CAR Review of New Evidence on PULSE Air Permeability Tests

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This short report summarises findings from four longer technical reports. It aims to draw out the implications for MHCLG and make recommendations. This report is independent, in that the authors were not involved in any of the lab or field tests cited, and have no financial or other interest in PULSE or Build Test Solutions.

The four technical reports are:

1. NPL's Review of the PULSE system[1]

This gives an outline description of the usual air permeability test using a blower door, and a description of the PULSE test using a gas canister to release a pulse of air, monitoring tank pressure and room pressure 50 times a second, and calculations based on a model to derive the air flow leaving the room. The most significant difference between the conventional test and the PULSE test is that the usual test raises air pressure within a building up to 50 Pa whereas the important part of a PULSE test is at a pressure of 4 Pa. 4 Pa is much closer to usual air pressure in buildings (although in high winds higher pressures – up to 10 Pa – are not unusual).

NPL say: "It is likely that this method could prove more accurate than the existing standard method, with fewer drawbacks." However, they also note that releasing gas from the PULSE equipment changes the temperature of the gas, which affects repeatability, and they recommend measuring the temperature of air in the tank and including this in the analysis to improve accuracy. BTS say they are working on this.

2. BRE's Lab Tests on the PULSE system[2]

This presents findings of BRE's lab-based comparisons of PULSE measurements against the usual blower door measurements – but at the same pressure ranges. That is, the PULSE tests operated at the upper limit of its pressure range, and the blower door tests operated at the bottom end of their pressure range. BRE set up a series of tests using chambers of different volumes and opening plates of known open areas. They subsequently carried out 12 repeatability tests in perfect conditions and with different starting pressures, to establish whether PULSE gave the same result.

The comparison between PULSE and blower door tests found an average difference between air flow rates measured of 6%, with the largest difference 15.5%. (Note that for one test there was no 'crossover', where the equipment was not able to take measurements at the same pressure.) The PULSE tests also gave a more accurate measurement of the open area in all-but-two cases, with an average difference between the two methods of 7%.

BRE say: "Different PULSE units under the same conditions ... produce repeatable results." However, they also say that based on the chamber testing: "There does not appear to be a straight forward way to extrapolate a 4 pa result up to 50 Pa." They continue: "Unless a correction factor can be derived from a larger dataset we do not see how PULSE could be used to determine compliance [with Part L of the Building Regulations]."

[1] A J Knott (2018) Review of "PULSE" Airtightness Measurement System. Teddington: NPL.
[2] BRE (2018) BRE Test Report: Pulse vs. Blower Door comparison airtightness chamber testing. Garston: BRE.

3. BRE's Innovation Park tests of the PULSE system[3]

This presents findings from five 'real-world' permeability tests on homes on BRE's Innovation Park. Four consecutive tests were carried out on each low-energy home, and the results were compared against blower-door tests.

As expected, the PULSE tests found much lower average permeability at 4 Pa than the blower door tests found at 50 Pa: the range was 0.17 to 0.99 m^3 for the PULSE tests and 1.50 to 4.75 m^3 for the average of pressurisation and depressurisation for the blower door tests. There was good overall agreement between the two test methods across a range of air leakage rates (for statisticians, the R^2 was 0.95).

The repeat tests also showed close agreement between successive tests of the same house: an average discrepancy of 2%, with a maximum difference of 3.8%. This was significantly better than similar repeatability tests using a blower door: average discrepancy of 3%, with a maximum discrepancy of 9.7%.

BRE say: "As can be seen in the summary of results, the... performance claims that the Innovation Park testing exercise sought to address have been met and exceeded." They also note that there was one hardware problem and one software problem with the PULSE system during the tests. BTS say these issues are now resolved.

4. Build Test Solutions' Field Trial Report[4]

This reports on permeability tests on a sample of 108 varied dwellings using PULSE and a blower-door test. There were multiple PULSE tests (six per home), and comparisons against tests using tracer gas to assess permeability on a sub-sample of 24 homes.

The multiple-test cases showed good repeatability: an average relative percentage difference from the mean of 4.7%, even when three tests on each home had ventilation paths sealed and another three did not. However, nearly 30% of homes had a maximum discrepancy of from 5% to 12% in the test results. (This could be due to the variation in gas-canister temperature noted by NPL above, and BTS say they will continue work on this.)

Comparisons between PULSE and blower-door tests also showed a very strong linear relationship between PULSE tests at 4 Pa and blower-door tests at 50 Pa, suggesting there is a fixed correction factor that could be applied of 5.3 (which responds to BRE's point in Reference 2 above).

Build Test Solutions say: "We recommend that the building regulations and supporting instruments place greater emphasis on quoting air permeability at a normal pressure difference, just as with France and Belgium." They also criticise the crude rule-of-thumb in SAP that divides air permeability at 50 Pa by 20 to derive an infiltration rate. Quite correctly, they say there is no scientific evidence behind this rule-of-thumb, and they provide 17 measurements indicating that there is not a constant conversion factor, and the factors they cite are all at least 30.

[3] BRE Global (2018) ETV Verification Test Report: Low Pressure Pulse Air Test Process. Garston: BRE.
[4] Build Test Solutions (2018) Pulse Field Trial Report. Lutterworth: BTS.

Implications for MHCLG

1. The basic physics behind the PULSE idea is sound and such tests could be carried out more quickly and economically than the conventional tests.

2. Not needing to fit a fan into a doorway is also a genuine improvement. (The door is hard to seal, time-consuming to fit, omits from the measurement leakage around the door, and skirts used around the fan introduce problems for repeatability.) Where the PULSE method falls down is that it does not help *find* the source of the leakage – which is possible using a blower door – and this is a significant drawback.

3. PULSE gives at least as accurate measurement of open areas and air flow as a blower-door test for most dwellings – even very air-tight ones.

4. PULSE also gives good repeatability, so the same dwelling will get the same test result on successive tests – somewhat better than successive tests using a blower door.

5. However, there remains a small flaw in the approach, which weakens repeatability of PULSE tests. This is to do with measuring the temperature of air within the PULSE canister, and BTS say they will resolve this by January 2019.

6. Based on the available evidence, it appears there is a fixed conversion factor between PULSE tests at 4Pa and conventional tests at 50Pa: 5.30.

Recommendations

1. The Ministry should give serious consideration to allowing use of the PULSE test as an alternative to blower-door tests to show compliance with Part L1A of the Building Regulations. It could readily be UKAS calibrated to provide a traceable tool suitable for compliance testing.

2. Consider adopting the 5.30 conversion factor within Building Regulations and SAP so there is a straightforward choice for developers about which test to use, and so that the new test results are meaningful for people already familiar with tests at 50 Pa.

3. Commission research into the ‘divide by 20’ rule of thumb currently used in SAP to derive infiltration rates from permeability tests.