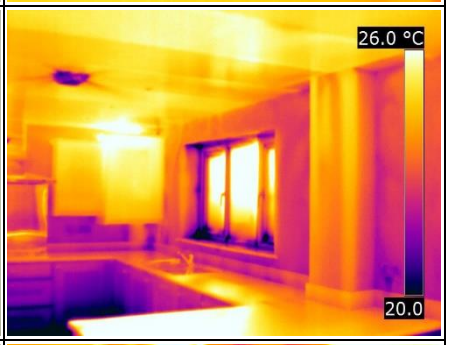
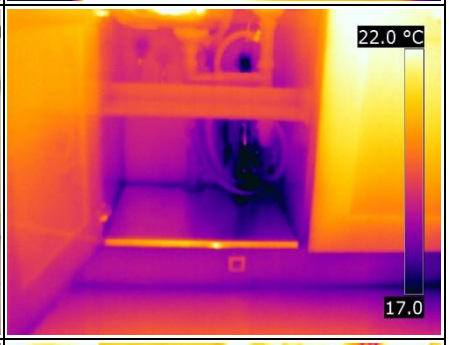
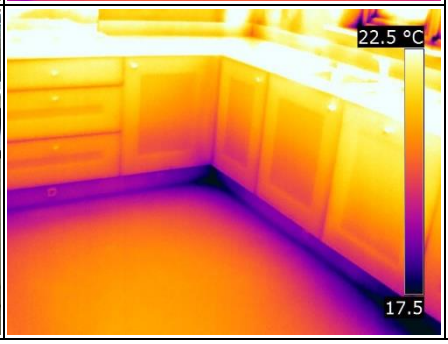
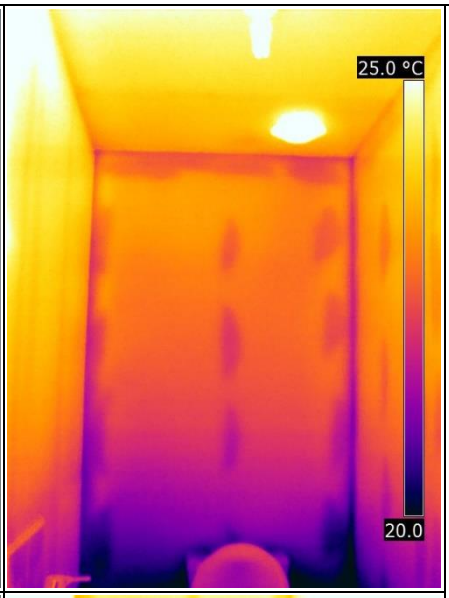
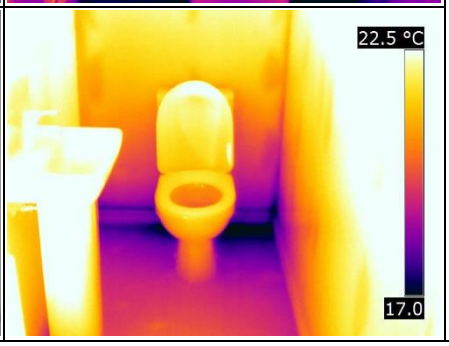
|  |  | The floor surface at the patio doors does not change significantly under depressurisation, indicating again this is a bridging issue rather than to do with air movement.<br>Air infiltration is an issue, with both direct infiltration from outside around the windows and indirect air movement around service penetrations, into the boxed-in service riser and into the intermediate floor void. |
|  |  | |
|  |  | |
|  |  | |


Ground Floor WC – Under natural conditions




Ground Floor WC – Under depressurisation

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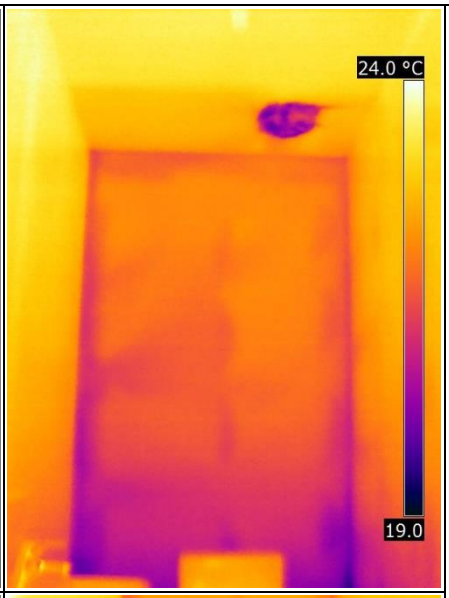
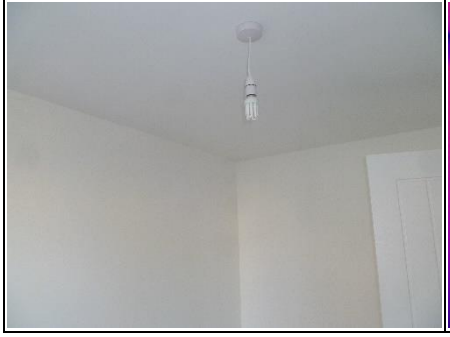
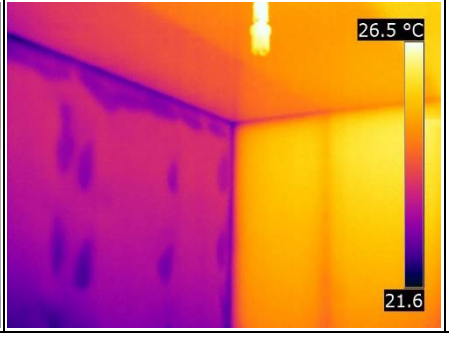
|---|---|---|
|  |  | Some air movement behind the plasterboard dry lining observed, it is unclear of the source and direction of movement but tends to look as if the air is coming from the adjacent study. |
|  |  | |
| Study – Under natural conditions | | |
|  |  | Plasterboard adhesive dabs appear coolest where the utilities meter boxes are situated on the external walls.<br>Some temperature stratification across the intermediate floor void can be observed, but it is unclear whether this is heat from the heating system pipework spreading toward the outside or cooler air from the gable wall junctions spreading inside. |
|  |  | |

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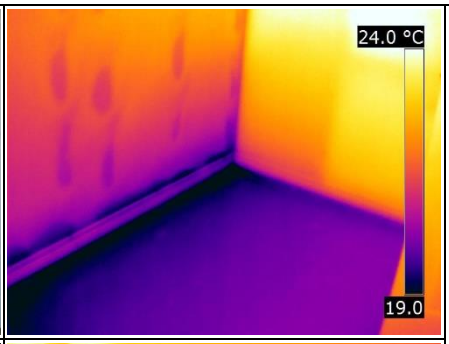
<tr><td>  </td><td> 
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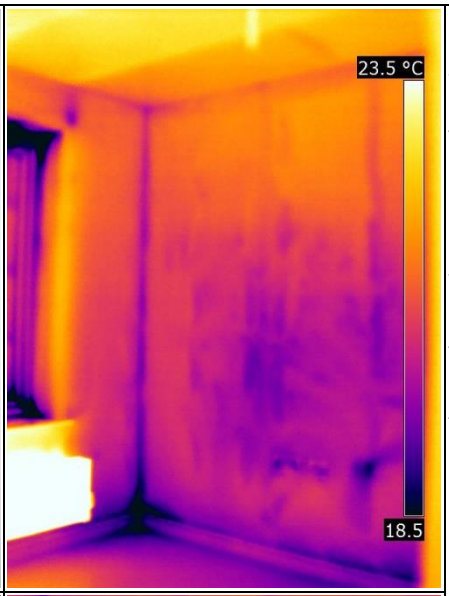
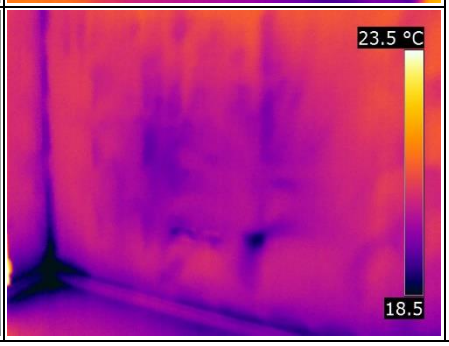
<tr><td colspan="3">Study – Under depressurisation</td></tr>
<tr><td>  </td><td> 
</td><td rowspan="2">SE Gable, position of electricity and gas meter boxes are more apparent under depressurisation, it is difficult to determine how much of the additional heat loss in this area is due to reduced insulation and how much is due to infiltration into the void behind the plasterboard dry lining. However, as air movement in this void may be continuing into the adjacent downstairs WC, it could be the major factor.</td></tr>
<tr><td>  </td><td> 
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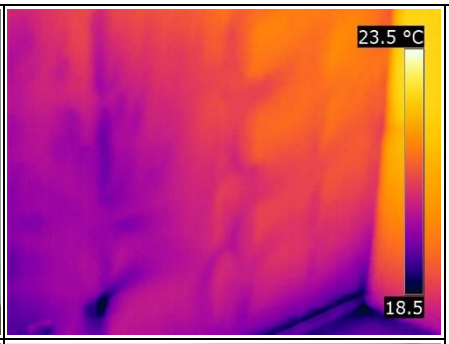
|  |  | |
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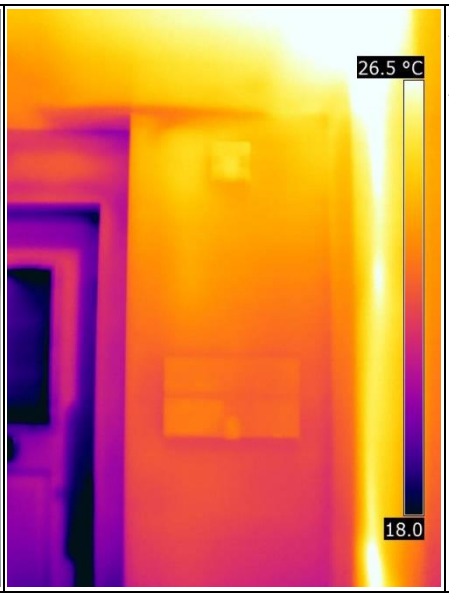
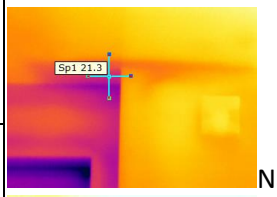
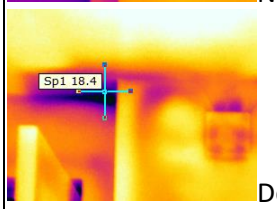
| Hall – Under natural conditions | | |
|  |  | A colder area at the junction of the external wall with the intermediate floor and boxed void was not observed from the external IR images. |


Hall – Under depressurisation

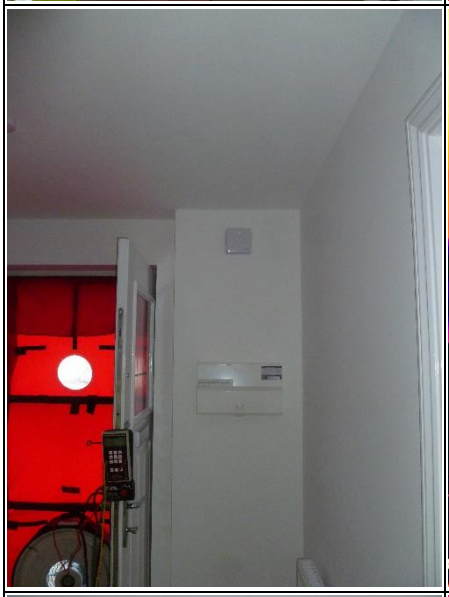

The indirect infiltration by the external wall junction with the lounge wall appears to be due to the penetration for the outside light.
The colder area at the junction of the external wall with the intermediate floor and boxed void appeared to worsen under depressurisation, this is deemed due to increased air movement which can be seen extending down the service void.

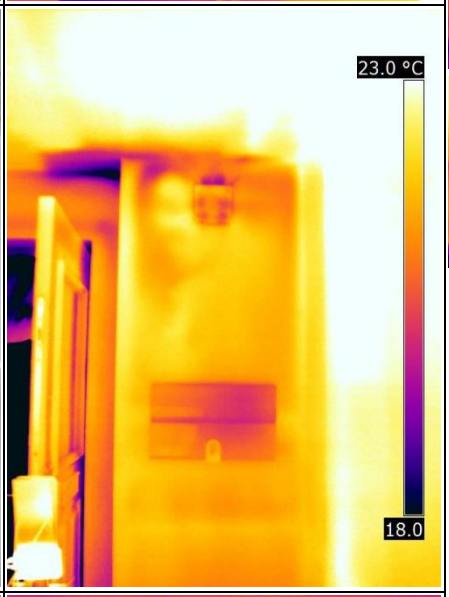



Natural




Depressurised







En-Suite – Under natural conditions

<table>
<tr>
<td>  </td>
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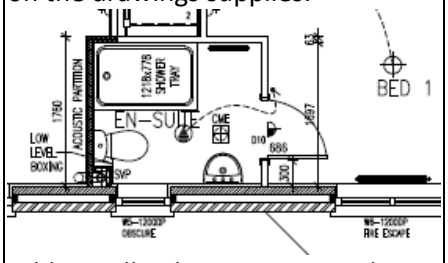
<td rowspan="3">Colder areas are visible at the junction of the ceiling and external wall, extending down the service void to the right of the window. The service void to the left of the window show warmer timbers than the air voids behind but no distinct thermal gradient beyond the natural temperature stratification in the room. This void was not present on the drawings supplies:<br> 
<br>Additionally, there appears to be some dislocation of the loft insulation around ceiling penetrations.</td>
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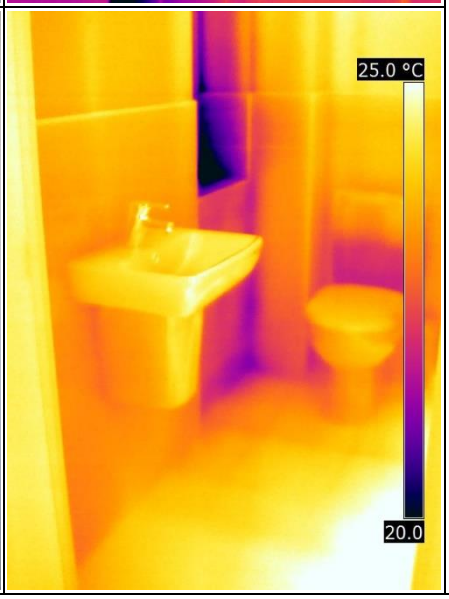
<td> 
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<tr>
<td colspan="3">En-Suite – Under depressurisation</td>
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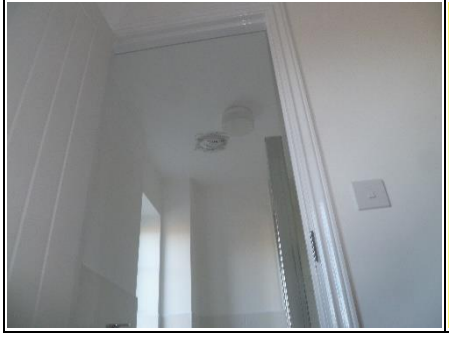
<td>  </td>
<td> 
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<td>Air being drawn in from the loft space was observed into the service voids, around ceiling penetrations and into the internal partition wall by the shower cubicle.</td>
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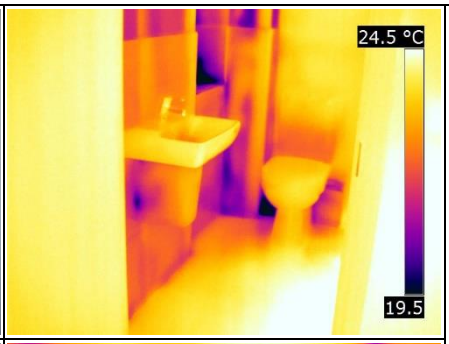
<tr><td>  </td><td> 
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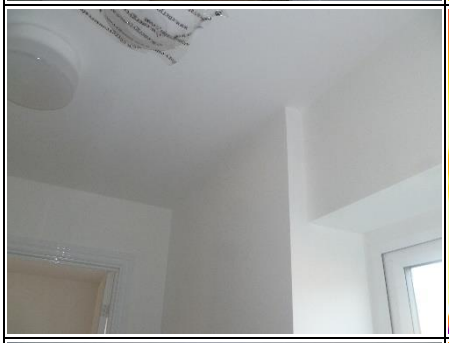
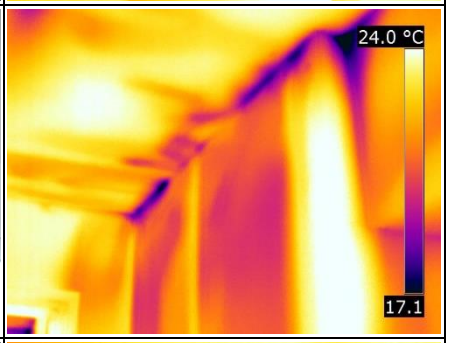
<tr><td>  </td><td> 
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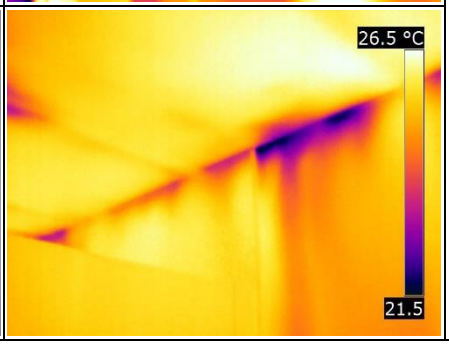
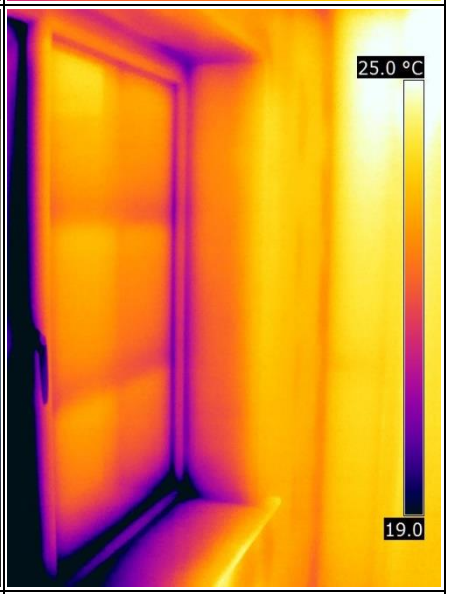
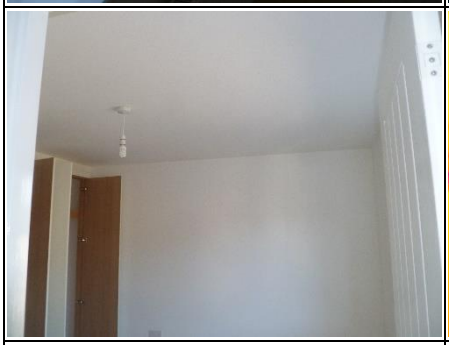
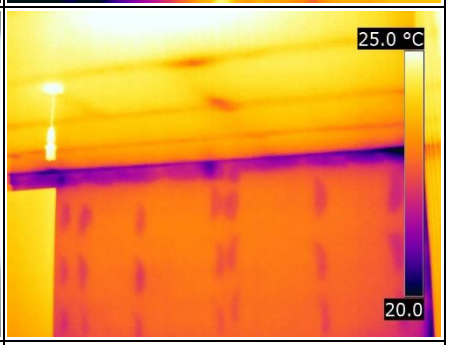
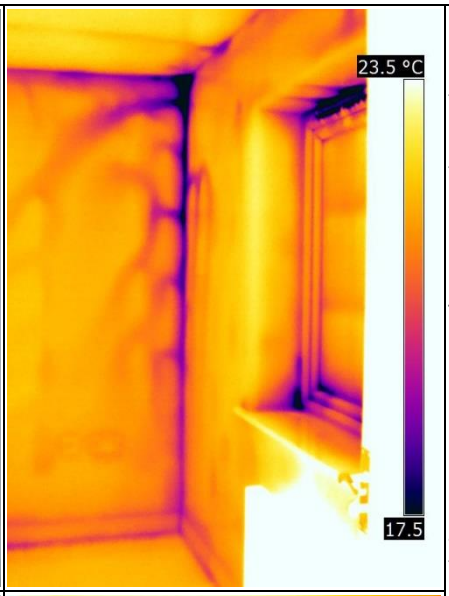
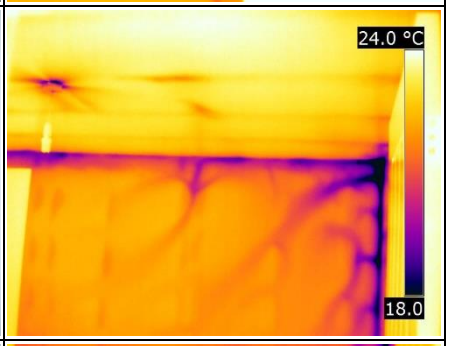
<tr><td>  </td><td> 
</td></tr>
<tr><td colspan="3">Bedroom 1 – Under natural conditions</td></tr>
<tr><td>  </td><td> 
</td><td rowspan="2">At ceiling level, under natural conditions, air would be expected to be leaving the building. This warmed air moving from behind the plasterboard to the loft space would be expected to make the tops of the external wall perimeter appear warmer, but there is still a clear colder section of wall at this junction at the wall plate and directly beneath the gable wall spandrel panels, raising questions about potential thermal bridging at these junctions.<br>The cooler areas of ceiling where addition timbers between the trusses dislodge the loft insulation</td></tr>
<tr><td>  </td><td> 
</td></tr>
</table>

| | | |
|---|---|---|
|  |  | from direct contact with the ceiling are not excessive.<br>The stratification of temperatures of the intermediate floor void visible from below is also clear from above.<br>Thermal bridging at jambs/head/sill is also apparent but not excessive. |
|  |  | |
|  |  | |
|  |  | |
|  |  | |

| Bedroom 1 – Under depressurisation | | |
|---|---|---|
|  |  | Under depressurisation colder air can be seen being drawn in from the loft through ceiling penetrations, into the void behind the plasterboard dry lining and into some partition wall voids and emerging at places at the intermediate floor perimeter.<br>The external wall at the ceiling perimeter, in particular, looks significantly colder than under natural conditions due to the change in air movement direction suggesting that air movement has a greater effect here than any thermal bridging or insulation discontinuity issues. |
|  |  | |
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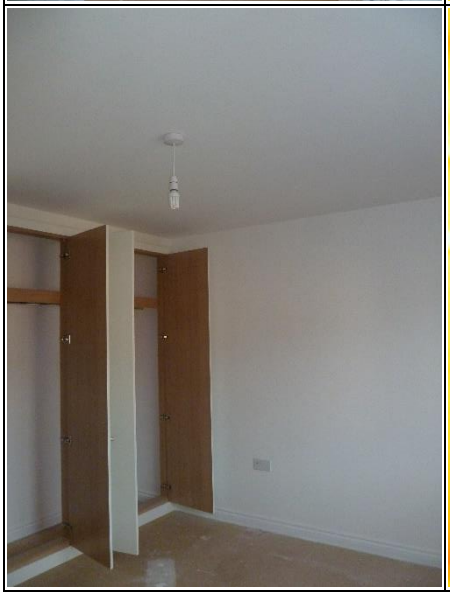
|  |  | |

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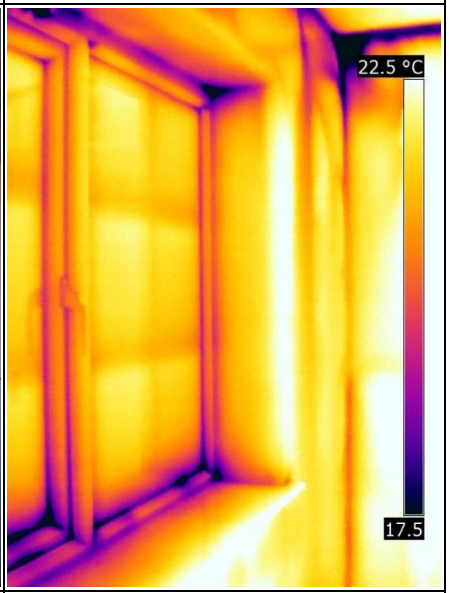
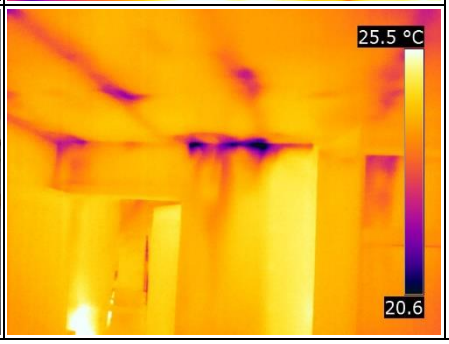
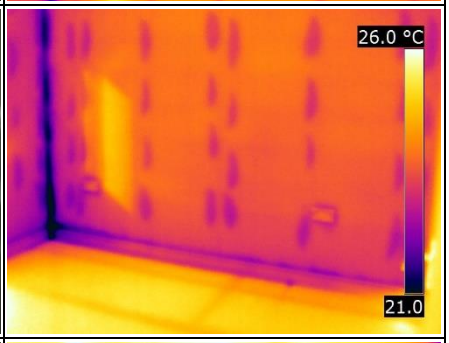
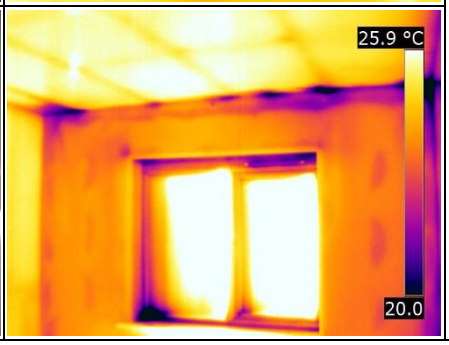
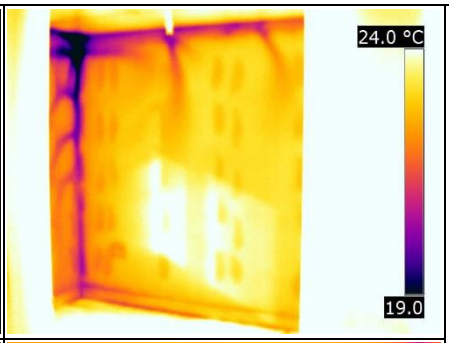
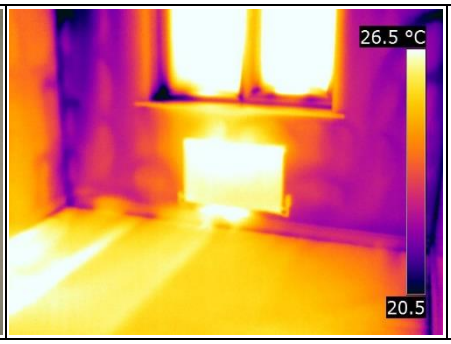
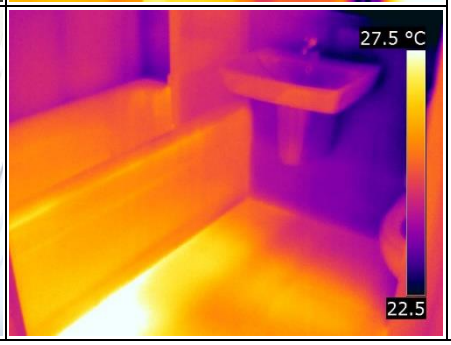
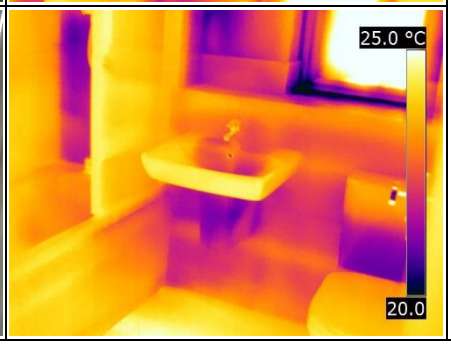
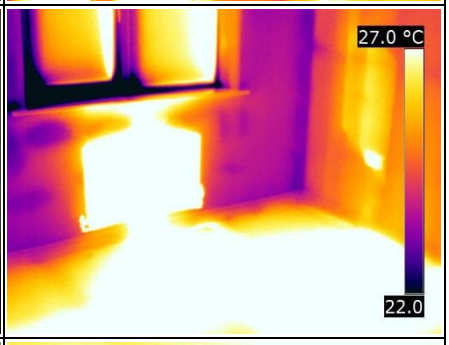
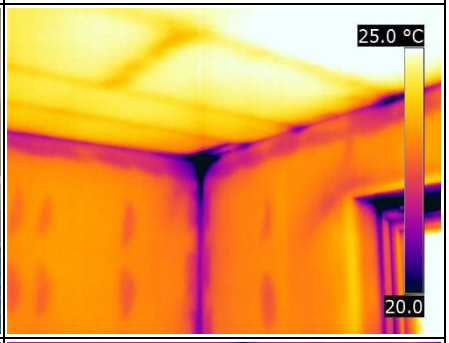
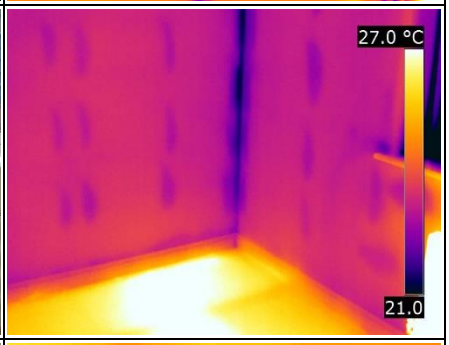
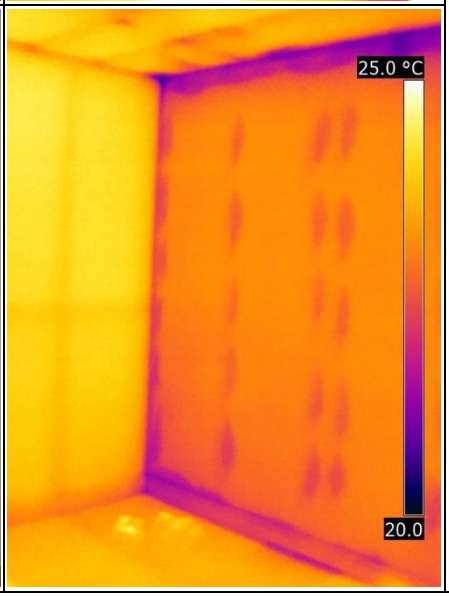
|  |  | |
|  |  | |
| Bedroom 4 – Under natural conditions | | |

| | | |
|---|---|---|
|  |  | Repeat of the observations for Bedroom 1. |
|  |  | |
|  |  | |
| Bedroom 4 – Under depressurisation | | |
|  |  | Repeat of the observations for Bedroom 1. |
|  |  | |

<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">As previously observed in the bedroom, with the cold strip at the wall plate more obvious in comparison to the boxed-in service void next to it.</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">As in the En-suite, cold air is drawn in around ceiling penetration, into the void behind the dry lining and into the boxed-in void.</td></tr>
<tr><td>  </td><td> 
</td></tr>
<tr><td colspan="3">Bedroom 3 – Under natural conditions</td></tr>
</table>

| | | |
|---|---|---|
|  |  | As previous bedrooms. |
|  |  | |
|  |  | |
|  |  | |
|  |  | |

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|---|---|---|
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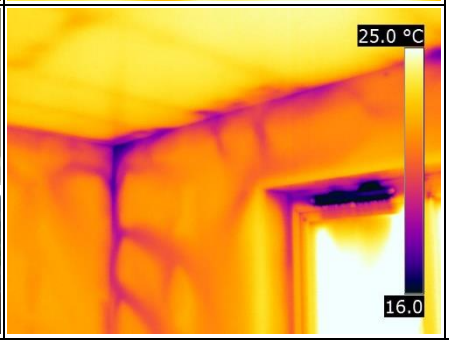
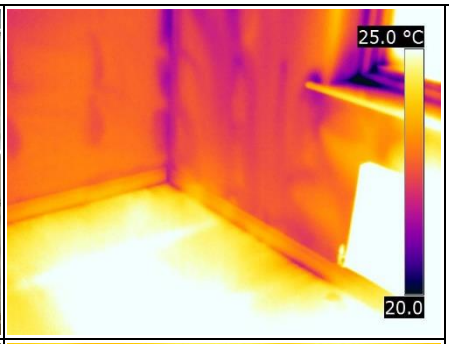
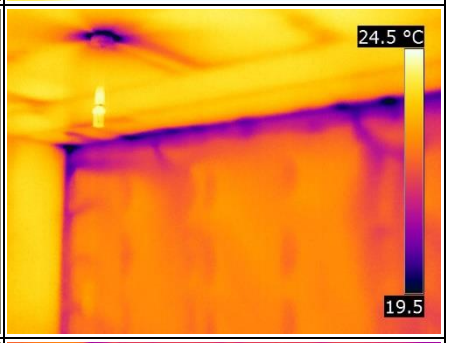
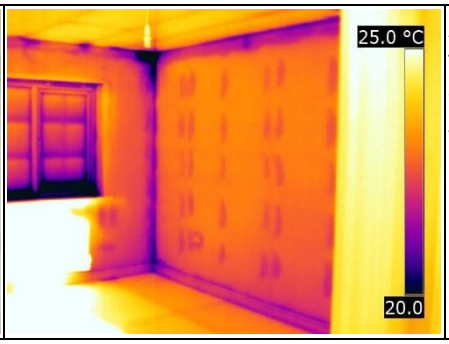
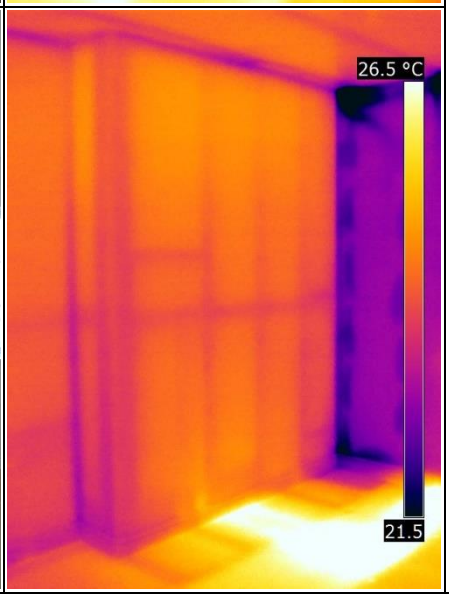
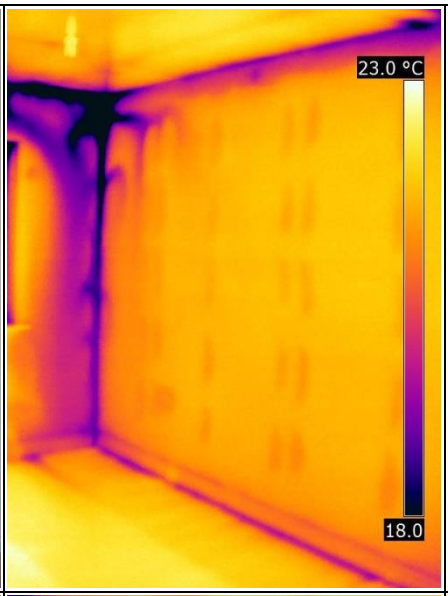
| Bedroom 3 – Under depressurisation | | |
|  |  | As previous bedrooms. |
|  |  | |
|  |  | |

| | | |
|---|---|---|
|  |  | |
|  |  | |
|  |  | |
| Bedroom 2 – Under natural conditions | | |
|  |  | As previous bedrooms.<br>The junction of the partition wall with the external wall backing on to the service void in the En-suite looks slightly cooler in places. |

| | | |
|---|---|---|
|  |  | |
|  |  | |
| Bedroom 2 – Under depressurisation | | |
|  |  | As previously observed in other bedrooms. |

<table>
<tr>
<td>  </td>
<td> 
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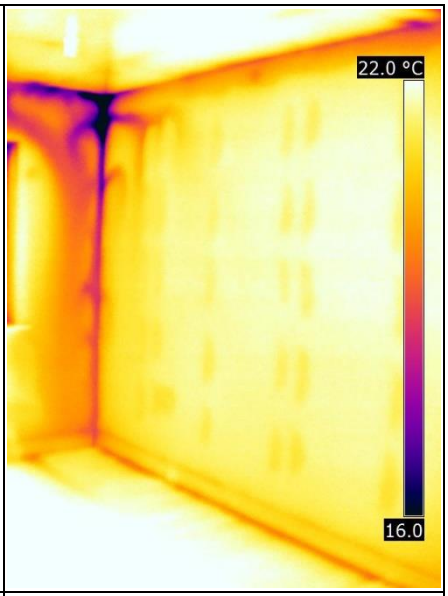
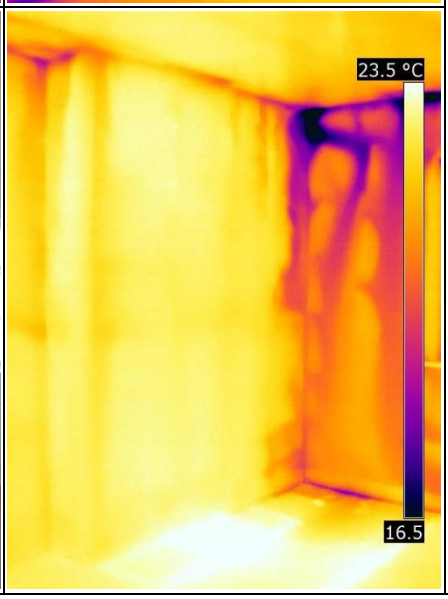
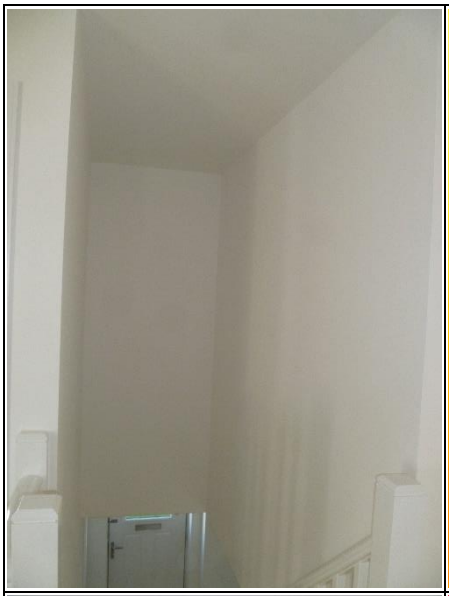
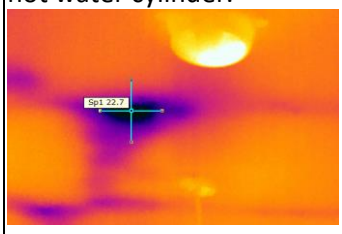
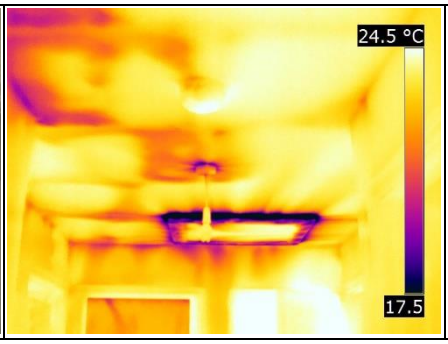
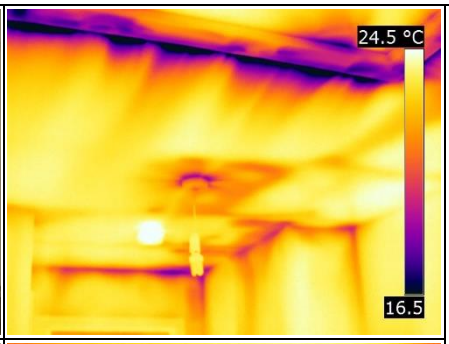
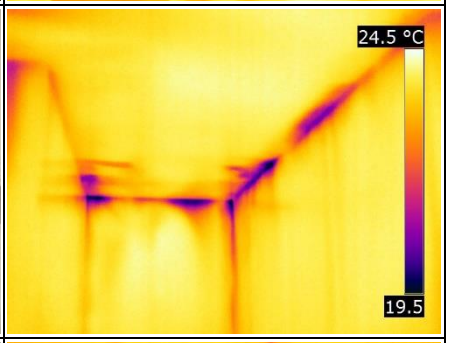
<td> 
</td>
</tr>
<tr>
<td>  </td>
<td> 
</td>
<td rowspan="2">Air can also clearly be observed being drawn down the junction of the partition wall with the external wall backing on to the service void in the En-suite, this void appear to link to the void behind the plasterboard on the external wall.</td>
</tr>
<tr>
<td>  </td>
<td> 
</td>
</tr>
<tr>
<td colspan="3">Landing – Under natural conditions</td>
</tr>
</table>

<table>
<tr><td>  </td><td> 
</td><td rowspan="3">Some areas of dislodged loft insulation appear, the level and span of the thermal image makes some of these appear worse than they are (e.g. the minimum temperature of 22.7 °C in the adjacent image) due to the nearby hot water cylinder.<br> 
</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 air could be seen infiltrating directly around ceiling penetrations, most significantly around the loft hatch door. Air could also be seen entering the internal partition wall voids.</td></tr>
</table>

<table>
<tr><td>  </td><td> 
</td><td rowspan="3"></td></tr>
<tr><td>  </td><td> 
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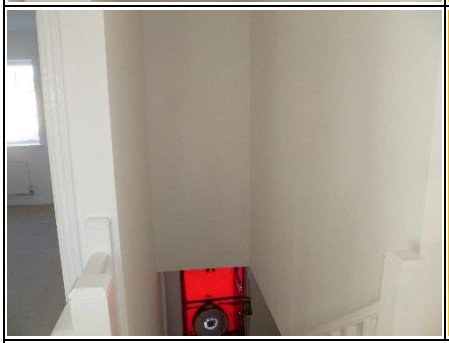
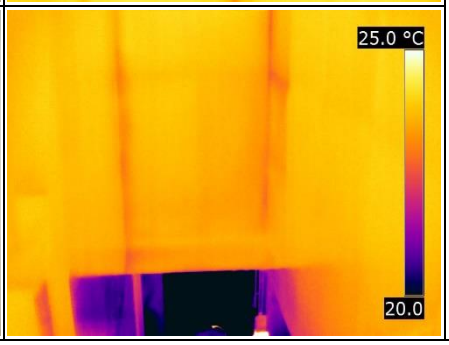
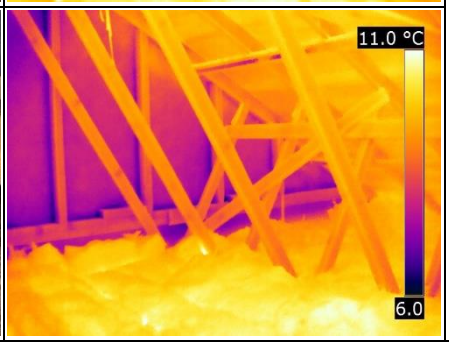
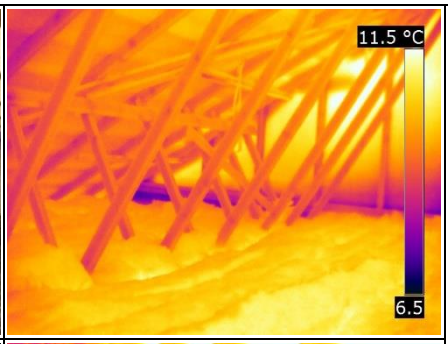
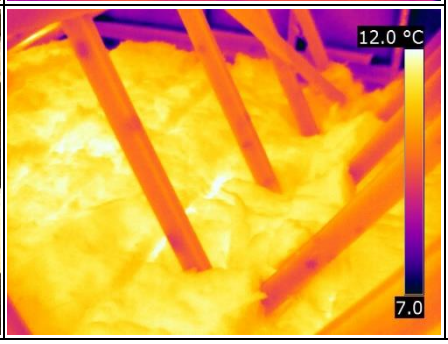
<tr><td>  </td><td> 
</td></tr>
<tr><td colspan="3">Loft – Under natural conditions</td></tr>
<tr><td>  </td><td> 
</td><td rowspan="2">The NW gable showed no signs of significant thermal bridging beneath the spandrel panel, suggesting that the cooler strip at the ceiling perimeter observed in the bedrooms below is unlikely to be due to thermal bridging.</td></tr>
<tr><td>  </td><td> 
</td></tr>
</table>

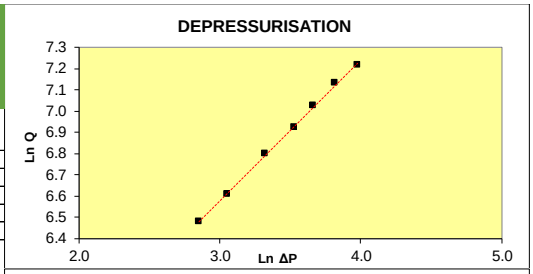
| | | |
|---|---|---|
|  |  | Direct solar on the SE gable hampered thermal imaging, but again no excessive thermal bridging beneath the spandrel panel was observed. |
|  |  | |
|  |  | The loft insulation itself appeared from above to be laid particularly diligently; many commonly observed errors had been avoided, with insulation inserted into the small gaps and well placed around awkward truss angles and penetrations. |
|  |  | |

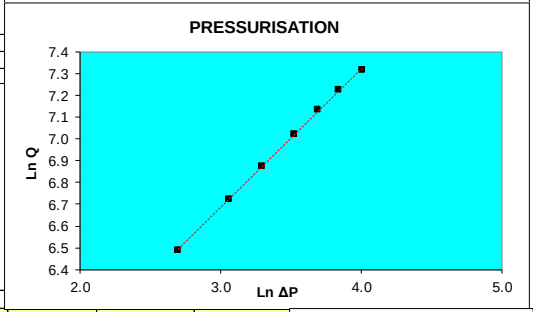
## Pressure Test Spreadsheet:

LEEDS BECKETT UNIVERSITY — Leeds Sustainability Institute

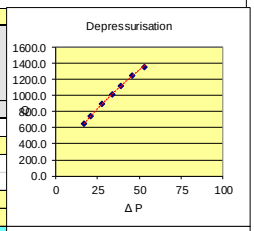
**MINNEAPOLIS BLOWER DOOR DATA INPUT AND CALCULATION**

| | | | | | |
|---|---|---|---|---|---|
| date: | 08/11/2017 | | Version 16d | 19 June 2017 | |
| test house address: | Plot 288 - St James Way, Crigglestone, Wakefield, WF4 3HY | | | | |
| company: | Knauf Insulation - Taylor Wimpey | | | | |
| house type: | Shelford | | | | |
| tester: | DMS | | | | |
| test reference number: | | | Blower Door & Gauge Used | Model 3 with DG700 | |
| outdoor temp (°C) | 8.2 | °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) | 20.8 | °C | | | |
| outdoor humidity (%rh) | 62.2 | %RH | | | |
| indoor humidity (%rh) | 51 | %RH | | | |
| outdoor barometric pressure | 1016.6 | mbar or hPa | Calculated Outdoor Air Density | 1.26 | kg/m$^3$ |
| indoor barometric pressure | 1016.5 | mbar or hPa | Calculated Indoor Air Density | 1.20 | kg/m$^3$ |
| temperature corr. fact. depress. | 0.957 | WARNING!! | description of main construction details: | | |
| temperature corr. fact. press. | 1.045 | Extreme Test | New build, masonry, blown full-fill, detached | | |
| wind speed (m/s): | 0.2 | Conditions | | | |
| baseline pressure diff (Pa) (+/-) | | Pa | | | |
| house width: | 8.15 | m | | | |
| house depth: | 8270 | m | | | |
| house height: | 4.92 | m | | | |
| floor area: | 129.05 | m$^2$ | | | |
| volume: | 317.47 | m$^3$ | | | |
| envelope area including floor: | 287.92 | m$^2$ | | | |
| Pressure Difference for ELA | 10 | Pa | | | |
| RESULTS: | | | | | |
| Q50 Mean Flow at 50Pa = | 1386.27 | m$^3$/h | | | |
| Mean Air Leakage at 50Pa = | 4.37 | h$^{-1}$ | | | |
| Mean Air Permeability at 50 Pa = | 4.81 | m/h or m$^3$/h/m$^2$ | | | |
| Equivalent Leakage Area = | 0.055 | 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 | 53.3 | 1427 | 1362.8 | OK | 53.3 | 3.976 | 7.217 | 1339.21 | 4.65 | 4.22 |
| *Approx 57 Pa* | b | 45.6 | 1311 | 1252.0 | OK | 45.6 | 3.820 | 7.132 | r$^2$ | 0.999 | |
| *Approx 49 Pa* | b | 39 | 1177 | 1124.0 | OK | 39 | 3.664 | 7.025 | $C_{env}$ | 97.808 | m$^3$/h.Pa*n* |
| *Approx 41 Pa* | b | 34.2 | 1066 | 1018.0 | OK | 34.2 | 3.532 | 6.926 | n | 0.665 | |
| *Approx 33 Pa* | b | 27.7 | 940 | 897.7 | OK | 27.7 | 3.321 | 6.800 | | | |
| *Approx 25 Pa* | b | 21.2 | 776 | 741.1 | OK | 21.2 | 3.054 | 6.608 | $C_L$ (corrected) | 99.303 | m$^3$/h.Pa*n* |
| *Approx 20 Pa* | b | 17.3 | 682 | 651.3 | OK | 17.3 | 2.851 | 6.479 | | | |




| 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 | 54.9 | 1442 | 1510.0 | OK | 54.9 | 4.006 | 7.320 | 1433.33 | 4.98 | 4.51 |
| *Approx 57 Pa* | b | 46.7 | 1314 | 1375.9 | OK | 46.7 | 3.844 | 7.227 | r$^2$ | 1.000 | |
| *Approx 49 Pa* | b | 40.2 | 1197 | 1253.4 | OK | 40.2 | 3.694 | 7.134 | $C_{env}$ | 116.838 | m$^3$/h.Pa*n* |
| *Approx 41 Pa* | b | 34 | 1070 | 1120.4 | OK | 34 | 3.526 | 7.021 | n | 0.641 | |
| *Approx 33 Pa* | b | 27 | 925 | 968.6 | OK | 27 | 3.296 | 6.876 | | | |
| *Approx 25 Pa* | b | 21.4 | 795 | 832.5 | OK | 21.4 | 3.063 | 6.724 | $C_L$ (corrected) | 116.805 | m$^3$/h.Pa*n* |
| *Approx 20 Pa* | b | 14.9 | 628 | 657.6 | OK | 14.9 | 2.701 | 6.489 | | | |