Guidelines for

Blower Door Testing

of

Passive Houses

Table of Contents

Document version: 1.51
Date: 04/11/2019
Author: Gavin Ó Sé, GreenBuild, Inch, Gorey, Co. Wexford, Ireland

Change History: 10 August 2011 – original document
07 September 2011 – added section on blower door fan set up
07 September 2011 – added section on treatment of window/door reveals
03 April 2012 – alterations to align document to newly uploaded Passipedia document http://passipedia.passiv.de/passipedia_en/planning/airtight_construction/airtightness_measurements_in_passive_houses main changes were addition of q50 section for larger buildings, sealing of HRV systems before a test, volume of stairwells
31 August 2012 – added section on multi-unit testing (guarded zone testing)
10 September 2013 – altered section on attic volume calculations, ref: Mosart & Soeren Peper PHI
07 July 2015 – edits and corrections -thanks to Colm Ó hÁonghusa for some pointers; added tracer gas method for leak detection thanks to Katariina Laine.
9 February 2018 – updates to make reference to the EN 9972:2015 that has replaced EN 13829:2000 for most testing in European countries. Links to passipedia article updated. Small edit to the q50 requirement for larger buildings.
04 November 2019 – small edit due to inaccuracy in a description – thanks to Ben Elliston of passivnous, Australia for reading the document closer than we had! Small edit to section on Method A and Method B comparison. Small edit to n50 – q50 difference. Add link to new (Sept 2019) Passipedia document on testing high rise passive house buildings. Added note and link to ATTMA TS4 for Passive House, in volume calc. section

Introduction

The Passive House standard is now widely accepted as a viable framework for the specification and building of very low energy and comfortable buildings. The standard calls for high performing building envelopes, with excellent insulation, low thermal bridging rates and and low air leakage rates, as well as emphasis on ventilation and building orientation.

The low air leakage rates that are required in the standard must be proven for each individual building by means of a “blower door” air tightness test. The air change rate must be below 0.6 airchanges per hour under test conditions.

This document seeks to provide clearer guidance on the blower door test as it pertains to the Passive House standard, and it is aimed mainly at blower door testers, specifiers, engineers and architects involved in the Passive House process, although of course it may also prove useful to others involved in Passive Houses.

After the first versions of this document were written, the Passive House Institute posted in March 2012 a more concise and relevant article than they ever had before on Passive House airtightness. The current version of this document is found at the link address below (Feb. 2018):

https://passipedia.org/planning/airtight_construction/airtightness_measurements_in_passive_houses

Although that article and this document cover a lot of the same ground, we will maintain this document to provide some further guidance and reasoning for the target audience. In the case where for any reason this document and the Passipedia article do not concur, the Passipedia document should evidently be taken to have priority. A login may be need to access the content of that document.

Background

When undertaking U Value calculations for the Passive House, there is a sheet in the PHPP that directs the process, so that it is done the same across all projects (or should be!).

When specifying technical components, such as ventilation systems or windows for example, the Passive House Institute itself can issue certificates for the components to prove the component's efficiency. Test certificates from other reputable laboratories who test to the correct standard can be also taken, albeit with a reduction factor in some cases. Thus, these details can be understood as relatively well comparable across projects.

For the blower door test, it is specified that the test must be undertaken to EN13829 Method A, and that the blower door reference volume, called Vn50 in the PHPP, is the full internal air volume of the building under test. So far, it seems clear.

However, many testers, architects, builders and specifiers find that there is still much room for doubt as to whether the test has been performed correctly, and if the result has been related to the correct building volume to determine the air change rate.

Also, as from 2015, European countries have gradually adopted EN 9972:2015 as an update and replacement to the EN13829 standard. Although the content of the two standards is close, there are a number of differences that might affect the understanding of the test results. For most of this document, we will continue to reference the EN13829:2000 standard as the main standard to be adhered to, but with a little extra section at the end for the things to watch out for if testing to EN9972:2015.

Reasons for doubt...

There are two main reasons for doubt to creep in as to the validity of the blower door test results for the Passive House:

1. The EN13829 standard is not implemented the same in different countries. Thus, even though Method A and n50 are specified by the Passive House Institute as being the Method required and the result reporting unit required for the standard, testers in different countries may approach blower door testing of the Passive House as they do the testing of houses for their national regulations.
2. There is no oversight or regulatory body in most countries to ensure that tests are performed the same by all testers. In most countries this is the case even for the national regulations, it is therefore even more so for the Passive house movement, which is purely voluntary. And even where this regulation might apply, the Passive House requirement of Method A and the volume calculation may not match national methodologies.

For example, 2 preparation methods are described in the EN13829, simply called Methods A and B; there are also 3 reporting units – given the terminology w50, q50 and n50, the extent of each of these can be reported on differently in different countries.

So it is that there is the danger, where even using the same preparation method, lets say, Method A, and the same reporting unit, say n50, that airtightness testers will find that if they compare notes with colleagues in their own countries and in other countries, whilst everyone will feel they are working to the correct standards, they are in fact not all following the same test preparation or unit calculation procedures.

From speaking to testers in various countries, where there is no regulatory overseeing body or voluntary testing association, it will be found that even the nationally stipulated methods and reporting units are not all understood the same by all testers. We would suggest this is even more so for the Passive House requirements, which are still a novelty in many areas. Also, for Passive House projects outside of Europe most testers involved in Passive House projects would have no familiarity at all of the EN13829 standard.

Follow German practices to eliminate doubt?

As the Passive House standard originated mainly in Germany, and all the early testing would have been in that country, then one would think that following the EN13829 practices as they are understood in Germany would lead to a fully acceptable and dispute free protocol for testing. However, it will be found that even among testers in Germany, there is disagreement on items requiring sealing or on the volume calculations.

Also in Germany, where many testers have been always testing to Method A, the national test preparation method to satisfy the building regulations was changed in the early 20-teens and specifically stipulated as Method B.

Therefore, we cannot reliably depend on following German practice alone in this regard, and we would argue that the Passive House Institute needs to either:

a) describe a test protocol in its entirety so that everyone follow the same procedure across the world, or
b) allow in the PHPP calculations some kind of discrepancy amount in blower test results, to allow for the fact that tests may be 5-10-maybe even 15% different across jurisdictions and even within jurisdictions, depending on how the testers understand the EN13829 regulation and the Passive house internal volume calculation.

That said, in practise, because of the types of openings that might be present in a passive House, the difference between method A and method B should be, for the main part, immaterial.

Reason for Passive House to have its own Test Protocol Extension to EN13829

Following on from item a) above, Greenbuild is submitting this document as a starting point for discussion. It may be that the PHI decides to follow option b) above, or indeed another option not though of here.

Based on option a) above: To allow tests to be properly compared across the world, and to be sure that the Passive House criteria is actually being fulfilled, it is important that everyone who is testing and specifying and building Passive Houses are all working to the same standard and assumptions, as it is with the U Value calculations and technical component performance certificates.

Thus this brief guide. We will look at the EN13829 standard to which the tests should be performed, with guidance given for items not specifically covered by the standard. We also very importantly give guidance on how the volume is calculated according to the Passive House standard.

For completeness, a small section on finding the leaks has also been included.

About the Author

The author, Gavin Ó Sé of GreenBuild in Ireland, has tested a number of certified passive houses. He holds the NSAI certificate to test to EN9972:2015, and formerly to EN13829:2000, the Passive House Consultant certificate and also has given training on Thermal Imaging and Blower door testing for the Passive House Academy in Ireland.

Blower door testing methodology

EN13829
Thermal performance of buildings. Determination of air permeability of buildings.
Fan pressurization method

This is the standard explicitly required by the Passive House Institute for conducting air pressure test to a Passive House. In some countries in Europe, this is also the standard used to test buildings according to national regulations.

It is recommended that anyone wishing to undertake testing for Passive Houses familiarise themselves with the contents of this standard. This document that you are reading now should only be understood to be an addition to and clarification of to the standard as it relates to Passive Houses, not a complete replacement for it.

Why EN13829?

The EN13829 is the European Norm for blower door testing. 'EN' standards are normally transposed into national standards by the national standards organisations of the member countries of the *European Committee for Standardisation*. Thus the EN13829 became the German Standard DIN EN13829, and this was taken as the acceptable blower door testing standard for Germany. As the Passive House movement was principally based in Germany, then the DIN EN13829 formed a reasonable basis for blower door testing of Passive Houses.

As the Passive House movement has grown to go well beyond German and European boundaries, there may be a case to be made for changing the standard for the tests to a wider international standard, such as ISO 9972, if this standard can be agreed on.

However, it will be found that the content of this ISO 9972 standard is very similar to the EN13829 standard. Also, it is important that the tests conducted in various countries by different testers and over time are comparable to each other. Migration to another test standard may cause a rupture in the comparability of test results. (Note: The Passive House concept was born before there was an international blower door test standard to test to. The author is not entirely sure how testing was carried out prior to adoption of EN13829, and how the results relate to the EN13829 generated results.) Therefore, it can be considered that the EN13829 standard is as good as any other, if implemented uniformly for Passive House tests across the world.

Overview of EN13829

There are 4 parts of the standard that we are interested in:

1. Acceptable Test conditions
2. Test Preparation Methodology
3. Test Methodology
4. Reporting

Acceptable Test Conditions

According to EN13829, for a blower door test to be acceptable, there are a number of conditions that need to be fulfilled:

- The Envelope of the building must be completed (or at least the part to be tested)
- Windspeed must be Beaufort scale 3 or less, or, if measured, 6 m/s or less
- A 500m.K rule applies – multiply the height of the building in meters by the inside/outside temperature difference in Centigrade, and the result should be less than 500.
- The static pressure (Zero Flow) difference between the inside and outside of the building with the envelope closed up, but with no test equipment running, must be less than 5 Pascal (Pa) over a 30 second average.
- These variables must be checked after the test also to ensure conditions have not changed.

There are also some references to acceptable equipment accuracy. Any tester with modern, regularly calibrated blower door and ancillary equipment will be fine in this regard.

Test Preparation Methodology

The EN13829 standard lists two principal test preparation methods, which are given as Method A and Method B.

They are given as follows (EN13829:200, pg 7):

> **Method A** (test of a building in use):
> The condition of the building envelope should represent its condition during the season in which heating or cooling systems are used.
> **Method B** (test of the building envelope):
> Any intentional opening in the building envelope shall be closed or sealed as specified in 5.2.2 and 5.2.3.

In summary, Method B allows more items to be sealed up or closed over during a test than Method A does.

The Passive House standard explicitly requires the test be performed to Method A, and thus the rule of thumb is that anything that can be closed, may be closed, all other items through the building envelope should be left as they are. The only exceptions to this are Mechanical Ventilation or Air Conditioning systems, which should be sealed off rather than just closed/turned off.

Appendix A at the end of this document contains a check-list of openings, to help you determine how to deal with openings as per the requirements of Method A, in case of doubt.

One of the main differences between methods A and B, for those countries where open fires are still common, is that those chimneys or flues with no damper or closing device on them are sealed for Method B, but are kept open and clear for Method A – thus there is a big hole straight away in the house envelope for a Passive House compliant test. (Also, soot danger when conducting test!)

Test Methodology

The test for EN13829 is a multi-point test, i.e. at least 5 sets of readings are taken at different induced pressure differences between the inside and the outside e.g. 60Pa, 50Pa, 40Pa, 30Pa, 20Pa.

To satisfy the EN13829 standard, the readings can be taken for pressurisation only, depressurisation only, or both sets of readings can be taken with the result being the average between the two.

The lowest pressure point allowed is 10Pa, or at least 5 times the Static pressure reading. Thus if you had a 3Pa 30 second average Static Pressure, then the minimum pressure allowed is 15Pa.

The highest pressure reached is up to the discretion of the tester given the site conditions, but for a any dwelling no matter what the size, or any non-dwelling small building it should be at least 50Pa. When testing larger buildings of greater than $4000m^3$, the lowest maximum pressure allowed is 25Pa. The result at 50Pa is then extrapolated from this result.

As noted above, the EN13829 standard allows for either a pressurisation or depressurisation test alone to be valid; however, the ***Passive House Institute requires both directions to be tested***, with the result being an average of the two, as reported at 50Pa.

Also, as the Passive House buildings are so airtight, it is unlikely that *any* building could not be tested fully to the 50Pa pressure with the correct equipment. Finally, for accuracy, we recommend that at least 10 pressure points are taken in each test direction, rather than the 5 stipulated in the standard. This does not mean necessarily going to higher pressures, but simply having smaller gaps between testing points – say 5Pa gaps instead of 10Pa.

Reporting

Most blower door equipment now comes with software (as an extra, or included in the package) which allows the report to be presented with the information required by the standard.

For those testers operating outside of Europe who may manually compile their reports rather than use an EN13829 compliant piece of software, strictly speaking the report should contain the following (EN13829:2001, pg 15):

> **7 Test report**
> The report shall contain at least the following information:
> a) all details necessary to identify the object tested: purpose of test (method A or B); post address and estimated date of construction of the building;
> b) a reference to this standard and any deviation from it;
> c) test object:
> - description of which parts of the building were subject to the test; apartment number;
> - net floor area and internal volume of space subject to the test and other required dimensions of the building;
> - documentation of calculations so that the stated results can be verified;
> - the status of all openings on the building envelope, latched, sealed, open, etc.;

- detailed description of temporarily sealed openings, if any;
- the type of heating, ventilating and air conditioning system;

d) apparatus and procedure:
- equipment and technique employed;

e) test data:
- zero-flow pressure differences $\Delta p_{0,1+}$, $\Delta p_{0,1-}$, $\Delta p_{0,2+}$, $\Delta p_{0,2-}$, $\Delta p_{0,1}$ and $\Delta p_{0,2}$ for pressurization and depressurization test;
- inside and outside temperatures;
- wind speed, barometric pressure if it is part of the calculation;
- table of induced pressure differences and corresponding air flow rates;
- air leakage graph (example: see Figure 2);
- the air flow coefficient, C_{env} , the air flow exponent, n, and the air leakage coefficient, C_L , for both pressurization and depressurization tests determined by the method indicated in clauses 4, 5 and 6 along with their confidence limits;
- air change rate, n_{50} , at 50 Pa, for pressurization and/or depressurization and mean value;
- derived quantity according to national regulation;

f) date of test.

In practice, few reports have *all* of this data and it mainly isn't required by those interested in the test results, but above all the address, date, air movement measures & static pressure results ***and*** the graph should be included, along with any notes on items temporarily sealed or variations from the EN13829 standard, as well as a mention as to which opening was used to house the fan equipment.

Additional Notes on Door Fan set up

When conducting an air pressure test on such airtight buildings, some of the air leakage measured may come through the set up of the test equipment itself. There are no specific rules on this from the PHI or in the EN13829, so common sense and details from the manufacturers must prevail.

The following can be taken as a general guide, and certainly it holds for Retrotec fans (as used by this reports author) – other fan makes may have different set-ups and so this should be checked with the manufacturers.

Air Leakage Possibility	Preparation
Where the blower door temporary panel meets the window/door reveal	Seal the temporary panel to the reveal
Where the blower door machine fits into the temporary panel	Seal the machine to the temporary panel
Around where the different flow rate rings fit into the blower door machine	**Do not** seal the machine itself – it will have been calibrated with these little leaks allowed for

Some items to note if testing to EN9972:2015

Most of what was said above about EN13829 holds true for tests to EN9972:2015. However, there are some differences in terminology and in volume calculations that need to be considered.

The main differences that we could distinguish between the standards are given below. As most of them involve the newer standard trying to establish greater accuracy with reduced tolerances for several items, these can be welcomed.

For Passive House testing, the pitfall would be to use the gross volume measurement as per the EN 9972:2015 standard rather than the net volume measurement of the older standard.

	EN13829: 2000	ISO 9972:2015
Pressure Measuring Device	±2 Pa in range 0 to 60 Pa	±1 Pa in range 0 to 100 Pa
Temperature Measuring Device	±1 K	±0.5 K
Product indoor/outdoor air temperature X Height	500 mK	250 mK
Zero flow pressure readings	Observe and note over a period of at least 30 sec.	Observe and note *at least 10 values* over a period of 30 seconds
Lowest Pressure Difference	10Pa, or 5 times the zero-flow pressure difference	10 Pa (±3 Pa) or 5 times the zero-flow pressure difference
Large Buildings	'Large building' specifically noted as being over 4000m^3	Reference to 4000m^3 removed
Building Volume	Net floor area times mean net ceiling height ('net' meaning floors, walls, voids are taken out as per local regulations)	Uses the gross internal dimensions rather than net internal dimensions ('gross' meaning the full internal dimensions are used)
Values of *n* and r^2		*n* between 0.5 and 1 *r2* not less than 0.98
Calculation notes		Small additions to the calculations to note that the air flow rate calcualtions referencing air density are ≈ to the same calculation type referencing temperatures, in Kelvin
Reference value uncertainty	Typically between 5% and 10%	Typically between 3% and 10%
Overall uncertainty	Generally ±15 %, up to ±40 % in windy conditions	±10 % in calm conditions, up to ±20 % in windy conditions
If you use humidity in the calculations		Measuring device accuracy of ±5% relative humidity. Meaure from outside when pressurizing, inside when depressurizing

Additionally, the unit references have changed somewhat, ones that might affect the passive House tester are:

EN13829: 2000	ISO 9972:2015
q50	q_E50
Q50	q50

The n50 unit is still used as before.

According to the Passive House passipedia article, the older style unit names should continue to be used on test reports for the passive House Standard.

	EN13829: 2000	ISO 9972:2015
1st Type	Method A – Building in Use	Method 1 – Building in Use
2nd Type	Method B – Building Envelope	Method 2 – Building Envelope
3rd Type	--(none)--	Method 3 – Specific purpose tests, such as compliance tests with particular inventorys of items closed/sealed

Finally, the test method names have been changed, as follows:

So the Method A up to now in EN13829:2000 can be considered equivalent with the Method 1 of the 9972:2015.

Testing one unit within a Multi- Unit building

In some cases, the airtightness test is to be carried out on just one unit in a multi unit building, such as a single apartment in an apartment block, or on one house in a terrace. Where the airtightness and thermal envelope of the unit follows the perimeter of the unit itself, then there is no difference to the testing method – it is simply a standard test to EN13829:2001 Method A.

However, if the airtightness and/or thermal envelope follows the envelope of the main building, then there are some other considerations, and a variant type of testing, called Guard Zone testing, may be appropriate. This type of testing is not specifically mentioned in the EN13829 standard, and therefore is not strictly in accordance with it. However, it has been used for Passive House projects, and is used in other cases where the effect of inter-unit leakages is to be factored out.

In the document **Untersuchung der Luftdichtheit in der Passivhaussiedlung Hannover-Kronsberg** (PHI 1999/4), the test procedure is documented for terraced passive houses. Although the main test procedure in place at the time that those tests were undertaken was before the formal adoption of EN13829:2001, it can be considered equivalent.

With Guard Zone testing, the unit under test is tested as per usual. Then, the test is repeated, but with any adjoining units brought to the same pressure as the unit under test, to negate the effect of the air leakage between the units. This means that any leakage measured through the test equipment of the main unit under test, should be that which is coming via the external envelope of that unit only.

The reasoning for undertaking such testing is that it is assumed that each unit will be occupied to much the same heat/comfort levels, so even if there is some air movement between units in a multi unit development, it does not affect the ***energy balance*** of the unit. Remember, the Passive House standard is more directly concerned with heat loss rather than with pollutant or sound transfer between units, but for those reasons achieving airtightness on a unit by unit basis should be seriously considered.

Similar testing can be done for upper level apartments, but numerous fans would be required to simultaneously pressurise/depressurise the neighbouring units[1].

1 More details on this type of testing can be found in the above named PHI document, or general, non Passive House specific information on multi-unit testing can be found by online searching for terms such as “Schutz Druckmessungen “ or “guard zone testing” along with the term 'blower door' or airtightness'. For example, see several documents from the University of Kassel (http://www.uni-kassel.de/fb6/bpy/de/forschung/veroeffentlichungen/index.html) or documents by Don Hynek (sometimes with associate contributors), such as - http://www.waptac.org/data/files/Website_docs/Events/Conferences/2011-DOE-National-Conference/Wednesday/W36-Multifamily-Applicability-of-Blower-Doors-Hynek.pdf

Passive House - Volume measurements

*To meet the passive House criteria, the tested building must have an airchange rate of <= **0.6 ACH** (Air Changes per Hour) @ 50 Pa*

Airchanges per hour

It will be seen in the section on reporting the pressure test results above, that the '*air change rate, n50*' value should be given in the report for pressurisation, depressurisation, and more importantly for Passive Houses , the mean value.

The term, “air change rate”, or “Air Changes per Hour (ACH)” means that the air volume in the building changes by the specified rate in the space of an hour, under the conditions mentioned. In this case it is under the test conditions at the standardised 50Pa pressure difference between inside and outside.

To be sure that the 0.6ACH per hour is being reached, then we need to be sure that the air flow rate at 50Pa is divided into the correct internal air volume amount.

The question is then - “what is the internal air volume of the building?”

Internal Air Volume

In the EN13829 standard, the internal air volume is given as follows: (EN13289:2001 pg 10)

> **6.1.1 Internal volume**
> The internal volume, *V*, is the volume of air inside the measured building or part of building. The internal volume is calculated by multiplying the net floor area (see 6.1.3) with the mean net ceiling height. The volume of furniture is not subtracted.

Regarding the net floor area mentioned above, it says (pg 11):

> **6.1.3 Net floor area**
> The net floor area A_F is the total floor area of all floors belonging to the internal volume subject to the test. It is calculated according to national regulations.

Thus strictly speaking to fulfil the EN13829 requirements, the exact same building tested by the same testers could have different blower door test results depending on how the floor area (and thus volume) is calculated in the country in which the house is located. Again, for cross country comparability, this is not an ideal scenario. Also, some countries may not have a national floor regulation to work from, and even if they do it may be quite different to those of other countries.

Therefore, it is very important that all testers are using the same volume calculation. In terms of using a floor area * mean ceiling height, it can be argued that the Treated Floor Area could be used as the floor area, yet this counts some spaces as 50%, and others as 60%, and so may be usable but not ideal, as we are really looking for the full net internal air volume.

The standardised volume used for Passive House style tests then is generally ***a room by room width*length*height*** calculation for all applicable rooms and spaces. This width*breath*height calculation takes in only the volumes to the finished surfaces of the room, and not the hidden spaces behind/over or under the visible surfaces. This is the so-called 'clear air volume'.

Note that if the test is a preliminary test, and the internal finishes are not yet in place, the volume measurements used should be those of how the building will be when finished.

The EN13829 standard has a way of defining the spaces applicable to the volume calculation (pg4):

> **3.2**
> **internal volume**
> deliberately heated, cooled or mechanically ventilated space within a building or part of a building subject to the measurement, generally not including the attic space, basement space and attached structures

What counts as an applicable room or space? – It is usually:

- in the conditioned (heated/cooled) envelope
- it is a usable space

It will be seen below that the note regarding the attic and the basement is not an absolute, and that they may be included in certain circumstances.

Passive House Volumes

Keeping in mind the definitions above from the EN13829 standard, we now look at the Passive House requirements. It bears noting that in Passive House calculations there are *3 types of volume measurements used*.

Unless all involved in a project are aware of this fact, this can lead to much confusion among participants in a Passive House project, and a blower door test may be related to the wrong volume.

Passive House Volume Designator	Note
V_e	**X – not the air volume for a blower door test** This is the main volume for a Passive House project is the gross enclosed volume of the Passive House object in its entirety. This is the largest volume involved.
V_{RAX}	**X – not the air volume for a blower door test** This is the 'effective air volume', or the ventilation volume, taken by multiplying the treated floor area by a standardised ceiling height of 2.5m.
V_{n50}	**Y – this is the volume to be used for the blower door test.** It is derived by doing a room by room air volume measurement – see appendix B for more details

Table 1: Passive House Volumes

To this end, it is vital that the blower door tester verify on site the volumes to be used in the calculations. As well as the width*length*height formula noted in the previous section, Appendix B gives an overview of how to deal with different spaces in buildings to determine if they count towards the internal volume or not.

Again, note that the internal air volume calculations do not necessarily directly correlate to a 'treated floor area * average ceiling height' volume.

Who Calculates the Volume?

Section 7 of EN13829 mentions that the volume calculations produced by the tester should be available in the test report. In many cases this is not strictly enforced, but it serves to show that the airtightness tester should have their own set of calculations for the building volume.

In terms of the Passive House certification however, there are two options:

1. The tester measures onsite the correct Vn50 volume and reports the results not only as an absolute flow rate (in m^3/hr @ 50Pa), but also as an air change rate (n50).
2. The Passive House consultant/Architect/Engineer on the scheme provides the tester with the Vn50, (which the tester s*hould* verify to their own satisfaction), and the result is reported by the tester as either an absolute flow rate (in m^3/hr @ 50Pa), or as an air change rate, with the proviso that mention is made as to the provenance of the volume calculation to which the air change rate pertains[2].

Whosoever calculates the volume of the building for the blower door test must be able to provide the volume calculations for scrutiny to the Passive House certifiers, if the building is to be certified.

In Britain, and perhaps some other jurisdictions, members of the Airtightness Testing and Measurement Association also run a building sizing componet to their training, and they have a specific standard TS4 – for Passive House testing (https://www.bcta.group/shop/attma-pht-technical-standard-l42018/), and so they would generally be considered acceptable sources for a building size also.

The q50 and Larger Buildings

Large buildings typically have a better area to volume ratio than smaller buildings, and thus they pass the n50 <= 0.6 airchanges criteria much easier. But are they really airtight enough?

The Passive house institute has introduced a requirement that the q50 must also be less than or equal to 0.6.

To further clarify:

- The q50 calculation is one based on the test airflow divided by the envelope area of the building. According to the EN13829 standard, the envelope area for the q50 is the external envelope based on internal dimensions of the envelope. The Passive House Institute will however also accept those based on external dimensions as on large buildings the difference will be negligible (but not the same!)
- Large buildings are described as those with an air volume greater than or equal to 4,000 m^3 in the EN 13829:2000 standard, but according to Passipedia for the purposes of the q50 reading it applies to buildings with a volume of >= .1500m^3.

2 As mentioned in the section called 'Background', above – even in Germany it isn't always done correctly! For example see: http://www.flib.de/Presse/presse_aktuell_7.html

Also, it should be noted that the units of the EN standards are in Metric Units, which may be an extra stumbling block in some jurisdictions where testers are unfamiliar not only with the procedures of the standard but also with the measurement units involved. This could be the case where for example the Passive House documentation mentions for larger buildings that the n50 (air change rate (ACH)) should not be used, and the q50 (Air permeability, in metric $m^3/hr.m^2$) should be used instead, also at a rate of 0.6 – so 06 $m^3/hr.m^2$. This appears from US based publications to equate to requiring a CFM/ft^2 reading for buildings over about 52,500ft^2.

As of Sept. 2019 also, the Passive House Institute has released a welcome document on testing high rise buildings. These are tricky because of inherent stack and wind pressure differences. We will just link to the document here:

https://passipedia.org/planning/airtight_construction/airtightness_measurement_of_high-rise_buildings_guidelines

you may need a login to passipedia to gain access to that document.

Leakage Detection

When undertaking the blower door test, even in the best sealed houses, there are always leaks.
The main methods of finding leaks are:

<table>
<tr><th>Method</th><th>Can find unexpected leaks?</th><th>Can measure severity?</th><th>Note</th></tr>
<tr><td>Hand</td><td>No</td><td>Not Well</td><td>Cheap and easy.
After some experience becomes easy to find leaks.</td></tr>
<tr><td>Feather Duster</td><td>No</td><td>Not Well</td><td>Similar to the hand method.
Allows others to see movement in the feathers if they don't believe that there is a leak there</td></tr>
<tr><td>Thermal Anemometer</td><td>No</td><td>Yes</td><td>Allows severity of leaks to be gauged
As with the feather, will prove a leak if others doubt its presence</td></tr>
<tr><td>Smoke</td><td>Yes</td><td>Moderately</td><td>Allows leaks to be visualised, and to a certain extent for their severity to be gauged.

There are 3 main types of smoke used, which we call:
mini-smoke – smoke puffers and pencils that are useful for determining draughts at specific locations
small smoke gun – hand held smoke guns are useful for especially around windows and to determine air movement paths in discrete areas of the building
Mega smoke – such as disco generators. These are handy for particularly larger, perhaps single skinned buildings, to determine leakage locations from outside.</td></tr>
<tr><td>Thermal Imaging</td><td>Yes</td><td>Moderately</td><td>Allows leakages to be located and visualised, as long as a temperature difference exists between inside and outside at time of test.</td></tr>
<tr><td>Ultrasonic</td><td>Yes</td><td>Yes</td><td>Allows leakages to be located and their severity to be gauged somewhat.</td></tr>
<tr><td>Tracer Gas</td><td>Yes</td><td>Yes</td><td>Can find particularly tricky leaks, but may need extra holes to be made to allow for the injection of tracer gas into the envelope</td></tr>
</table>

Table 2: Leakage Detection Methods

As can be seen, some methods, such as Ultrasonic, smoke and Thermal imaging, are good for finding the locations of leakages. Other methods, such as by hand, feather or thermal anemometer will simply confirm that leaks are where you have suspected them. You are unlikely to come across leaks unexpectedly using these methods - A good tester will have a fair idea where the leaks are and go looking in those areas in any case .

Leak detection is usually an important part of doing a blower door test – it is not only the leakage rates we are interested in, but also where are the remaining problems, and how bad are they.

Many projects will have at least 2 blower door tests. The first will be at the completion of the airtight envelope and will give a preliminary reading of the airtightness of the building. The project really needs to be at the 0.6 ACH at this stage, and considerable care will still be required while finishing the building to ensure that follow on trades and equipment installations do not damage or disrupt the airtightness layer. This preliminary test is also most useful for finding many of the leaks still present. Incidentally, for leakage detection, any large fan placed in a sealed off opening in the house envelope will help you find leaks in the building envelope, it is just that the blower door machine is controllable and allows measurements to be taken at specified pressures.

According to the Feb 2018 Passipedia article on Blower door testing for Passive Houses (available here if you have a Passipedia account), only one test is compulsory. This test is best done at the completion of the airtight envelope for the reasons given above. Greenbuild would still recommend 2 tests, to be sure that rogue subcontractors have not compromised the build.

Appendix A : EN13829 Method A – Openings

The EN13829 regulation states (EN13829:2001, pg 7):

> Method A (test of a building in use):
> The condition of the building envelope should represent its condition during the season in which heating or cooling systems are used.

And:

> Close all intentional exterior openings of the building or part of the building to be tested (windows, doors, fireguard).
> For the purpose of method A (building in use) do not take any further measures to improve the airtightness.

Despite the last sentence above, the standard does then state on pg 8:

> Air terminal devices of mechanical ventilation or air conditioning systems shall be sealed. Other ventilation openings (for example openings for natural ventilation) shall be closed for purposes of method A and sealed for method B.

Therefore, the spirit of the regulation is that the building is as close in condition as possible to its normal use, except that any leakage point that can be closed should be closed, and that air conditioning and air handling units should have their terminations sealed.

Whilst it is easy to understand the spirit of the regulation, in practice testers come across many items that either cause confusion for themselves, or where other project participants (such as the builder) will disagree with them and insist on temporary sealing of items that really should not be temporarily sealed for the test, e.g. a letterbox or a stove door.

The following is a list as exhaustive as possible. Note that some items, such as door-slot-letterboxes and open flued fires are not elements that you would normally find in a passive house. This list is a compilation of similar lists from the Passive House Institute Training Manual for Passive House consultants, Flib Beiblatt (http://www.flib.de/Publikationen/FLiB_Beiblatt_zur_DIN_EN_13829.pdf) and input from the author of this piece.

Category	Item	LEAVE OPEN	SEAL	TURN OFF or CLOSE	Comments
Doors	Cat Flap			X	Close if possible, or else leave as is
Doors	Cellar door to an unheated basement / basement corridor / staircase			X	Doors open, if rooms heated, other wise closed See notes on the volume calculation.
Doors	Exterior doors			X	Possibly locked to prevent unwanted entry during test. Ensure emergency exit point available.
Doors	Flaps / doors / hatches to unheated building areas (garage, storage rooms)			X	Possibly locked to prevent unwanted entry during test
Doors	Hatches to storage space under roof (particularly in dormer style houses)			X	Close if possible, or else leave as is
Doors	Interior doors	X			Open, but secured to prevent slamming
Doors	Keyholes	X			No action. Can leave key in place

Category	Item	LEAVE OPEN	SEAL	TURN OFF or CLOSE	Comments
Doors	Letterbox			X	Leave closed
Doors	Trap door to attic			X	Doors open, if attic is heated and a habitable space, otherwise closed. **See notes on the volume calculation also.**
Doors	Wardrobe & Cupboard doors			X	Leave closed
Fires	Fireplaces in the heated building area, room air dependent			X	Ensure fire extinguished, remove ash
Fires	Fireplace in the heated building area (not room air dependent)			X	Ensure fire extinguished, remove ash, close off supply air if possible
Fires	Ventilation for combustion air in the boiler room/fuel storage			X	Close if possible, or else leave open
Fires	Opening of a ventilated cavity of a chimney in the heated building space	X			Close if possible, or else leave open
Fires	Tiled stove/ built-in oven /auxiliary cooker - room air independent			X	Ensure fire extinguished, remove ash. Doors/hatches closed
Fires	Tiled stove/ built-in oven /auxiliary cooker or similar - room air dependent			X	Ensure fire extinguished, remove ash, close supply air if possible
Mechanical	Central vacuum cleaner system			X	Turn off, close room sockets
Mechanical	Kitchen Extractor hood			X	Stopped.
Mechanical	laundry dryer in heated part of building with exhaust towards outside			X	Close if possible, or else leave as is
Spaces	Cover plates of installation ducts with pumps/installation in heated space	X			Leave as is
Spaces	Empty conduits to unheated building areas (e.g. for later assembly of solar systems)	X			Leave as is
Spaces	Laundry chute to unheated part of building			X	Close if possible, or else leave as is
Spaces	Suspended ceiling				Leave as is
Ventilation	Duct ventilation outlets in heated building area		X		Normally once only at the machine – seal the inlet and outlet to outside. However, sometimes sealing on a room by room basis is a more viable option if the inlet/outlet of the unit are not accessible. A note in the test record is required in any case as to how the ventilation system was sealed
Ventilation	Earth-to-air heat exchanger (supply air ventilation system)		X		
Ventilation	Fresh air openings (for mechanical extract air system)			X	Close, no action
Ventilation	Supply/extract air outlets (supply/extract ventilation system)		X		
Windows	Ventilator on windows/skylights			X	Close if possible, or else leave as is
Windows	Missing window handle		X		Seal, entry in test documentation
Windows	Roller shutter belt feed through	X			Leave as is
Windows	Windows in unheated rooms			X	Close

Table 3: Method A Building Preparation

If you come across other items, please forward to contact@greenbuild.ie

Appendix B : Volumes allowable in the Passive House Blower Door Test

As noted above, the EN13829 standard states the following:

> **3.2**
> **internal volume**
> deliberately heated, cooled or mechanically ventilated space within a building or part of a building subject to the measurement, generally not including the attic space, basement space and attached structures

A space is not counted as heated/cooled/conditioned only if it houses the heating/cooling/conditioning equipment, i.e. There must be a systematic distribution of heat/cooling or conditioning to the area and/or it must be expressly designed.

However, for Passive House measurements the following also applies:

- It is the “clear air volume” that counts – e.g. Not counted are air volumes such as: Air inside partition walls, floor cassettes, behind plasterboard in service cavities, above suspended ceilings.
- Only clear air volumes *within* the conditioned space of the building count – e.g. an unheated enclosed porch outside the main building does not count
- The attic space may or may not count toward the volume. Do not count it if it is outside of the thermal/airtight envelope. (*Remainder of this section on the Attic Space changed Sept 2013 following discussions with Certifiers Mosart, and Soeren Peper of PHI:*) If it is within the thermal/airtight envelope and accessible, if even only with intermittent access (e.g. a foldable stairs and attic hatch door), then it may be counted, with the hatch door open for the test. This is not the same procedure as for some other jurisdictions following the EN13829 standard, where the attic space is excluded under the same circumstances.
- The basement counts if it is heated/cooled. Sometimes, a basement may have a room outside of the main conditioned space, particularly if this room is reached by a separate outside door. In these cases this part of the basement is not counted.
- Under the stairs: Generally for simplicity the stairs is treated as if it were not there and the whole area of the stairwell is taken as air volume. However, if there is no access to under the stairs, you would exclude that part but still include the volume of clear air above the stairs. If the little area under the stairs is a closed off little room or storage area e.g. a toilet, then include it.
- Door and Window reveals. Normally not included. Although we make clear above that the volume as based on the treated floor area is not the same as the clear air volume of the house for blower door testing purposes, typically the window and door reveals are not included in either volume calculation[3]. Depending on the building size and the number of big reveals, a case can be made for including them where the reveal is full height (or nearly full height) and deeper than about 30cm. However, better if you can make the grade without looking for these extra few m^3!

3 For details of how they are dealt with in the TFA, see the Passipedia section on Treated Floor Area

Below is an example cross section through a building. Areas in blue are not counted for the blower door test volume. If the area under the stairs was closed in then this may also not be counted. The attic area is shown as green as this is not counted in some cases, but is in others – see above. (Of course, if it is counted, the air barrier layer (in red) should be going up over the roof space).

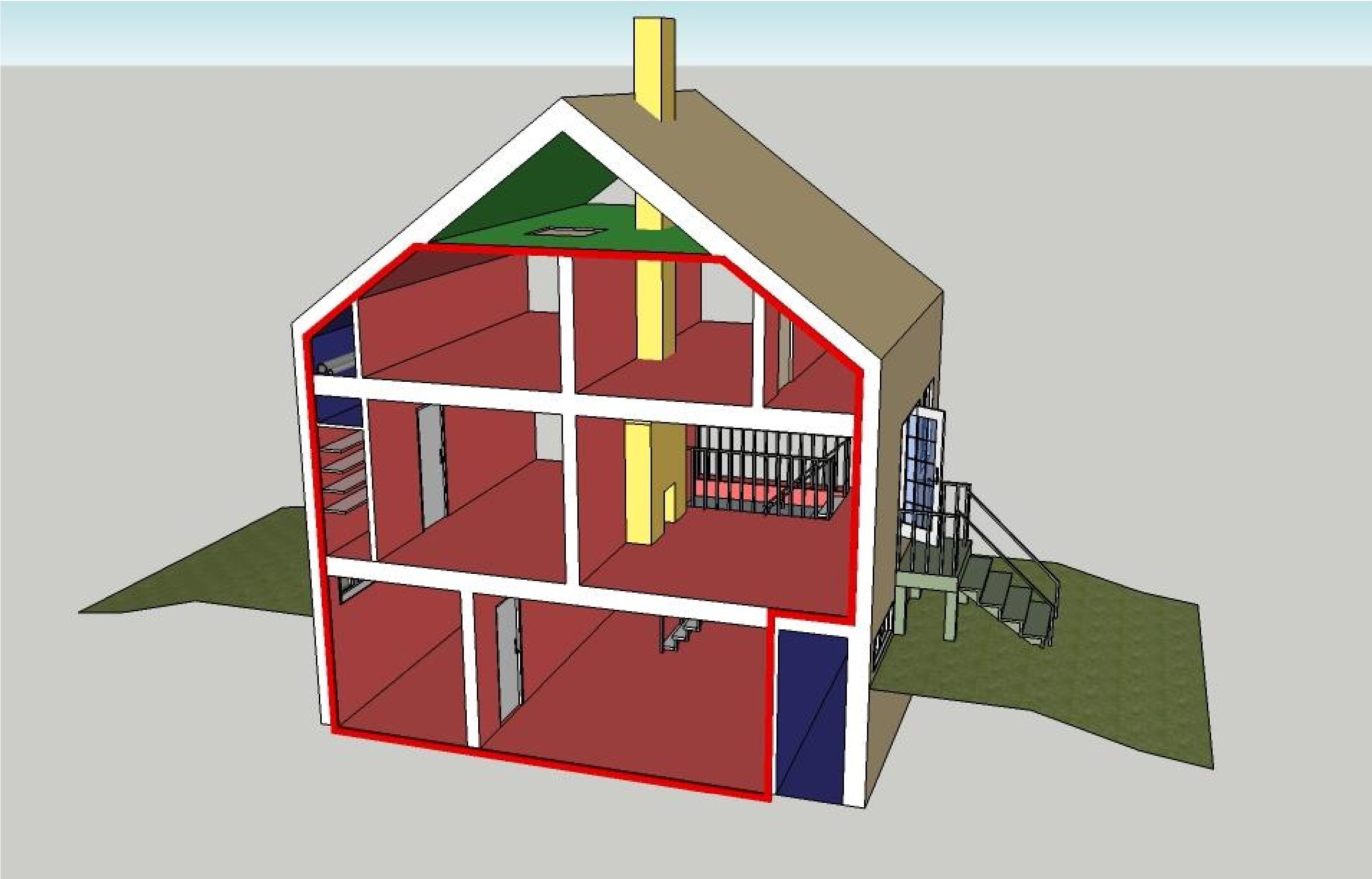

Figure 1: House Section (image courtesy of Andrea Hobbs)

Red line:	Airtightness layer of envelope
Red rooms:	Count the volume on a room by room basis
Blue rooms/spaces:	Do not count the volumes
Green room & Under stairs:	Count volume in certain cases (see above)