Certification of airtightness systems

The Passive House Standard is characterised by very high energy savings compared with conventional new builds. This is achieved by means of highly efficient building systems and highly efficient components. Besides careful detail planning, the use of highly efficient components is also a prerequisite for this. As a rule, these components are two to three times more efficient than the corresponding commonly used products. This high level of efficiency is crucial for achieving the Passive House Standard.

However, for the designer it is often very difficult to assess the energy efficiency, durability and the necessary energy parameters of a component as the available standard parameters are frequently unrealistic or are not accurate enough; reliable project planning using manufacturers' data alone is often not possible.

As an independent authority, the Passive House Institute tests and certifies products in respect of their suitability for use in Passive House buildings. Products that carry the **Certified Passive House Component** seal have been tested according to uniform criteria; they are comparable in terms of their specific values, and are of excellent quality with regard to their energy efficiency. Their use facilitates the designer's task and contributes significantly to ensuring the faultless functioning of the resultant Passive House building.

Component certification

In the area of airtightness, **airtightness systems** are tested as they are applied in Passive House buildings. The focus is not on the individual product alone; instead, the entire system as a whole is put to the test with the corresponding connections.

Testing will take place under the aspects of "**airtight window connection**", "**surface sealing**" and **"penetrations"**.

Thus, for example, **window sealing** are tested in solid and wooden walls, the bonding of **sealing membranes and composite wood boards** (surface sealing) to concrete/plaster, adjacent wood panels or membranes and the joining of these materials with each other are tested. With regard to **"penetrations"** 14 typical cable and pipe penetrations in composite wood boards and concrete building components will be tested for airtightness at the same time. Each kind of connection will be specially prepared threefold by the PHI and tested for airtightness at different pressure stages. The measurement of the volume flow rate will take place using a highly precise laminar flow element.

Besides the testing of the systems in realistic situations, the corresponding instructions for use will also be examined for their practical applicability; installation will take place strictly in accordance with the manufacturer's instructions. If any uncertainties arise in the process, suggestions for improving these will be devised and submitted to the manufacturer.

The **Certified Passive House Component** certificate will be issued if the limiting values are complied with. The measurement results (test report) and the instructions for use (revised if applicable) will be made available to building owners and designers in the component database (https://database.passive-house.com) under the heading "Airtightness systems". After certification, details about the component will also be published in the IG-Passivhaus/iPHA component newsletter (www.passivhaus.de).

Limiting values for certification classes

Airtight window connection

Products for airtight and thermal bridge minimised installation of PH windows in wall openings.
Airtightness testing of the window to wall joint sealing in solid and lightweight wall constructions will be carried out. Window frames made of PVC as well as wood will be tested in the process.

The required values for PH certification for a "*window connection*" can be taken from the following table:

Class	**Air permeability per unit length** @ 50 Pa [m³/(hm)]
ph**A+**	≤ 0.05
ph**A**	≤ 0.30
ph**B**	≤ 0.50
ph**C**	≤ 0.80

Surface sealing

Systems for surface sealing of walls, roof, floors in lightweight or solid constructions.

Testing of the airtightness of the sealing systems will take place in accordance with DIN 12114. System-specific butt joints and connections are included:

0 Material on its own without a connection
1 Force fitting of similar adjacent surfaces
2 Adjacent surfaces consisting of airtight composite wood board
3 Adjacent concrete building component/plastered surface

The required values for PH certification for "*surface sealing*" can be taken from the following table:

Class	**Air permeability per unit area** @ 50 Pa [m³/(hm²)]
ph**A**	≤ 0.10
ph**B**	≤ 0.18
ph**C**	≤ 0.25

Airtight penetrations

Products or methods will be tested for airtight penetrations through the airtight layer for cables and pipes.

Testing will be carried out for airtightness of penetrations in membranes, airtight wood composite boards and concrete surfaces. Different cables and pipes that are typically used in constructions will be specified which will penetrate the corresponding building component. Sealing will be carried out using the products or methods of bonding. All 14 penetrations together will be tested for airtightness. About twice this number of penetrations are typically present in a single-family house. The 14 penetrations will therefore be created and tested twice for each surface sealing (wood composite board, concrete, airtight membrane).

Cables and pipes to be sealed:

#	Penetrations by	Number
1.	House connection cable, external diameter 25 mm (NYY-J 5x16 mm²)	1
2.	Cable, external diameter 8.3 mm (NYM 3 x 1.5), *inserted separately*	2
3.	Telephone cable, external diameter 5.0 mm (J-Y(ST)Y 2 x 2 x 0.60 mm), *together in one penetration*	5
4.	Twin cable, external diameter 2 x 5.0 mm (Twin 2 x WF65 satellite/antenna)	1
5.	HT pipe DN 50 (smooth pipe)	1
6.	HT pipe DN 110 (smooth pipe)	1
7.	Empty conduit for electrical cables (corrugated pipe) 25 mm, external diameter, *inserted separately*	2
8.	Spiral seam pipe DN 180 (exhaust air or outdoor air)	1
	TOTAL number of penetrations	**14**

The cables and pipes will be passed through either the composite wood board, the concrete slabs or the airtight membrane in accordance with the manufacturer's instructions using the provided sealing material. The pipes themselves will be closed at one end. All 14 penetrations will be tested together for airtightness at positive and negative pressure with pressure stages between ca. 50 and 300 Pa. The penetrations will be tested for airtightness at the bond with the surface sealing (membrane, composite wood board, and concrete) as well at the sealing with the cable or pipe.

The overall value of all 14 penetrations together will be recorded and shown as the result. On account of the double setup and testing for each surface sealing material (membrane, wood board and concrete) there are six measurement results. For each surface material the total will be calculated from both tests with 14 penetrations each, and will be stated as the resulting value for that material group. The average of the three total values will be calculated for the certification.

Thus altogether 14 x 6 = 84 penetrations will be set up, sealed and tested.

Measurements to be performed:

Penetration through:	**Number of penetrations per setup**	**Number of assemblies (corresponding to test measurements)**	**Total number of penetrations tested**
Airtight membrane	14	2	28
Concrete	14	2	28
Wood composite board	14	2	28
		Total number of penetrations	**84**

The objective of well-sealed penetrations is that the airtightness values for the surface sealing should not be significantly worsened due to the penetrations. The specified value is derived from the limit values for window connections. The sum total of the circumferences of the tested cables and pipes serves as the basis for this.

Air permeability based on the circumference of the penetrations

class	@ 50 Pa [m³/(hm)]
ph**A+**	≤ 0.05
ph**A**	≤ 0.30
ph**B**	≤ 0.50
ph**C**	≤ 0.80

After performing the six series of measurements, the measurements will be evaluated in the form of a test report. The respective certificate for a **Certified Passive House Component** will be issued if the limit values are complied with.

Rationale behind the certification classes

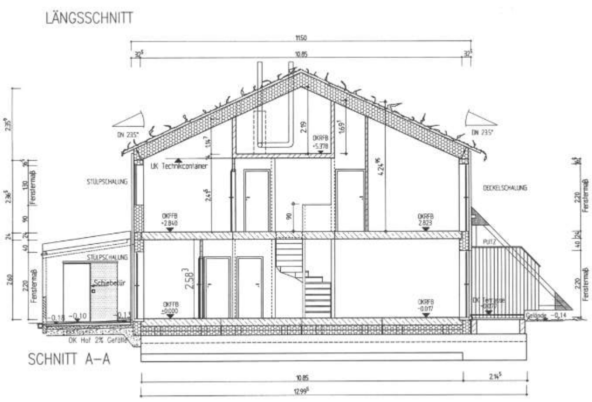
If the air permeability of the three product categories (surface sealing, window connection, penetration) is taken as a basis for the certification of airtightness systems, the influence of these quality levels on a building can be exemplified. The requirements for the three areas are summarised in the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

Air permeability @50 Pa			
	Surface sealing	**window connection**	**Penetration**
	area-related	**length-related**	**Based on the circumference of the penetrations**
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 1.: 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.

1 Example 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.

These joint lengths result for the building:

Wall to floor or roof	Wall to wall	Windows and doors (installation)	Windows and doors (sealing)	Pene-tration	Envelo-ping opaque	Envelo-ping window/ door
109 m	31 m	46 m	38 m	2,3 m	355 m²	20 m²

Table 2.: 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 n_{50} = 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 q_{E50} = 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).

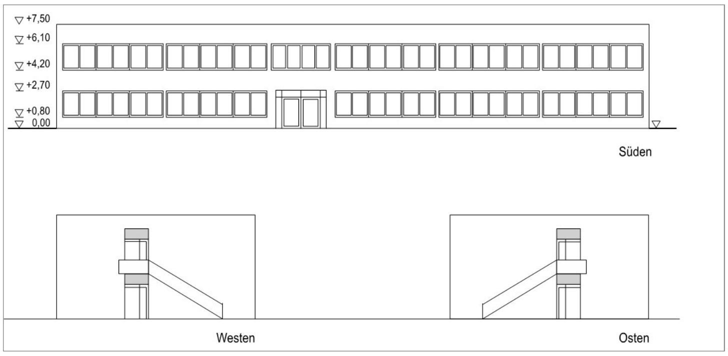
	Area	Windows/ doors	Pene-tration	Windows/ doors sealing joint	**Total**	Share of n_{50} = 0,6 h^{-1}	Share of n_{50} = 0,4 h^{-1}	Share of q_{E50} = 0,6 m³/(h m²)
Length / Area	355 m²	46 m	2,3 m	38 m				
	m³/h	m³/h	m³/h	m³/h	**m³/h**			
ph**A+**	36	2	0,1	18	**56**	**25%**	38%	40%
ph**A**	36	14	0,7	18	**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 3.: 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.

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	Envelo-ping opaque	Envelo-ping window/ door
402 m	45 m	497 m	367 m	8,5 m	2375 m²	346 m²

Table 4.: 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 n_{50} = 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 q_{E50} = 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 $m^3/(h\ m^2)$
Length / Area	2.375 m²	497 m	8,5 m	367 m				
	m³/h	m³/h	m³/h	m³/h	**m³/h**			
phA+	237	25	0,4	173	**455**	**19%**	29%	28%
phA	237	149	2,6	173	**673**	**29%**	43%	41%
phB	427	249	4,3	173	**1037**	**44%**	67%	64%
phC	594	398	6,8	173	**1465**	**63%**	94%	90%

Table 5.: 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 (n_{50} = 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 n_{50} = 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 n_{50} = 0.12 to 0.38 h^{-1} could be expected.

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 (n_{50} = 0.6 h^{-1}) and also the significantly better, average value for passive houses (n_{50} = 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.