D3.3- Methods for identifying the locations of leakage pathways

This report is prepared by UNOTT for Built2Spec project to complete the task 3.1.3 in WP3

Locations of typical leakage pathways

It is commonly known that most of the leakage pathways are located at the junctions between walls, window, door frame and wall, wall and floor, wall and roof, and services penetrations, as shown in Figure 1.

Figure 1 Location of leakage pathways in a typical dwelling

Using current standard blower door method, the identification of leakage pathways is usually implemented by depressurising the target house and detecting the location of leaks with the assistance of a smoke pen or thermal image camera on a point-to-point basis.

Two methods are proposed in this report for the purpose of detecting the location of leakage pathways.

Method 1: Simple fan; Method 2: Pulse test

Method 1: Detecting the location of leakage pathways using a simple fan

This method is the same with the conventional blower door method. Instead of using high spec blower door fan unit, a cheap off-shelf portable fan can be used to replace it to detect the location of leakage pathways in the blower door. The schematic of leakage detection using a portable fan is shown in Figure 2. It can also be done in depressurisation mode by simply turning the fan around.

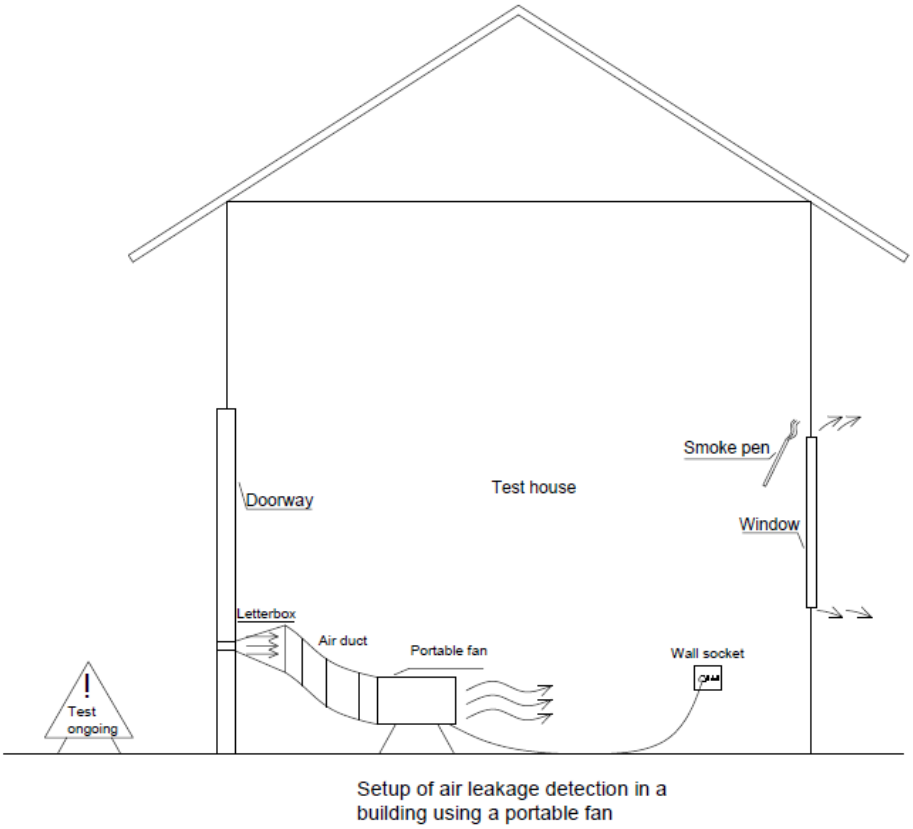


Figure 2 Schematic of air leakage detection using a portable fan (pressurisation mode)

This method can be implemented by installing the portable fan to the building fabric via a air duct. So the building can be depressurised or pressurised for locating the leakage pathways using a smoke pen or thermography camera. In Figure 3, a portable fan is connected to the letterbox of a door and the air can be drawn into the house from outdoor to pressurise the house. Meanwhile, a smoke pen can be used to pinpoint the locations of leakage pathways. Or a thermal image camera can be used when the building is depressurised with temperature difference between indoor and outdoor. More work will be carried out in M30-M36.

Figure 3 *Setup of a portable fan for leakage detection through letter box*

Method 2: Detecting the location of leakage pathways using the pulse test

Considering the pulse test is de-skilled, easy and quick to perform and also able to show the result instantly after the test, it can be used to pin point the location of leakage pathways in a quantified way. It takes longer to carry out than method 1.

The procedures for detecting the location of leakage pathways in a house using the pulse unit include:

- Prepare a pencil and sticker notes.
- Visually inspect the envelope of the house and identify the suspicious locations where the leakage pathways are, primarily focus on the typical locations, as shown in Figure 1.
- Mark each suspected location with pencil, write down the location ID on a sticker note and stick it next to the mark.
- List the marked locations down in a table, such as Table *1*.
- Plan the pulse test in order to confirm if they are leakage pathways.

Take a house with 5 suspicious locations for leakage pathways as an example.

- Table 1 Lists of suspicious locations for leakage pathways

Location ID	Description	Location	Leaky?
1	Junction of window and wall (bottom)	Living room	Positive
2	Penetration of toilet drain pipe through wall	Ground floor toilet	Negative
3	Kitchen sink drain pipe through wall	Kitchen cupboard (under the sink)	Negative
4	Junction between the window and wall (top)	Bedroom	Negative
5	Gap between door and floor	Front door	Positive

This can be implemented by following the procedures below:

1. Prepare the building for airtightness test according to the procedures described in ISO9972, charge the pulse unit in the meantime.
2. Reset the compressor switch from ‘auto’ to ‘off’ after it is fully charged, or when needed.
3. Carry out a pulse test according to the manual and read the Q_4 (air permeability at 4 Pa) from the LCD screen on the control box, and plot it in Figure 4 as the baseline. If time allows, do this twice and take the average as the baseline.
4. Draw out the lines that represent ±5% of the baseline Q_4. Mark the zone between ±5% as the ‘NO’ zone and the one below -5% as the ‘YES’ zone. (Note: ±5% is the measurement uncertainty of current pulse unit), i.e. the percentage of improved airtightness by sealing each location compared to the baseline value needs to be above 5% in order to confirm if the location is leaky.
5. Temporarily seal ‘location 1’ with tape and measuring Q_4 afterwards and plot it in Figure 4 and remove the temporary sealing on ‘location 1’ after the test.

6. Repeat step 4 to location 2 - location 5 one by one.
7. After all the tests, the Q_4 of each location is mapped in Figure 4 and can be determined if it is leaky. If Q_4 is located in the 'YES' zone, it suggests that location is leaky. If the Q_4 is located in the 'NO' zone, it suggests the location is not leaky. In this case, location 1 and 5 are leakage pathways, location 2, 3 and 4 are not. Once identified, Table 1 can be updated.
8. Also the leakage level of each location can be quantified, and used to inform the operative or project manager to make cost and time effective remedial decision if necessary.

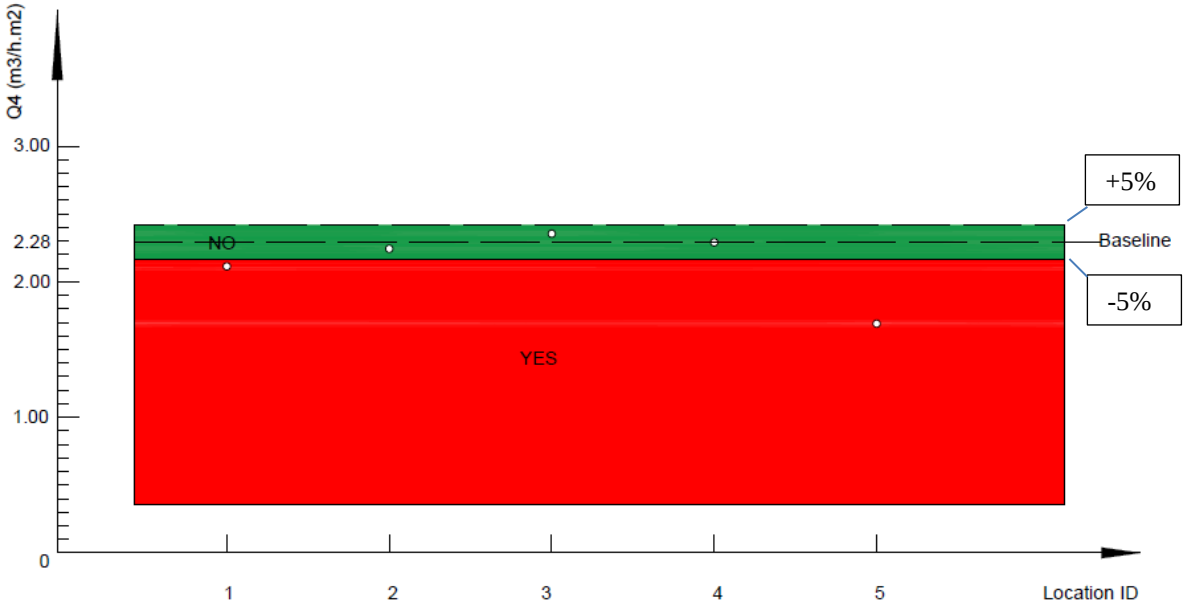


Figure 4 Airtightness test roadmap of baseline comparison

Leak detection in a real house

This test is done in an end-terrace two bedroom house. The test house and the setup of the unit are shown in Figure 5.

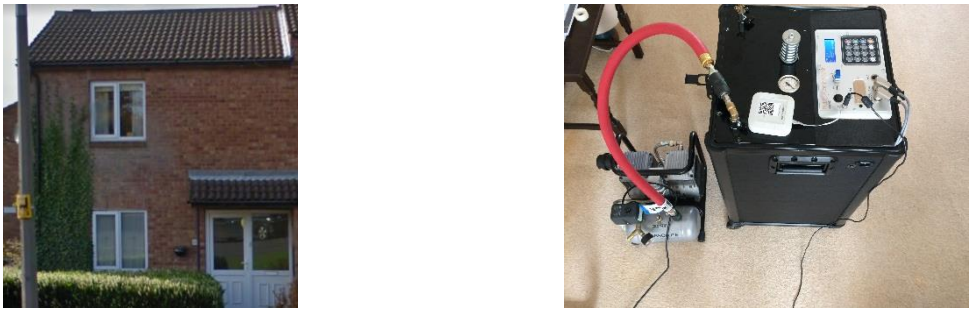
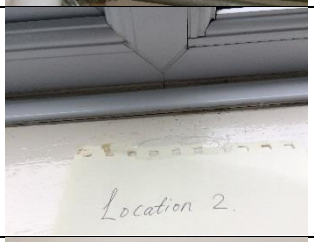


Figure 5 Test house and setup of the pulse unit in it

With sticky notes and pencil, the locations of possible leakage pathways are inspected. For demonstration purpose, three locations were selected for detection tests as listed in Table 2.

- Table 2 Lists of suspicious locations for leakage pathways

Location ID	Description	Location	Photo	Leaky?
1	Penetration of toilet drain pipe through wall	First floor toilet		Positive
2	Window frame (bottom)	First floor guest bedroom		Negative
3	Curtain fittings	Ground floor living room		Negative

The testing procedure follows the ones listed above. The results in each scenarios are listed in Table 3

Table 3 Air tightness improvement after sealing up each location

Location ID	Q_4 ($m^3/h \cdot m^2$)	Improved airtightness	Leaky
1	1.61	13.4%	Yes
2	1.81	2.7%	No
3	1.89	-1.6%	No
Baseline	1.86	N/A	N/A
Note: Improved airtightness has to be above 5% in order to confirm the location is leaky.			

Hence, it can be confirmed that location 1 is leaky, location 2 and 3 are not leaky. By sealing up the location 1, the airtightness of the house can be improved by 13.4%.

Method 2 takes longer to do compared to Method 1, hence is not suitable for situations when an immediate diagnostic is required. However, the benefit of method 2 is that it allows you to make more informative decision on remedial measures.