PULSE

FAQS

BUILD TEST SOLUTIONS

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Pulse FAQS

1. What is the purpose of air leakage measurement? 3
2. How are air leakage measurements used? 3
3. What is the Pulse air test? 3
4. Why measure at low pressure? 3
5. What are the intended applications for the Pulse test method? 4
6. How do the results compare between a blower door and Pulse test? 4
7. Can Pulse be used for regulatory testing? 5
8. What range of building sizes can Pulse cover? 5
9. How is the PUSLE equipment configured and what are the logistics of handling a Pulse machine? 5
10. What are the power requirements for the equipment? 5
11. How long does a Pulse test take? 6
12. What is the calibration and maintenance requirement associated with the Pulse equipment? 6
13. Can Pulse be used to identify leakage paths? 6
14. How are the outputs from Pulse captured? 6
15. How repeatable is the Pulse test? 7
16. Is the low pressure Pulse technique recognised under a national or international standard? 7
17. Is the air pulse uniform throughout the building or enclosure being tested? How does the 4pa pulse deal with more complex building forms, for example? 7
18. Does Pulse generate a localised pressure that gets weaker as it disperses throughout the building? 7
19. How is Q4 calculated? 8
20. Can a single ‘n’ value (power law flow coefficient) be used to represent all pressures? 8
21. How does the Pulse controller choose the time period for analysis? 8

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1. What is the purpose of air leakage measurement?

Air leakage measurement provides a means of quantifying the rate at which a building or enclosure loses air or 'leaks'. The extent of such leakage can have a considerable impact on the energy required to condition a space, be that in the form of heating, cooling or ventilation. Where very leaky, conditioned air can readily escape but it can also mean that polluted external air can enter the building, especially where mechanical systems such as extractor fans are actively sucking air not only from the room as intended but also via the leakage paths.

2. How are air leakage measurements used?

The commonly perceived purpose of testing air leakage is to produce a benchmarking comparison between buildings or enclosures. However, in reality, air leakage results are used to determine total ventilation rates for energy calculations in SAP within the UK (and other energy modelling tools elsewhere) and, to a lesser extent, for indoor air quality. As such, determining the correct air leakage rate is important for more than simple benchmarking and, if incorrect, can lead to errors in SAP/energy assessments and also incorrect HVAC system design/setup or indeed will potentially lead to unhealthy buildings.

3. What is the Pulse air test?

Pulse is a portable compressed air based system which is used to measure the air leakage of a building or enclosure at an ambient pressure level (4Pa). A concept originally pioneered by the University of Nottingham, the system releases a small burst of air which generates a rate of airflow through the gaps and cracks in the building façade. The change of internal pressure of the building in response to the released air pulse and the subsequent flow through the building envelope is seen as a pulse and its representation is characteristic of the building's leakage.
Pulse dynamically measures building air leakage directly at low pressure maintaining the building integrity. Crucially, this provides an air change rate measurement that is representative of normal inhabited conditions, helping to improve understanding of energy performance and true building ventilation needs.

4. Why measure at low pressure?

A 4Pa reference pressure is generally considered the typical pressure differential across a building envelope over the course of the seasons (i.e. representative whole year average). It is the pressure used as an infiltration reference in the ASHRAE Handbook of Fundamentals, ASTM E741 and within the building codes used in France and Switzerland.
In the UK, CIBSE TM23 also cites that calculation of effective leakage areas performed at a reference pressure between 4 Pa and 10 Pa is more representative of normal weather-induced conditions. It is this low pressure differential field of measurement where Pulse is most truly unique and innovative. Whilst the well-established blower door fan method is a useful stress test of the fabric and able to be used for leakage path diagnostics, the motive behind introducing the Pulse test is in seeking to more accurately measure, understand and act upon the true air leakage characteristics of buildings.
A measurement at low pressure provides insight into the background ventilation rate of a building, helping to assess the suitability and likely performance of the ventilation system specified or already installed. It is also particularly important where accurate whole-building energy performance calculations are required or where risks such as poor ventilation system performance or associated matters such as poor indoor air quality or overheating are a high priority.

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5. What are the intended applications for the Pulse test method?

The primary purpose Pulse has been developed is to measure new and existing buildings at low pressure in order to assess their air leakage characteristics under normal conditions. For airtight new builds, this can be beneficial in assessing the suitability of installed mechanical ventilation systems. For existing builds, the low pressure self-enclosed nature of the system means it causes minimal disruption to occupants.

Other applications of the system do however include the testing of individual rooms, including in healthcare facilities where pressure management and containment is critical. The system may also be used to test labs, cleanrooms, refrigeration chambers, offshore temporary refuge rooms, silos, rooms that rely on gaseous fire suppression to name but a few.

6. How do the results compare between a blower door and Pulse test?

For building regulations and standards compliance purposes in the UK, the standard reference pressure difference at which air permeability or air change rate is stated is 50 Pa.

The performance of a building at 4Pa does not correlate directly with its performance at 50 Pa, therefore conversion is required based on the building type and nature of air leakage. This is because testing at higher pressures creates different flow characteristics and can also cause greater levels of air leakage by forcing convoluted leakage paths or unduly stressing the building envelope.

Nevertheless, based on testing across a large sample of residential buildings, a linear relationship can be observed and a conversion factor of 5.3 may be applied to a 4 Pa result in order to convert it to 50 Pa for the purposes of regulatory reporting. That is, a 50Pa AP_{50}/ACH_{50} can be converted to a 4Pa AP_4/ACH_4 by a simple *division of 5.3*. For example, an ACH_{50} of $5hr^{-1}$ is equal to an ACH_4 of $0.9hr^{-1}$.

Alternatively, results at 50 Pa must be calculated by extrapolation using the flow equation

$$Q = C(\Delta P)^n$$

the values of C and *n* are derived from a power law least squares curve fit of the flow and pressure measurements obtained in the range up to the maximum pressure difference recorded during the test.

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7. Can Pulse be used for regulatory testing?

The introduction of the low pressure pulse technique as an approved method has been proposed within a consultation on the Building Regulations for England in September 2019. This public consultation concludes in January 2020 with the new regulations expected to formally come in to force from Autumn 2020. It is possible that the method could be accepted sooner or indeed able to be recognised as an approved method and applied against schemes working to older versions of the regulations but confirmation of this won't be until after the current consultation has closed.

We hope that once the Building Regulations in England makes the move towards Pulse that other regulatory bodies will follow suit. There are of course also nations which don't specify a specific air tightness test procedure. Equally, we are happy to work with you to explore the possibilities of accelerating regulatory acceptance in your country of interest.

8. What range of building sizes can Pulse cover?

The latest MK2 version of the Pulse unit standardises around a 40 litre air receiver. A single 40L tank will deliver a flow rate of 450 m^3/hr @4Pa. This makes it suitable for the majority of residential new build applications. Where leakage exceeds 10 air changes per hour @ 50Pa in medium to large residential properties, two 40L air receivers can be tethered in order to deliver twice the flow rate. For non-residential testing further air receivers can be added and released simultaneously.

9. How is the PUSLE equipment configured and what are the logistics of handling a Pulse machine?

In simple terms, the three main components that form the Pulse device are an air receiver, a compressor and a small Pulse controller. The latest version of the product, Pulse MK2 can be ordered now for delivery from February 2020. This system comprises a rugged air receiver with protective aluminium end caps which weighs ~12kg and may be carried over the shoulder or on your back like a rucksack. This includes pockets for carrying ancillaries including the Pulse controller. This leaves both arms free for carrying the standalone portable compressor which weighs a further ~13kg.

The set-up for a test involves a total of four connections, with an air hose connected from the compressor to the air receiver and a data cable run from the air receiver on to the Pulse controller. The air receiver is then charged and a test is able to be released. No external penetrations to the building envelope are required.

10. What are the power requirements for the equipment?

The Pulse controller operates from a 24v DC power supply and is powered by the adapter provided. The air compressor can be purchased in either a 110V or 230V mains option with specialist set-ups also available, for example van based compressors that can charge the air receivers whilst on the move or for where there is limited power on site.

11. How long does a Pulse test take?

A Pulse test takes less than 15 minutes from start to finish. The Pulse test first requires the tester to enter the building and set up the equipment (2 minutes), the compressor is then switched on to charge the air receiver (8 minutes from empty to 10 bar for the 40L air receiver). The tester is then encouraged to use this charging time to measure up and prepare the building. The Pulse test itself then takes approximately 15 seconds to execute, with results instantly captured within the controller. The operative may then pack down the equipment and move on to the next plot.

This time benefit increases significantly as the complexity of a given testing situation grows. For example, with non-residential testing, the same controller is used with simply more air receivers connected back to it.

12. What is the calibration and maintenance requirement associated with the Pulse equipment?

It is recommended that in accordance with the Pressure Equipment Directive (PED), Pulse equipment is visually inspected by a competent person once every 24 months to assess for damage, corrosion or any faulty parts. During this inspection, it is recommended that sensor calibration is also checked using temperature and pressure calibration instruments that are traceable to national standards. The sensors that make up the system comprise a pressure transducer and fast response temperature sensor fitted to the air receiver and both a low pressure differential pressure sensor and room temperature sensor mounted in the Pulse controller.

The Pulse product manual also details self-calibration check procedures which involve a user testing a building or enclosure and then introducing a ‘known-opening’ plate into a window opening. We’re also occasionally asked about building site dust clogging up the air release nozzle but the main function of this device is as a pneumatic silencer, and the diffusion of air as part of the test process will keep the component sufficiently clear.

13. Can Pulse be used to identify leakage paths?

Pulse cannot provide the sustained pressures required to undertake leakage diagnostics. Pulse is instead intended to provide quick measurements to determine pass/fail or to instruct on the extent of the leakage for a given state of construction or refurbishment.
In recognition of the value that leakage diagnostics can provide, especially where there are high compliance failure rates, Build Test Solutions also offer its Leak Checker product. This is a small window mounted fan that can be used to create a steady state pressure differential of 20-30Pa. This allows leaks to be identified and also visualised with the use of tracer smoke or thermography.

14. How are the outputs from Pulse captured?

The brain of the Pulse device is its controller which houses a processor, memory and the main sensors. The controller simply requires the user to enter the building volume and envelope area and then at the push of a button the Pulse is released and the processor automatically calculates the result. This result is shown immediately on the screen of the device but is also automatically saved and stored. Individual or batch results may then be downloaded either directly via USB from the controller memory for onward analysis and reporting. Depending on the user’s level of expertise and intended use for the data, either the full raw data from a Pulse test or just the coefficients and final test result figures can be communicated.

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15. How repeatable is the Pulse test?

A high level of repeatability is a critical factor in demonstrating measurement accuracy. We see excellent repeatability with a relative percentage difference (RPD) from the mean of repeated tests falling comfortably within +/- 5% for all tests. Generally, the Pulse operative has very limited effect on repeatability, with test set-up being very simple and with the tests themselves conducted at the single push of a button

16. Is the low pressure Pulse technique recognised under a national or international standard?

The latest proposed 2020 version of CIBSE TM23 documents the Pulse procedure alongside the blower door fan technique. Build Test Solutions are also in discussions with both BSI and relevant International Standards committees about the creation of a new internationally recognised standard that details the low pressure pulse method.

17. Is the air pulse uniform throughout the building or enclosure being tested? How does the 4pa pulse deal with more complex building forms, for example?

We have measured the internal pressure in the middle of buildings and also at multiple points throughout them (up to three storeys high) without detecting any noticeable differences. We have also undertaken numerical analysis (using CFD software) that shows the pressure across the test space equalises almost instantaneously and certainly by the time of the important quasi-steady analysis period. This is due to the fact that the air pulse disperses at the speed of sound (approx. 340 metres per second) and is a long wavelength infrasonic frequency. Just as with a conventional blower door test, the only requirement is that internal doors are kept open in order to ensure full and equal pressurisation.

18. Does Pulse generate a localised pressure that gets weaker as it disperses throughout the building?

The pulse spreads at the speed of sound (approximately 340 metres per second) and is a long wavelength infrasonic frequency that simply doesn't get absorbed or slowed down within typical building environments in the same way shorter acoustic wavelengths do. The pressure transducer currently used for measurement within the Pulse device samples at 50Hz and it is very clear in all our data that the enclosure pressurises almost instantaneously and quickly, and consistently reaches a quasi-steady state before then decaying. For equal pressure distribution within very large buildings, we can tether multiple units evenly throughout the building and release them simultaneously.

It is worth noting that if the internal pressure tapping is too close to the nozzle outlet there is a risk of it being affected by turbulent flow from the nozzle but this risk is reduced by having the controller positioned a suitable distance from the air receiver.

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19. How is Q4 calculated?

Q4, (the air leakage flow rate at 4 Pa), is obtained in the same way the blower door test obtains the Q50 (leakage rate at 50 Pa). A curve fit is made to the plot of leakage against pressure difference, and then the leakage corresponding to 4 Pa is calculated. This can be done by using either the power law or quadratic equation, and in practice (with experimental data) is simply a case of flipping the axes to convert between them. While the quadratic equation has been shown (both numerically and experimentally) to provide a better model of low-pressure leakage, in practice it doesn't really matter that much which is used for fitting measured data as long as it isn't extrapolated outside the measurement range.

20. Can a single 'n' value (power law pressure exponent) be used to represent all pressures?

It is incorrect to say 'n' is a building property and will be constant. The pressure exponent 'n' is a function of both the opening geometry and the flow regime through it. As such, 'n' does actually change with flow rate (and therefore pressure difference). This isn't apparent when fitting the power law to test results as it is a function of the measured points themselves. However, if you extrapolate outside the measured data range it can be expected to incur significant uncertainty (either up or down) as the flow regime is unknown.

21. How does the Pulse controller choose the time period for analysis?

In short, we have identified a period of quasi-steady flow between the peak of the pulse and the closing of the valve, by matching theoretical curves with experimental ones. We have also shown that, by using the same equipment configuration, we can rely on a certain time range to always give a quasi-steady flow. In practice, this can be seen by plotting the measured pulse pressure against time, as a period where the driven pressure drop steadily decreases (some change in pressure is actually desirable, in order to give a range of values).

The theoretical curves are obtained using a model based on the quadratic equation. An advantage of the quadratic relationship is that you can represent the steady and unsteady elements of the flow separately, which is impossible with the power law as it assumes one flow type as representative of the total. During the analysis period, the steady flow is typically around 99% of the total flow (hence quasi-steady) for openings up to approximately 3.5 metres in length, at which point the inertia in the openings starts to increase the unsteady component.

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