Criteria and procedures for Certified Passive House-Components: Airtightness Systems

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Contents

The certification of airtightness systems is carried out independent of climate zones.

Legal note: The sole objective of tests and ratings discussed here is the air permeability of the samples. Moisture transport and protection against ingress of water as well as any other building physics related, practical or structural implications are not addressed. This remains the sole responsibility of the applicant, designer or manufacturer. The Passive House Institute (PHI) assumes that all filed documents are free of rights of third parties. The applicant declares by filing the documents for testing and evaluation that she possesses all rights in the documents to the full extent.

1 Preamble

The Passive House standard realizes a significant reduction in energy consumption when compared with conventional new buildings. This is achieved through highly efficient building fabric and building services combined. Alongside careful detailing the use of particularly energy efficient components is required. In many instances such products provide a two- to fourfold energy efficiency improvement over common implementations. This level of energy efficiency is key for achieving the Passive House Standard.

For designers, however, it is often difficult to assess components as regards energy efficiency, durability and characteristic values: Available specifications based on old standards are often not practical or sufficiently accurate. A dependable design based on manufacturer information alone is often not possible.

The Passive House Institute (PHI) as an independent organisation assesses and certifies products with regard to their aptitude for use in Passive House buildings. Products certified as “Certified Passive House Component” have been assessed along coherent criteria, are comparable in terms of the stated characteristic values and of excellent energy-related quality. Such airtightness products offer a great help to ensure a sufficiently airtight building envelope. Using these simplifies the work of designers significantly and contributes noticeably to delivering flawless quality in highly energy efficient building projects.

2 Systems approach

Airtightness products are always assessed as an airtightness system: not a single product is tested but a complete, problem solving system, comprising all required components is put on the test rig.

A distinction is made between area sealing systems and different kind of systems for linear joints. Primarily assessments are offered for “Surface Sealing”, “Airtight Window Connection”, “Penetrations” and “Wooden Beam Sealing”. Other joining solutions may be tested and certified depending on the particular case.

2.1 Importance of good instructions for use

Besides a thorough assessment of the systems in a near-realistic set-up the respective instructions for use are also tested for practicality. Guidelines must convey, in due brevity, clear, well-illustrated and comprehensive instructions to the practitioner. All test samples are built by PHI staff strictly according to these manufacturer instructions. If uncertainties are experienced suggestions for improvement are presented to the manufacturer. Every test sample is built three times to reflect random effects in the results.

3 Testing procedure

The leakage flow rates of each test sample are measured at test pressures ranging from approximately 50 Pa to 350 Pa, in pressurisation and depressurisation, using a highly accurate laminar flow device. Leakage of the test rig is determined and considered separately, for each test run. A regression calculation yields a result normalised for 50 Pa. The final result is based on the mean of pressurisation and depressurisation test results from all samples.

4 Certification Criteria

If the limit values are met the product under consideration is assigned to a certification class and a certificate “Certified Passive House Component” is issued.

Surface sealing

Class	Permeability **area**-related @ 50 Pa [m³/(hm²)]
phA	≤ 0,10
phB	≤ 0,18
phC	≤ 0,25

Linear Joint
Window installation, Penetrations, Wooden Beams

Class	Permeability **length**-related @ 50 Pa [m³/(hm)]
phA+	≤ 0,05
phA	≤ 0,30
phB	≤ 0,50
phC	≤ 0,80

Table 1.: Limits of certification classes

A test report documenting the test results and the (edited, if applicable) instructions for use document are published along some product images in the PHI’s on-line component database. (https://database.passivehouse.com), in the section “Air Tightness Systems”.
New certifcations are also announced internationally in a dedicated components newsletter of iPHA.

5 Surface Sealing

Systems for surface sealing of wall, roof and floor in massive and framed construction can be tested. Tests are carried out similar to DIN EN 12114. System-immanent joints and connections are included in the test samples:

0	Base material w/o connection (not considered for final result)
1	Base material w/ joint within base material
2	Base material w/ joint to airtight wooden board
3	Base material w/ joint to concrete member/rendered surface

Table 2.: Joint types surface sealing

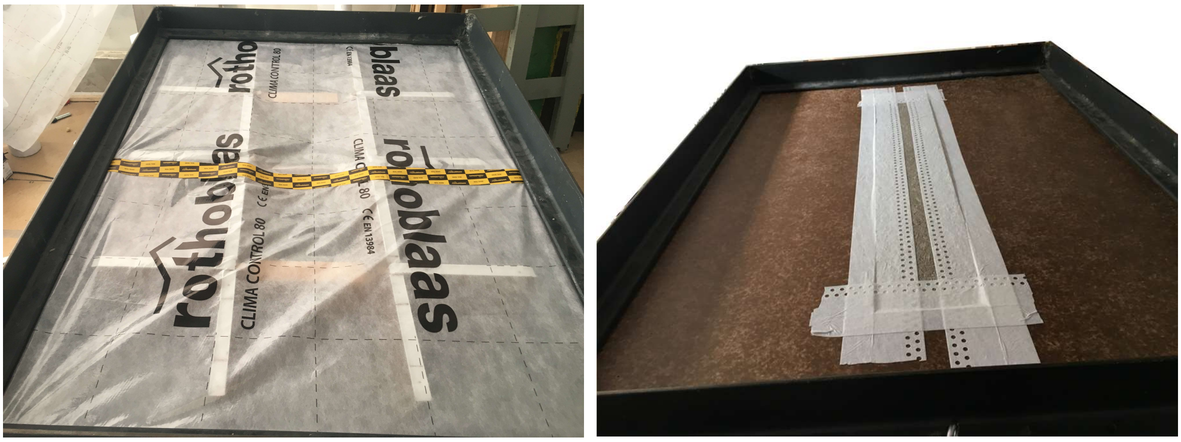


Figure 1: Test setup surface sealing. Left case 1 (table 2), right case 3 (table 2), tentative

6 Window Connection

Products for airtight connections of windows with the reveal. Tests are carried out on massive and wooden framed walls. Moreover, both plastic frames and wooden frames are used in the samples. For massive walls a preferred thermal bridge optimised installation method within the insulation layer must be prescribed by the manufacturer.

1	Wooden frame, concrete wall
2	Wooden frame, framed wall
3	Plastic frame, concrete wall
4	Plastic frame, framed wall

Table 3.: Frame and wall combinations for tests of window connections

Each type of sample per table 3 is built and tested three time, resulting in 12 individual measurements. The mean of all results is considered the overall result.

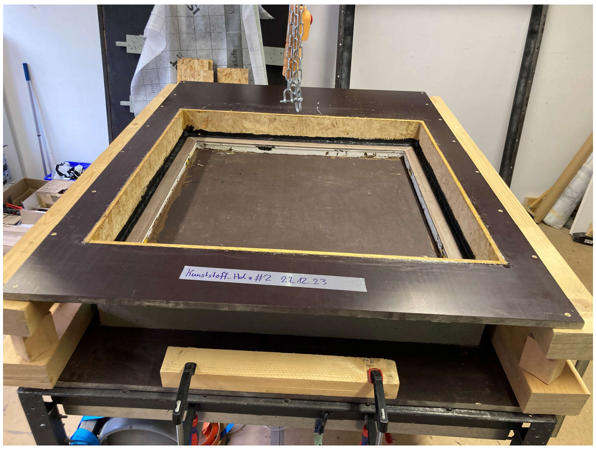



Figure 2: Test setup window connection. Left wooden frame in front-of-wall installation system on concrete wall, right plastic frame in framed wall, tentative

7 Penetrations sealing

Tests are carried out for products or methods for the airtight feed of cables, pipes and ducts through the airtight layer of a building. Test cases include building airtightness layers of membrane, wooden board or concrete/render. A set of 14 different, typical cables, pipes and ducts have been selected for testing. Tests are carried out simultaneously for all 14 elements. In a house approximately twice the number of these situations occurs. Hence, all 14 penetrations are built into each test sample (membrane, board, concrete) twice.

#	Penetrating element	count
1	Main grid connection cable od 25 mm (NYY-J 5x16 mm²)	1
2	Mains power cable od 8,3 mm (NYM 3 x 1,5) *single feed through*	2
3	Telephone cable od 5,0 mm (J-Y(ST)Y 2 x 2 x 0,60 mm) *bundled in one spot*	5
4	Twin cable od 2 x 5,0 mm (Twin 2 x WF65 satellite/antenna)	1
5	Drain pipe DN 50 (smooth surface)	1
6	Drain pipe DN 110 (smooth surface)	1
7	Electrical conduit (corrugated) od 25 mm *single feed through*	2
8	Spiral seam duct DN 180 (air)	1
	total	**14**

Table 4.: penetrating elements to be sealed

Thus all results are obtained sixfold, due to the paired samples for either base airtight layer type (membrane, board, concrete/render). For each base material the sum of both measurements represents the result for the material. The total certification result is the mean value of all three cases and is related to the total circumference of all penetrating elements.

Base material	Penetrations count per sample	Samples count	Total count of penetrations sealed
Membrane	14	2	28
Wooden board	14	2	28
Concrete/render	14	2	28
		Total	**84**

Table 5.: Overview of penetrations for testing

Figure 3: Test setup for penetrations in membrane, tentative

8 Wooden Beam Sealing

Shakes inevitably develop over time in grown wood, due to changes in humidity and present a potential for leakages and moisture-related damage. It is, therefore, stongly advised to avoid any need to seal wooden beams into the airtight layer by good design practices. This yields the most simple, secure and cost-effective constructions.
The testing scheme for wooden beam sealing into the airtight envelope presented here is hence aimed primarily at solutions in the *refurbishment* context.

8.1 Tight connection along the perimeter and filling of shakes

A reliable connection along the usually sawn and unfinished perimeter of the beam is necessary but not sufficient for an airtight result. Decades-old wood has developed shakes of varying width, depth and path geometry. A reliable and productive sealing solution for this peculiarity is key for the overall success of the sealing effort. Systems eligible for certification must further allow application in all attitudes (horizontal, vertical, from above and overhead) and under space constrained conditions.

8.2 Testing procedure

For testing systems are applied according to the manufacturer's instructions.
Specimen blocks with artificial shakes of standardised geometry have been defined, made from common, unfinished timber, according to the dimensions given in figure 4. Usual tolerances for sawn timber apply for the exterior dimensions, while timber without natural shakes is used exclusively.
Each specimen is installed three times and included in the test. Random effects occurring in the wood and in diligent workmanship are thus reflected in the sample, comprising 4 x 3 = 12 specimens.

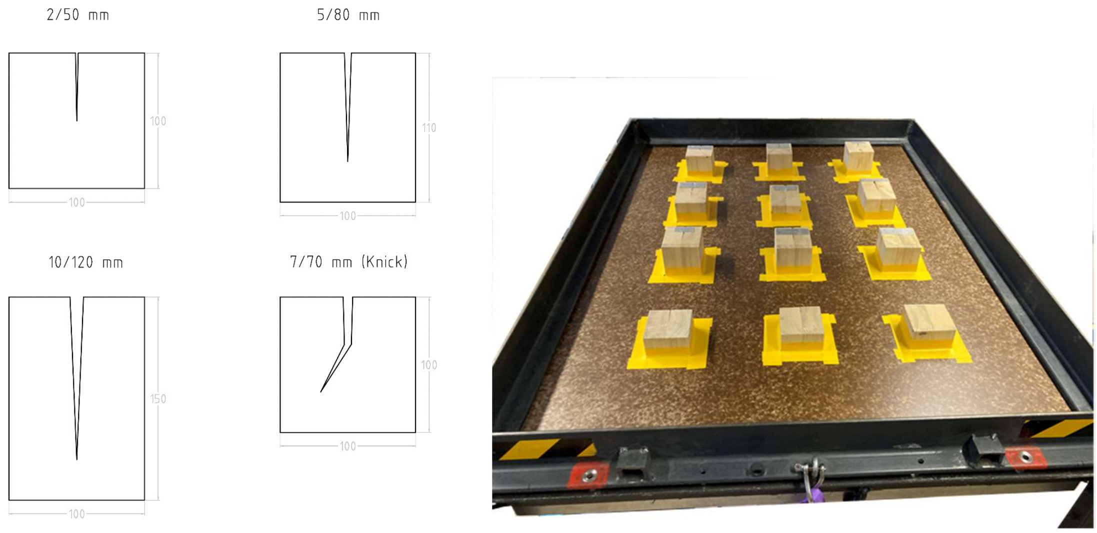


Figure 4 left: Specimen blocks with different artificial shake geometries. Right: Test setup wooden beam sealing, tentative

Aitightness systems for wooden beam sealing are tested with three base materials for surface sealing, membrane, wooden board and concrete/render. For each case a complete set comprising 4 x 3 specimen blocks is built and tested. Thus, a total of 3 x 12 = 36 beam connections are included in the overall result. The mean leakage flow is related to the total circumference of one sample.

9 Appendix: Rationale behind the certification classes

If the air permeability of the three product categories (surface sealing, window connection, penetration) is used as a basis for the calculation of the resulting airtightness of buildings, the influence of these quality levels on a building can be exemplified. The requirements for the three areas are summarised in the following table:

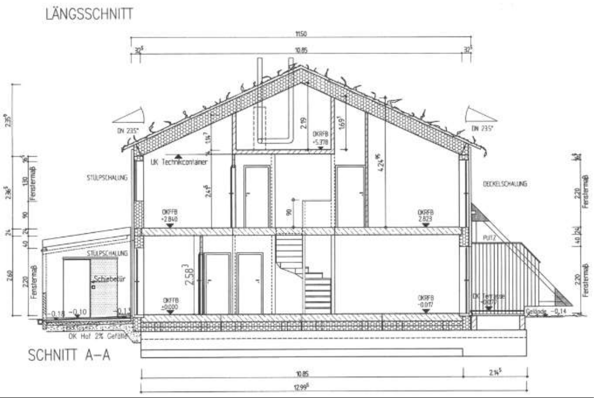
Air Permeability @50 Pa			
	Surface Sealing	**Window Connection**	**Penetrations**
	Area-related	Length-related	Length-related (circumference)
Class	[m³/(hm²)]	[m³/(hm)]	[m³/(hm)]
ph**A+**		≤ 0,05	≤ 0,05
ph**A**	≤ 0,10	≤ 0,30	≤ 0,30
ph**B**	≤ 0,18	≤ 0,50	≤ 0,50
ph**C**	≤ 0,25	≤ 0,80	≤ 0,80

Table 6.: Requirements for the air permeability of the certificate classes

Using two buildings as examples (terraced house and school building), the requirements for airtightness according to the certification classes are applied and their effects illustrated.

9.1 Example 1: Terraced House

The calculations were carried out for a terraced house without a basement with ground floor and first floor as well as a technical cabinet in the roof. The house width is 6 m, the living area 127 m² and the air volume 372 m³. The area of the airtight layer is 375 m².



Wall to floor or roof	Wall to wall	Windows and doors (installation)	Windows and doors (sealing)	Pene-tration	Envelope area opaque	Envelope area windows
109 m	31 m	46 m	38 m	2,3 m	355 m²	20 m²

Table 7.: Joint lengths and component areas of the "terraced house" model building

The requirements from the certificate classes can now be used for all wall surfaces, the joints of the windows and doors as well as for all penetrations. Thus, the maximum expected leakage volumetric flows in the respective class are calculated for this building as a sum for the three fields. The requirements and tests of the surface sealing (wall, floor or roof) already include the connections to neighbouring components. In addition, the sealing joint between the frame and sash of windows and doors must be taken into account. For this purpose, the maximum leakage flow of the best class (class 4) according to standard DIN EN 12207 is used. This is a maximum of 0.5 m³/(hm) at 50 Pa and is used for all Passive House certificate classes.

The maximum leakage flow of a class calculated in this way is compared with the total leakage flow for the air tightness test requirement of n50 = 0.6-1 (Passive House limit value) and 0.4 h-1 (usual value for Passive Houses). Since the building has an internal volume of 372 m³, the two maximum permissible leakage flows are 223 and 149 m³/h respectively.

In addition, the proportion of the volumetric flow that results from the evaluation of the requirement with respect to the envelope area (suggested qE50 = 0.6 m³/(h m²)) is calculated. For the terraced house this is 236 m² x 0.6 m³/(h m²) = 142 m³/h. This requirement is particularly meaningful for larger buildings (from 1,500 m³ internal volume).

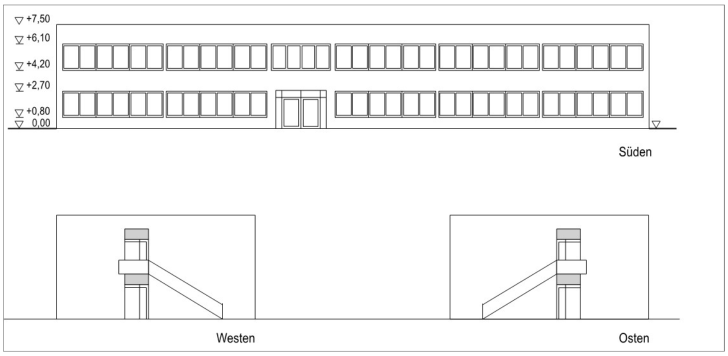
	Area	Windows/ doors	Pene-tration	Windows/ doors sealing joint	**Total**	Share of n_{50} = 0,6 h^{-1}	Share of n_{50} = 0,4 h^{-1}	Share of q_{E50} = 0,6 m³/(h m²)
Length / Area	355 m²	46 m	2,3 m	38 m				
	m³/h	m³/h	m³/h	m³/h	**m³/h**			
ph**A+**	36	2	0,1	18	**56**	**25 %**	38 %	40 %
ph**A**	36	14	0,7	18	**68**	**30 %**	46 %	48 %
ph**B**	64	23	1,2	18	**106**	**48 %**	71 %	75 %
ph**C**	89	37	1,9	18	**145**	**65 %**	98 %	103 %

Table 8.: Leakage contributions according to certificate classes for the model building "terraced house"

It can be seen that for the n_{50} = 0.6 h^{-1} Passive House requirements for the air tightness of this terraced house, between about 25 and 65% of the leakage is expected from the regular surfaces and fixtures. The rest, i.e. 35 to 75% of the volume flow, could be "available" for unforeseen leakages or, conversely, produce a further improved result. Small additional leakages, which are regularly found on construction sites, are therefore already covered with a safe margin. With the higher requirement of n_{50} = 0.4 h^{-1} this potential/reserve drops about 2 to 60 %.
If no further leaks were to occur in the building due to careful execution and only the regular components, as covered by the certification scheme, contributed to the leakage, air tightness values of n_{50} = 0.15 to 0.39 h^{-1} could be expected.

9.2 Example school building

The calculations were carried out for a school building with no basement, ground floor and first floor. The dimensions of the floor area are approx. 50.5 m x 16.7 m. The heated area is 1,235 m² and the air volume is 3,889 m³. The building area of the airtight level is approx. 2,720 m², which includes 314 m² of window openings and 32 m² of door opening areas.



The following joint lengths result for the building:

Wall to floor or roof	Wall to wall	Windows and doors (installation)	Windows and doors (sealing)	Pene-tration	Envelope area opaque	Envelope area windows
402 m	45 m	497 m	367 m	8,5 m	2375 m²	346 m²

Table 9.: Joint lengths and component areas of the "School" sample building

As in the example of the terraced house, the requirements from the certificate classes can be used for the wall surfaces, the connections of the windows and doors as well as for all penetrations. Here, too, the maximum permissible leakage volume flows in the respective class are calculated for the school building.
The maximum leakage volumetric flow of a class calculated in this way is compared with the total leakage flow for the air tightness test requirement of n50 = 0.6-1 (limit value for passive houses) and 0.4 h-1 (usual value for passive houses). Since the school has an internal volume of 3,889 m³, the two maximum leakage volume flows are 2,333 and 1,556 m³/h respectively.
In addition, the proportion of the flow that results after evaluating the requirement with respect to the envelope area

(suggested qE50 = 0.6 m³/(h m²)) is calculated. For the school building, this amounts to 2,720 m² x 0.6 m³/(h m²) = 1,632 m³/h. This requirement is particularly meaningful for larger buildings (from 1,500 m³ internal volume).

	Area	Windows/ doors	Pene-tration	Windows/ doors sealing joint	**Total**	Share of n_{50} = 0,6 h^{-1}	Share of n_{50} = 0,4 h^{-1}	Share of q_{E50} = 0,6 m³/(h m²)
Length / Area	2.375 m²	497 m	8,5 m	367 m				
	m³/h	m³/h	m³/h	m³/h	**m³/h**			
ph**A+**	237	25	0,4	173	**455**	**19 %**	29 %	28 %
ph**A**	237	149	2,6	173	**673**	**29 %**	43 %	41 %
ph**B**	427	249	4,3	173	**1037**	**44 %**	67 %	64 %
ph**C**	594	398	6,8	173	**1465**	**63 %**	94 %	90 %

Table 10.: Leakage contributions according to certificate classes for the model building "School"

It can be seen that for the Passive House requirements for the air tightness of the school (n50 = 0.6 h-1), between about 20 and 60 % of the leakage is required by the regular surfaces and fixtures. The rest, i.e. 40 to 80 % of the volume flow, is "available" for unforeseen leakages or, conversely, to produce a further improved result. Small additional leakages, which are regularly found on construction sites, are therefore already covered with a safe margin. With the higher requirement of n50 = 0.4 h-1 this reserve/potential drops to only about 6 to 70 %.
If no further leaks were to occur in the building due to careful execution and only the regular components, as covered by the certification scheme, contributed to the leakage, air tightness values of n50 = 0.12 to 0.38 h-1 could be expected.

9.3 Summary

In a real building, air tightness products of different qualities are usually used. Therefore, it makes sense to consider the ranges of all certificate classes. It can be seen that the limit value for air tightness (n50 = 0.6 h-1) and also the significantly better, average value for passive houses (n50 = 0.4 h-1), can be met with some certainty using the tested materials, if gross errors are avoided.
Small accidental leakages usually occur on the construction site, which pose a challenge if the limit values are not to be exceeded. The limit values of the product certification are chosen in such a way that practical reserves for these additional leakages are ensured.