Test Report

Airtightness test of airtight window connection system TYTAN WINS FLEX

Manufacturer: Selena Industrial Technologies Sp. z o.o.

Airtightness system: Window connection

Darmstadt 24.04.2024

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Commissioned by:	Selena Industrial Technologies Sp. z o.o. Pieszycka 3 PL 58-200 Dzierżoniów
System:	TYTAN WINS FLEX
Product names:	Tytan Professional WINS External Liquid Foil Tytan Professional WINS FLEX PU-Gun-Foam Tytan Professional WINS Internal Liquid Foil
Further system components:	front-of-wall window installation system MARBET CBM, System foam adhesive for above, trimming knife for PU-foam

1. Introduction

The connection of windows to the airtightness layer is a critical point in the airtightness of a building. In a Passive House, high airtightness of the building is an important pillar of the overall concept. In order to ensure that the tested products deliver their performance in actual installation, a realistic test is carried out to ensure suitability for timber and massive construction.

2. Criteria

The airtightness of the window-wall joint is tested on massive and framed walls. Both plastic and wooden window frames are tested. The values specified for PH certification of surface sealing are given in Table 1:

Table 1: Requirement classes for the certification of „Airtightness system Window connection“ to Passive House Institute specifications

Class	**Air permeability based on length** @ 50 Pa [m³/(hm)]
A+	≤ 0,05
A	≤ 0,30
B	≤ 0,50
C	≤ 0,80

In addition, there must be a comprehensible processing guideline/instructions for use for the installation of the system, according to which the installation for the test is carried out.

The timber and PVC window frames suitable for passive houses used for the test have two different frame widths "t_F" due to their design characteristics. The timber window frame with 108 mm installation depth (product SmartWin), the PVC frame with 85 mm installation depth (manufacturer Aluplast).

The joint width (frame to installation wall, circumferential) is as follows during the test:

15 mm ± 3 mm.

2.1 Wall structures for holding the test specimens

The samples are installed in wooden framed and solid walls or wall sections. Appropriate structures are available for this purpose. The wooden walls are made of airtight OSB boards and screen printing plates, which are glued airtight with epoxy resin. The installation situation in solid walls is represented by airtight lightweight concrete panels in conjunction with a front-of-wall installation system for thermal bridge-optimized window installation. The openings for installing the windows each have dimensions of 1030 x 1030 mm.

Fig. 1: **Wall systems in timber (left) and solid construction (right) with pre-wall installation system for installing the window frames. The installation areas for the window frames each have a clear dimension of 1030 x 1030 mm.**

2.2 General requirements: Airtight layer / substrate

When creating the airtight layer, it must generally be ensured that the components that form the airtight layer are connected directly to each other without any interruptions. If the airtight layer is created through the interior plaster in massive construction, it must be ensured that the internal liquid foil is in direct contact with the interior plaster. When using front-of-wall installation systems, the front-of-wall system must be connected to the interior plaster in an airtight manner (see Figure 2), as it becomes part of the airtight layer. In the work process, this means that the reveal and perimeter around the window opening on the outer surface of the wall (bonding surface for the front-of-wall system) must be plastered (or a smooth coat must be applied) BEFORE the front-of-wall system’s beams are installed. In the case of concrete walls this is, however, not required, as the concrete itself is a homogeneous airtight component.

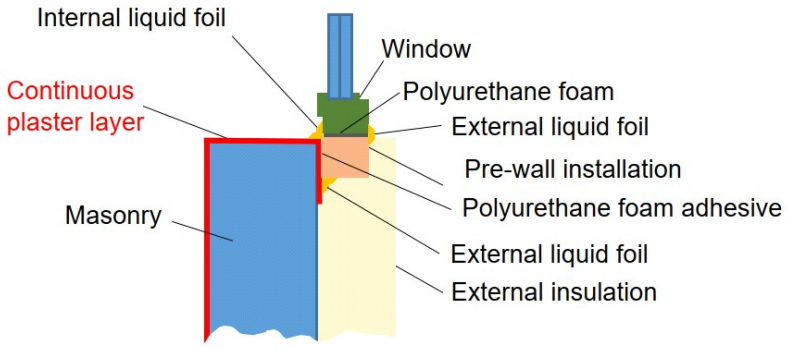

Fig. 2: **For airtight installation of the window frame, the interior plaster must be connected to the front-of-wall installation system without interruption (Fig schematic).**

In general, the window reveal must be prepared before the window is installed in addition to the plaster layer / smooth coat described above. Care must be taken to ensure that the reveal is clean, dry and even. This must also be observed in timber construction.

3. Material to be tested

The client supplied two different liquid foils and a PU foam (Polyurethane foam TYTAN WINS FLEX) to seal the gap between the reveal and the window frame. First, the PU foam is used to fill the gap between the reveals and the window frame. The "Internal liquid foil TYTAN WINS FLEX" is used to seal the internal transition between the window frame and the airtight layer, while the "External liquid foil TYTAN WINS FLEX" is used for the external transition.

The fresh liquid foil on the inside should be applied with a minimum thickness of 1 mm and a maximum thickness of 3 mm, while the outside should be applied with a minimum thickness of 2 mm and a maximum thickness of 3 mm and then left to cure.

The absence of thermal bridges and impermeability to driving rain were not tested as part of the present investigation.

The following products were delivered by the client on October 4, 2023:

- 2xTytan Professional WINS External Liquid Foil
- 3xTytan Professional WINS FLEX PU-Gun-Foam
- 2xTytan Professional WINS Internal Liquid Foil
- 3xTytan Professional WINS foam adhesive for window sill
- 24x front-of-wall bar CBW W10
- Instructions for use of „marbet bausystem“ front-of-wall installation system
- Instructions for use of Tytan Professional WINS FLEX

4. Installation of airtightness system and window frames in the wall structures

The window frames were located in the reveal using „Trag-Teller-System“ „Justa TT“ by Innoperform GmbH.

The airtightness system was applied according to the instructions for use: PU-foam was applied to the gap and spayed with water to aid curing. After the foam hardened the special knife provided was used to trim the foam flush with the window frame.

Finally, the appropriate type of liquid membrane was applied inside and outside, overlapping onto the window frame and the sill, respectively to form a continuous airtight layer.

In order to reflect the influence of workmanship each of the four variants of samples (wooden frame in massive wall, plastic frame in massive wall, wooden frame in framed wall, plastic frame in framed wall) was built three times. Thus, 12 units were available for testing.

5. Measurement procedure

After sufficient curing time in the installed state, the samples of wall mock-ups with window frames installed using the airtightness system were measured as entire units.

The measurements are carried out at various pressure differences in accordance with DIN 12114. The following pressure levels are set as positive and negative pressure for the measurement: 50, 100, 150, 200, 250, 300 and 350 Pa. For each measurement on the wooden walls, the leakage of the measuring stand was first measured and documented. For this purpose, the wall section is sealed with an airtight wooden box. The air leakage of the measuring stand determined in this way is deducted from the subsequent measurement result. These zero measurements are carried out as a complete series of measurements for positive and negative pressure.

For each measurement, the delivered volume flow is measured for each individual pressure difference. The pairs of measured values can be used to calculate the leakage coefficient C in accordance with DIN 12114 Appendix B. This leakage coefficient is equivalent to the joint leakage coefficient a from DIN 18542 at 10 Pa.

Compensation degrees are determined from the two zero measurement series and the two actual measurement series using regression analysis. After deducting the inherent leakage of the measuring stand (zero measurement), the leakage flow is determined as the mean value of the positive and negative pressure. This value is divided by the length of the joint to obtain the specific leakage flow per meter of connecting joint.

Fig. 3: Measuring device with a laminar flow element with wooden wall section (left) and solid wall section (right)

The measurements of the airtightness system were carried out in the period from 20.12.2023 to 05.01.2024.

6. Measurement results

The measurement results are listed in the following tables and figures, sorted by solid and timber walls and by timber and PVC windows. The requirement classes for the certification of airtightness systems are entered in the diagrams. The tightness class "BG-R" according to DIN 18542 is also entered in the diagrams as a comparative value from the standardization.

6.1 Installation in timber construction of plastic window frames

Installation situation	
Solid construction	
Wood construction	x

Window frame material	
Plastic	x
Wood	

Table 2: Measurement results of the three measurements of the plastic frames in timber construction

Druckstufen		Pa	50	100	150	200	250	300	350
montierte Probe	H_KS_1								
Volumenstrom Gesamt		m³/h	0,04	0,18	0,20	0,22	0,24	0,26	0,27
Leckage des Messtandes		m³/h	0,05	0,18	0,21	0,23	0,25	0,26	0,27
spezifischer Luftvolumenstrom		m³/h	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Längenbezogenen Leckagevolumenstrom		m³/(h m)	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00
montierte Probe	H_KS_3								
/olumenstrom Gesamt		m³/h	0,05	0,18	0,21	0,22	0,24	0,25	0,26
eckage des Messtandes		m³/h	0,05	0,18	0,20	0,22	0,24	0,25	0,26
spezifischer		m³/h	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Längenbezogenen Leckagevolumenstro		m³/(h m)	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00
montierte Probe	H_KS_4								
Volumenstrom Gesamt		m³/h	0,07	0,21	0,24	0,27	0,29	0,31	0,32
Leckage des Messtandes		m³/h	0,07	0,21	0,24	0,26	0,28	0,30	0,31
spezifischer Luftvolumenstrom		m³/h	0,00	0,00	0,00	0,00	0,01	0,01	0,02
Längenbezogenen Leckagevolumenstrom		m³/(h m)	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00

Mittelwerte für Q50,Q10

Q50 (PHI - Bewertung) : **0,00** (±0,01) m³/(h m) Q10 (a-Wert) : **0,32** (±0,01) m³/(h m)

ergibt Luftdichtheitsklasse PHI **A+** Q50 ≤ 0,05

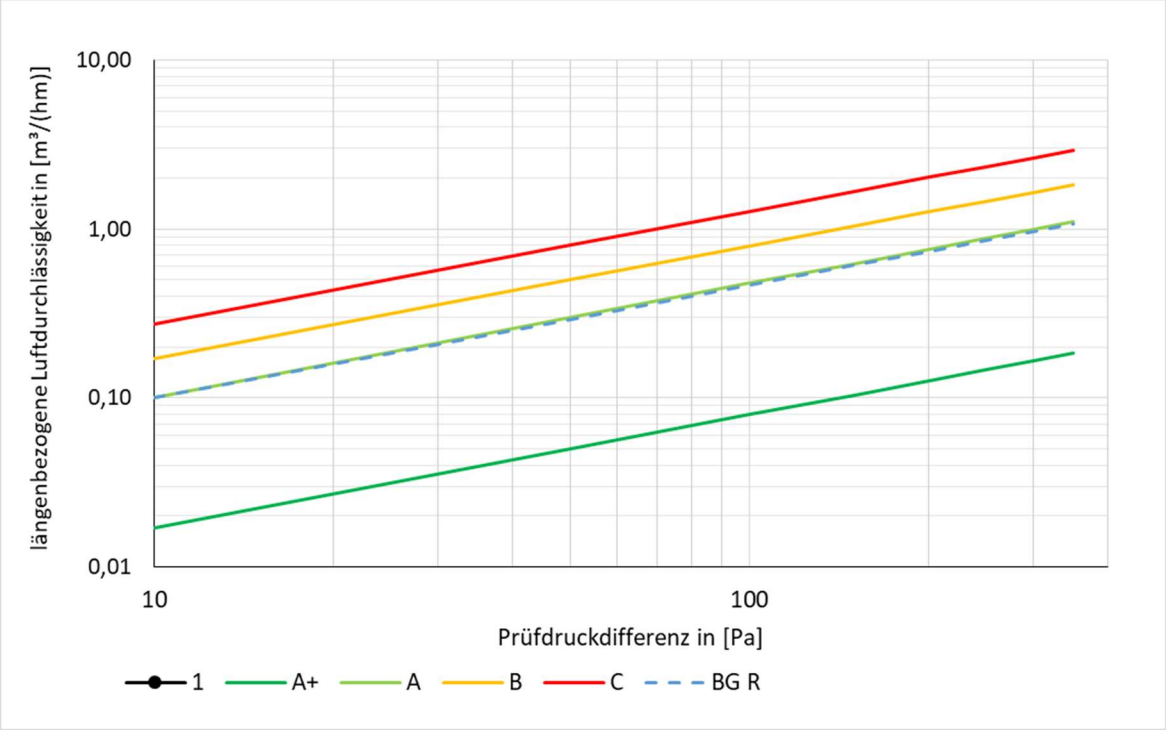

Fig. 4: **Measurement series of sample "H_KS_1" (timber construction/plastic frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

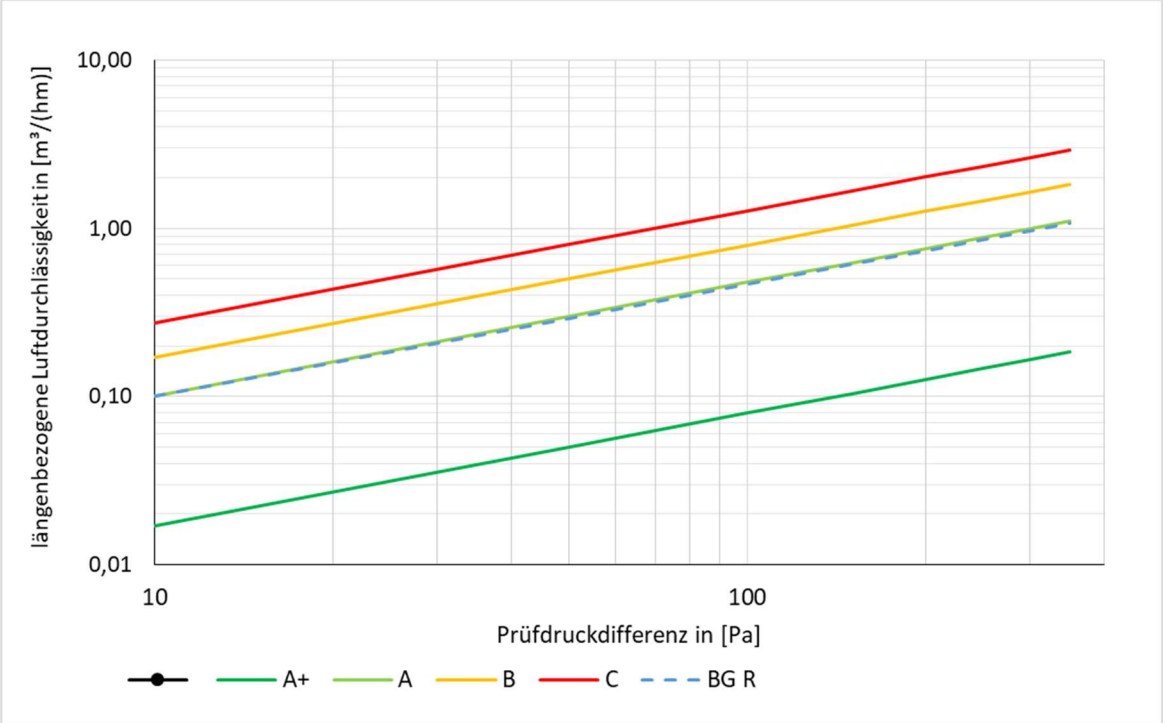

Fig. 5: **Measurement series of sample "H_KS_3" (timber construction/plastic frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

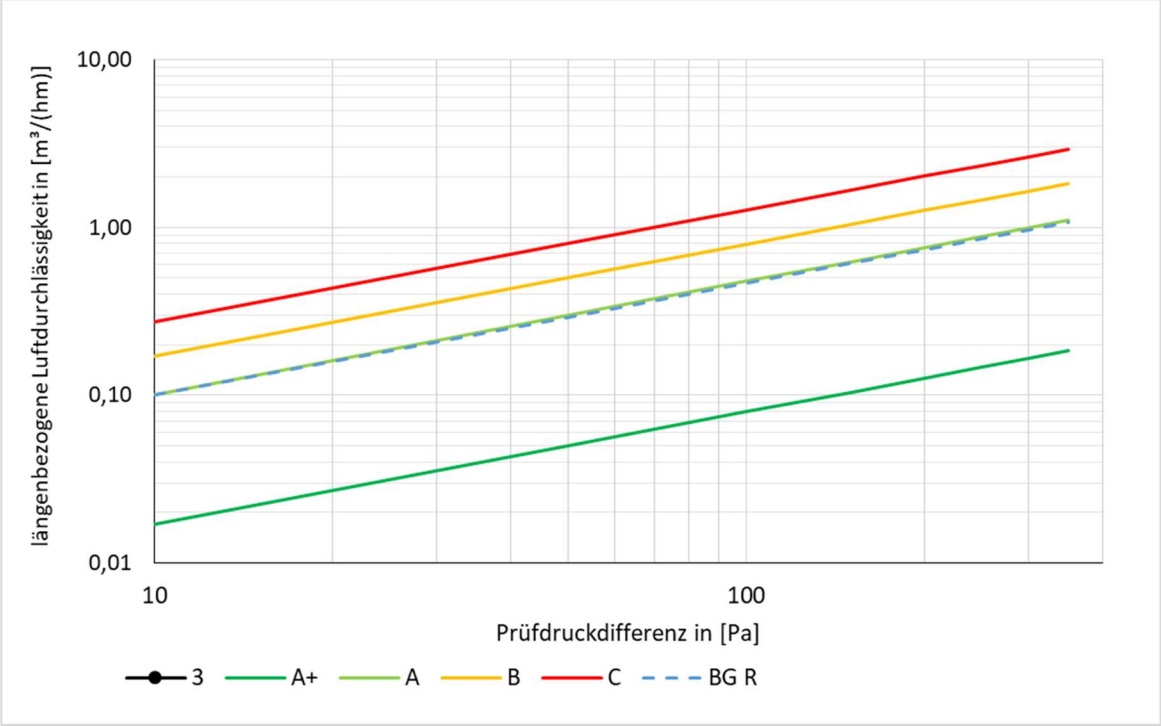

Fig. 6: **Measurement series of sample "H_KS_4" (timber construction/plastic frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

6.2 Installation in wood construction of wooden window frames

Installation situation	
Solid construction	
Wood construction	x

Window frame material	
Plastic	
Wood	x

Table 3: Measurement results of the three measurements of wooden frames in timber construction

Druckstufen	Pa	50	100	150	200	250	300	350
H_H_1								
Volumenstrom Gesamt	m³/h	0,05	0,18	0,21	0,23	0,24	0,26	0,27
Leckage des Messtandes	m³/h	0,05	0,18	0,21	0,22	0,24	0,25	0,26
spezifischer Luftvolumenstrom	m³/h	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00
H_H_2								
Volumenstrom Gesamt	m³/h	0,05	0,18	0,20	0,22	0,24	0,25	0,26
Leckage des Messtandes	m³/h	0,05	0,18	0,20	0,22	0,23	0,24	0,25
spezifischer Luftvolumenstrom	m³/h	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00
H_H_3								
Volumenstrom Gesamt	m³/h	0,05	0,19	0,22	0,24	0,26	0,28	0,29
Leckage des Messtandes	m³/h	0,06	0,20	0,23	0,25	0,27	0,28	0,30
spezifischer Luftvolumenstrom	m³/h	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leckagevolumenstrom	m³/(h m)	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00

Mittelwerte für Q50,Q10

Q50 (PHI - Bewertung) : **0,00** (±0,01) m³/(h m) Q10 (a-Wert) : **0,16** (±0,01) m³/(h m)

ergibt Luftdichtheitsklasse PHI **A+** Q50 ≤ 0,05 a ≤ 0,17

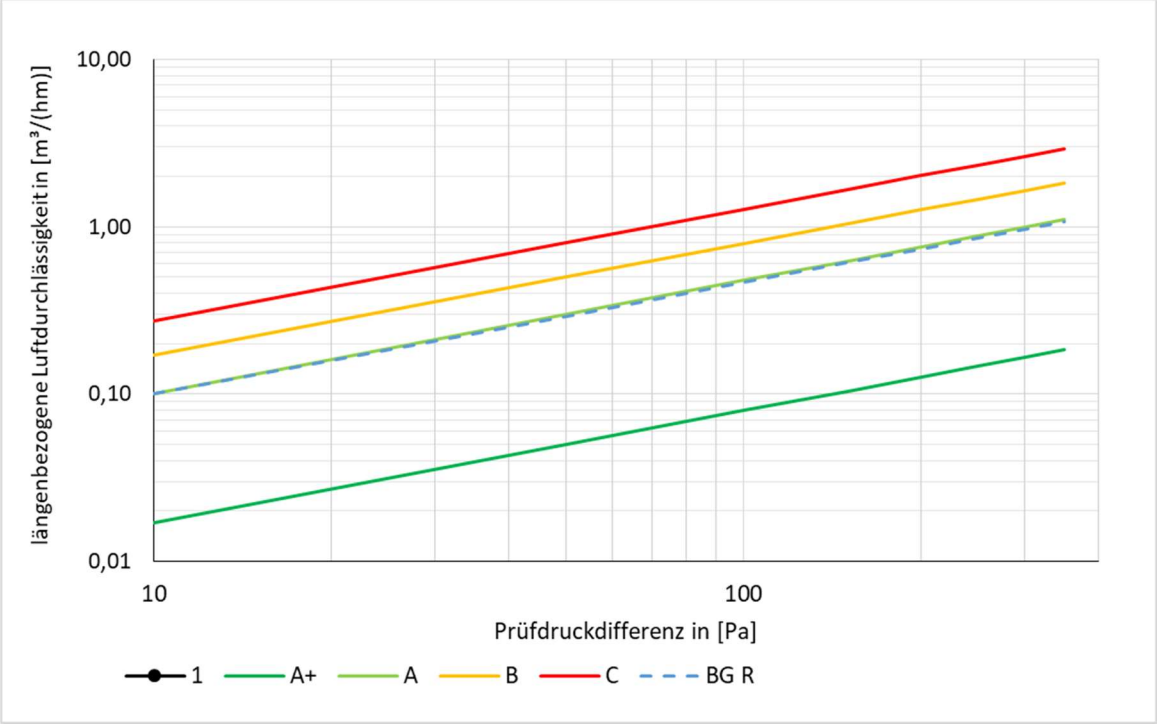

Fig. 7: **Measurement series of sample "H_H_1" (timber construction/timber window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

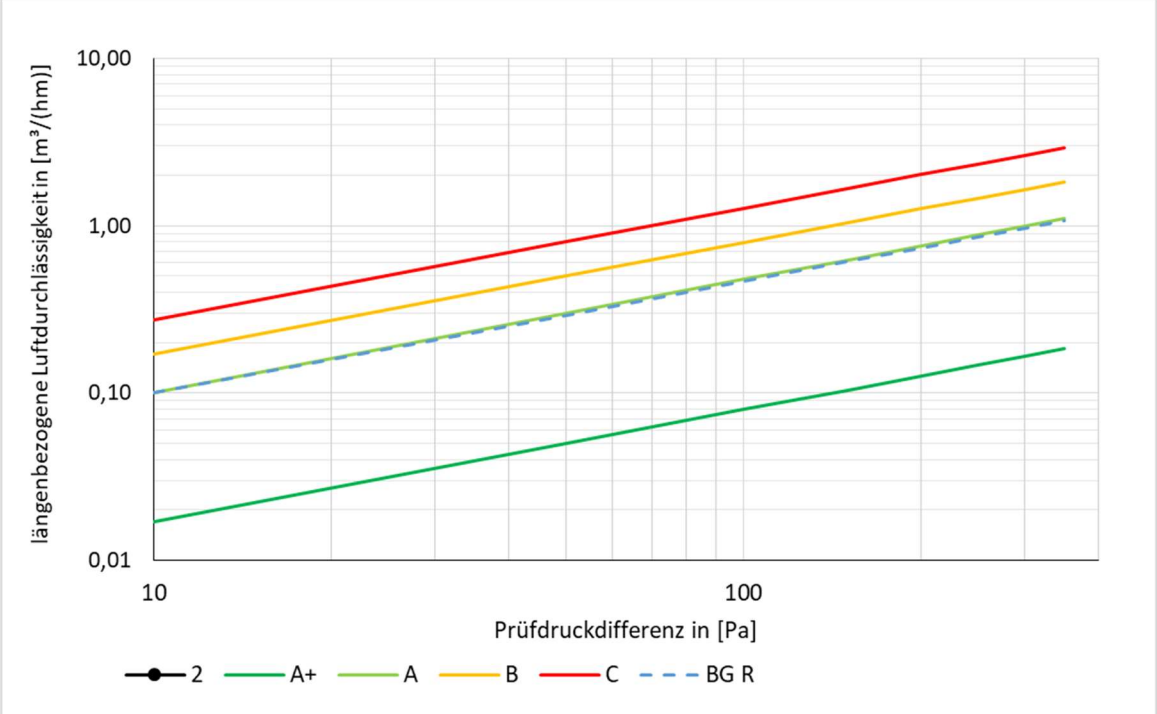

Fig. 8: **Measurement series of sample "H_H_2" (timber construction/timber window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

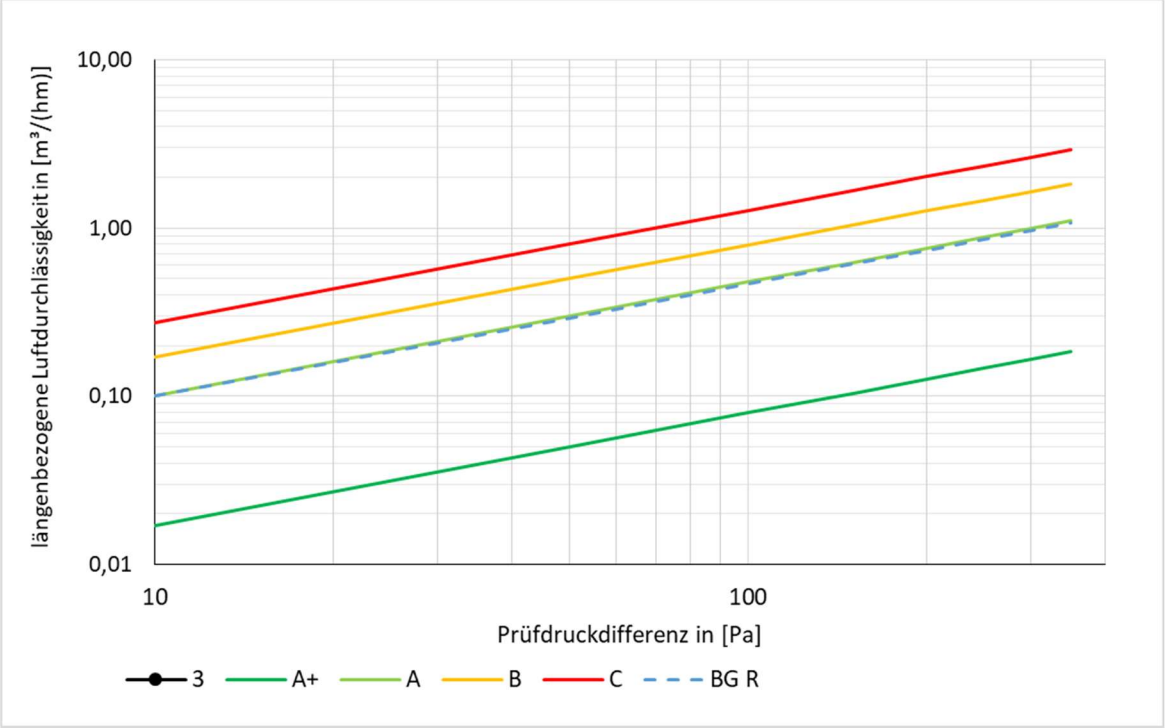

Fig. 9: **Measurement series of sample "H_H_3" (timber construction/timber window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

6.3 Installation in solid wall of plastic window frames

Installation situation	
Solid construction	x
Wood construction	

Window frame material	
Plastic	x
Wood	

Table 4: Measurement results of the three measurements of the plastic frames in solid construction[1]

Druckstufen	Pa	50	100	150	200	250	300	350
BT_KS_1								
Volumenstrom Gesamt	m³/h	0,14	0,34	0,41	0,47	0,53	0,58	0,62
Leckage des Messtandes	m³/h	0,00	0,07	0,09	0,11	0,13	0,14	0,15
spezifischer Luftvolumenstrom	m³/h	0,19	0,27	0,32	0,37	0,41	0,44	0,47
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,05**	0,07	0,08	0,09	0,10	0,11	0,12
BT_KS_2								
Volumenstrom Gesamt	m³/h	0,13	0,32	0,39	0,45	0,50	0,55	0,59
Leckage des Messtandes	m³/h	0,00	0,07	0,09	0,11	0,13	0,14	0,15
spezifischer Luftvolumenstrom	m³/h	0,18	0,25	0,30	0,34	0,38	0,41	0,44
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,04**	0,06	0,07	0,08	0,09	0,10	0,11
BT_KS_3								
Volumenstrom Gesamt	m³/h	0,18	0,38	0,47	0,53	0,59	0,64	0,69
Leckage des Messtandes	m³/h	0,00	0,07	0,09	0,11	0,13	0,14	0,15
spezifischer Luftvolumenstrom	m³/h	0,23	0,31	0,37	0,42	0,47	0,51	0,54
Leckagevolumenstrom	m³/(h m)	**0,06**	0,08	0,09	0,11	0,12	0,13	0,14

Mittelwerte für Q50,Q10

Q50 (PHI - Bewertung) : **0,05** (±0,01) m³/(h m) Q10 (a-Wert) : **0,19** (±0,01) m³/(h m)

ergibt Luftdichtheitsklasse PHI **A+** Q50 ≤ 0,05 a ≤ 0,27

[1] The deviations are due to rounding

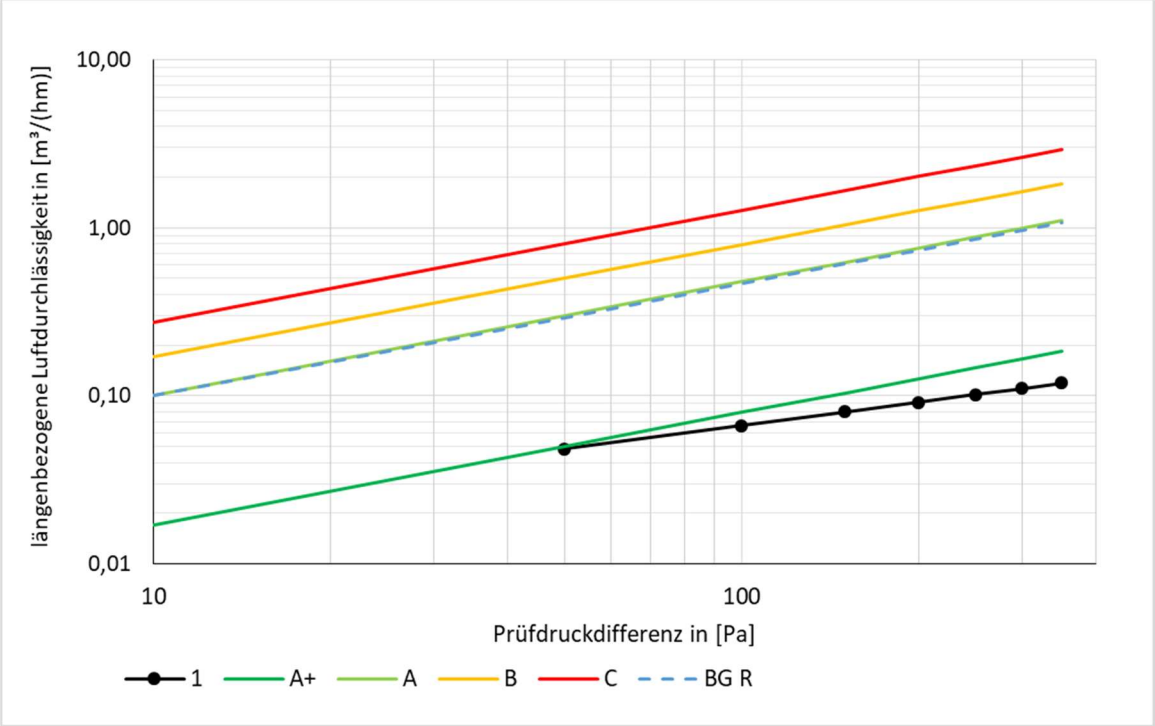

Fig. 10: **Measurement series of sample "BT-KS_1" (solid construction/plastic window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

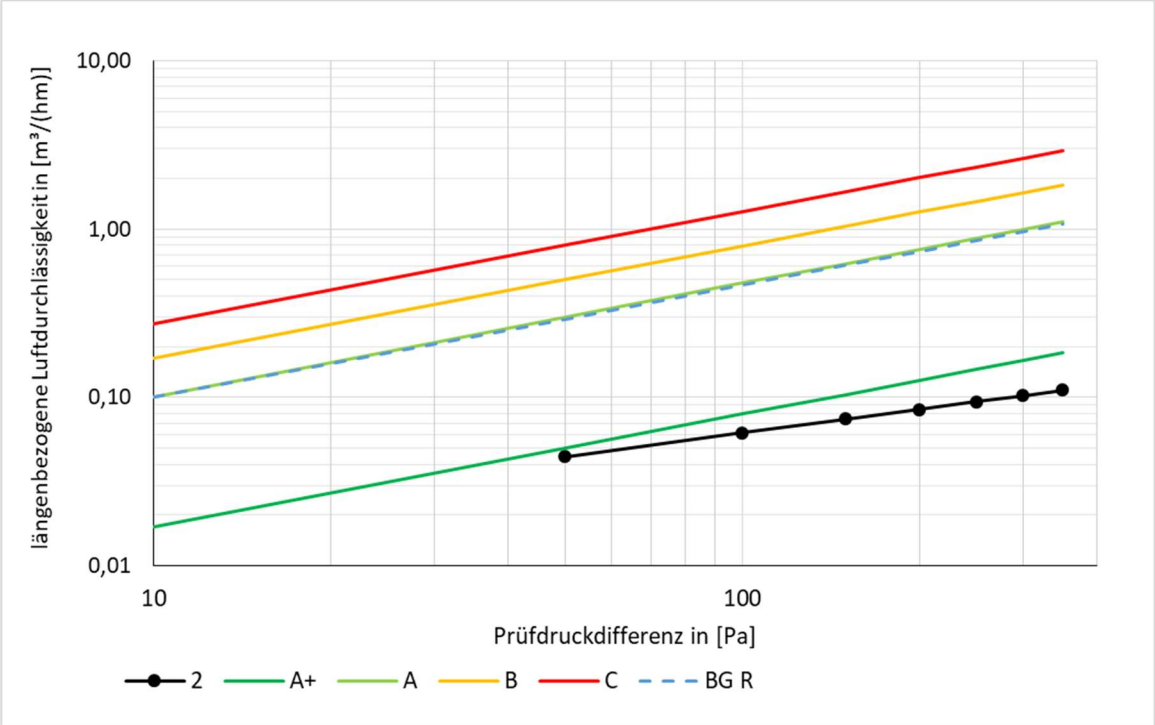

Fig. 11: **Measurement series of sample "BT-KS_2" (solid construction/plastic window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

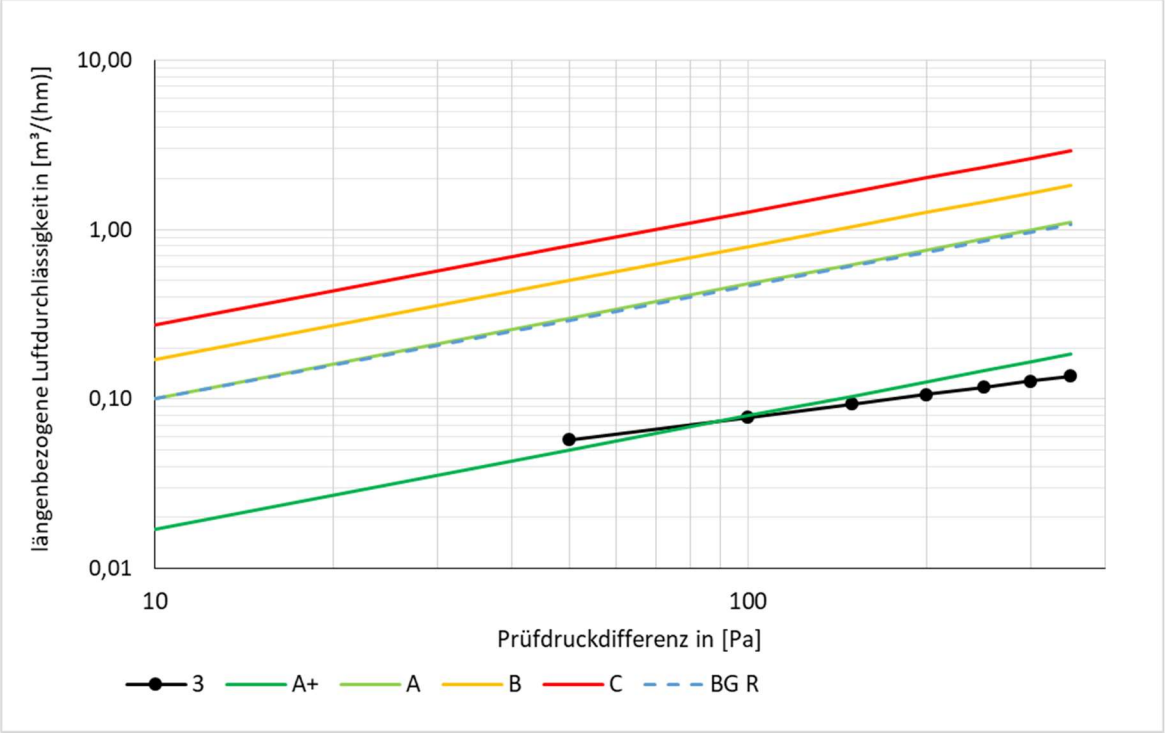

Fig. 12: **Measurement series of sample "BT-KS_3" (solid construction/plastic window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

6.4 Installation in solid wall of wooden window frames

Installation situation	
Solid construction	x
Wood construction	

Window frame material	
Plastic	
Wood	x

Table 5: Measurement results of the three measurements of the timber frames in solid construction[2]

Druckstufen	Pa	50	100	150	200	250	300	350
BT-H_1								
Volumenstrom Gesamt	m³/h	0,08	0,24	0,28	0,32	0,35	0,38	0,40
Leckage des Messtandes	m³/h	0,00	0,07	0,09	0,11	0,13	0,14	0,15
spezifischer Luftvolumenstrom	m³/h	0,13	0,17	0,19	0,21	0,23	0,24	0,25
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,03**	0,04	0,05	0,05	0,06	0,06	0,06
BT_H_2								
Volumenstrom Gesamt	m³/h	0,21	0,45	0,56	0,66	0,74	0,82	0,89
Leckage des Messtandes	m³/h	0,00	0,07	0,09	0,11	0,13	0,14	0,15
spezifischer Luftvolumenstrom	m³/h	0,26	0,38	0,47	0,55	0,62	0,68	0,74
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,07**	0,09	0,12	0,14	0,15	0,17	0,18
BT_H_3								
Volumenstrom Gesamt	m³/h	0,12	0,30	0,37	0,42	0,46	0,51	0,54
Leckage des Messtandes	m³/h	0,00	0,07	0,09	0,11	0,13	0,14	0,15
spezifischer Luftvolumenstrom	m³/h	0,17	0,23	0,28	0,31	0,34	0,37	0,39
Längenbezogenen Leckagevolumenstrom	m³/(h m)	**0,04**	0,06	0,07	0,08	0,09	0,09	0,10

Mittelwerte für Q50,Q10

Q50 (PHI - Bewertung) : **0,05** (±0,01) m³/(h m) Q10 (a-Wert) : **0,11** (±0,01) m³/(h m)

ergibt Luftdichtheitsklasse PHI **A+** Q50 ≤ 0,05 a ≤ 0,17

[2] The deviations are due to rounding

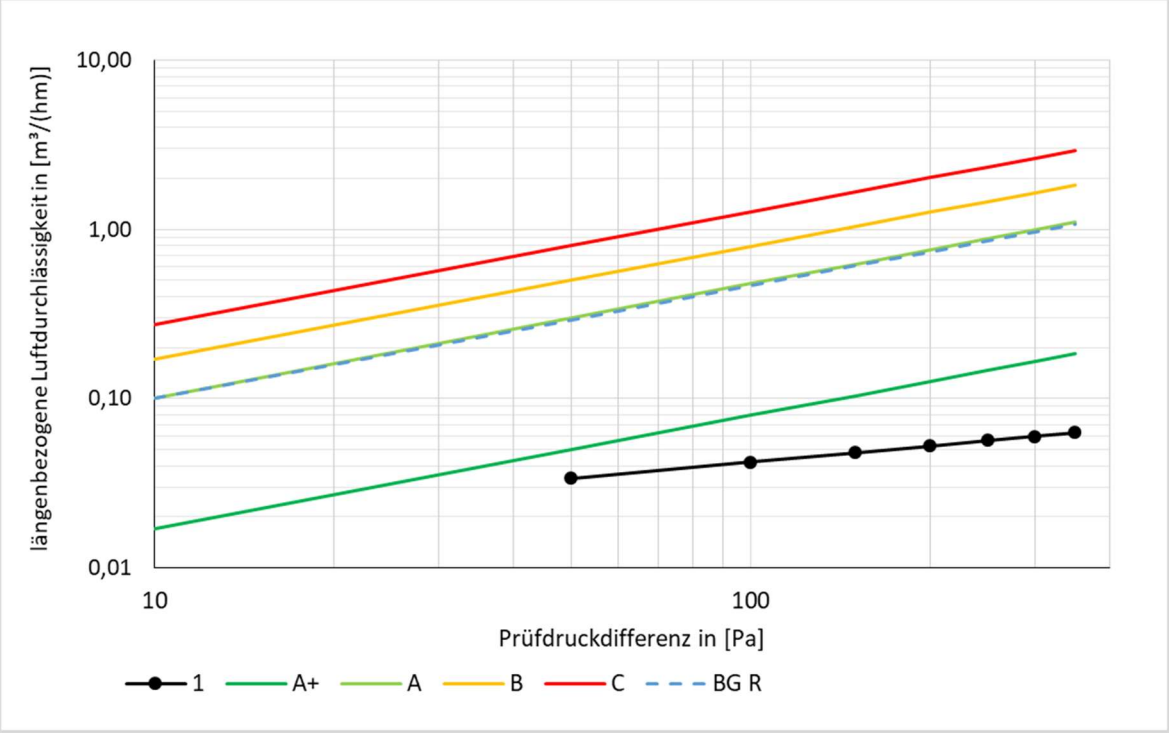

Fig. 13: **Measurement series of sample "BT-H_1" (solid construction/timber window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

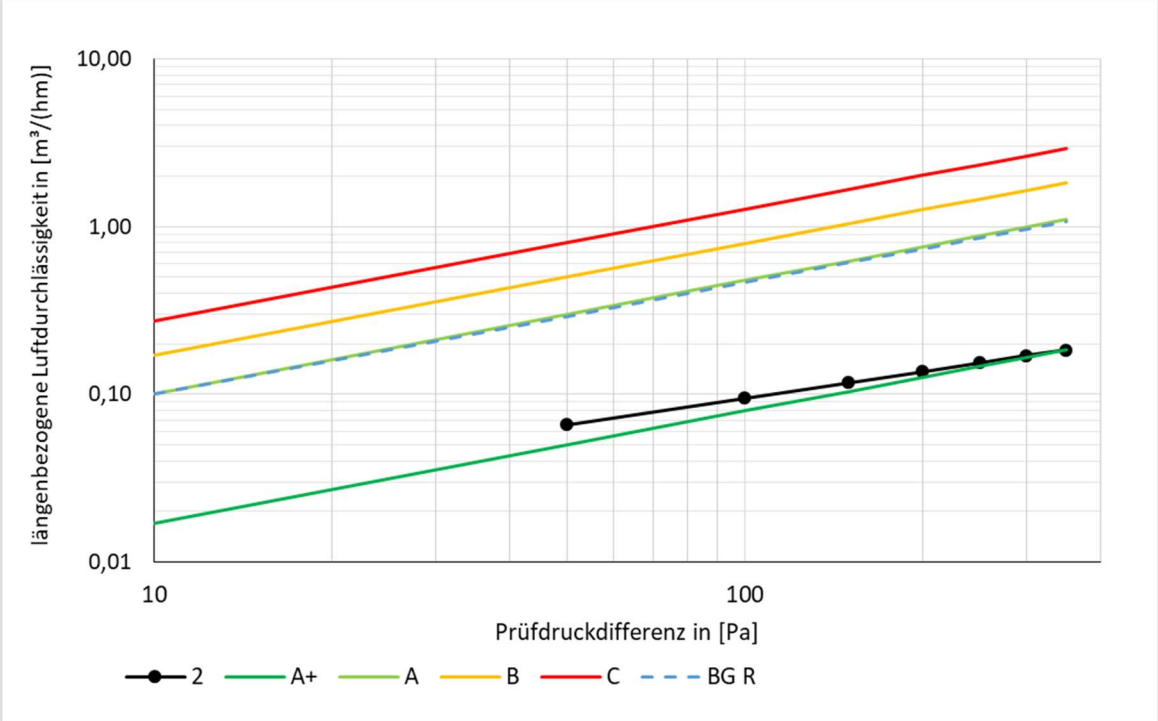

Fig. 14: **Measurement series of sample "BT-H_2" (solid construction/timber window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

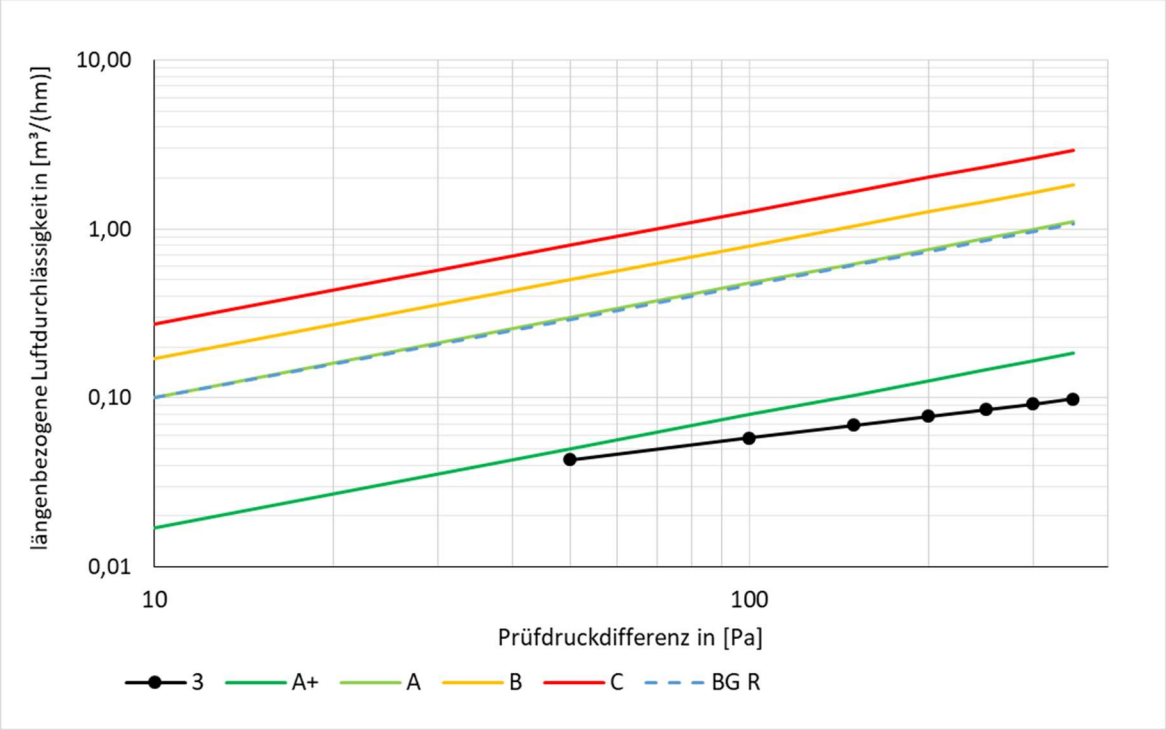

Fig. 15: **Measurement series of sample "BT_H_3" (solid construction/timber window frame). The certificate classes A+ to C according to PHI and the requirement BG R according to DIN 18542 are also entered.**

7. Measuring conditions

The average indoor climate conditions during the curing period of the installed airtightness system and during the measurements were as follows:

Room temperature: 18.7 °C
Indoor air humidity: 38.8 % rH

8. Measuring devices

A LaminarMasterFlow element from TetraTec® Instruments was used to measure the volume flow. The differential pressure was measured with an Automated Performance Testing System (APT).

Table 6: Overview of the measuring devices used

Device name	Device Typ	Serial-no.	Measurement range	Measurement accuracy
LaminarMasterFlow	LMF	PH796	0-85 l/min	2% in the range of 8-80 l/min
Automated Performance Testing System	APT	0072 4	0-2000 Pa	1 %

9. Results

The measurement results of the tests are compiled according to frame material and installation method and the overall mean value is calculated. The result is an average air permeability of 0.02 (±0.016) m³/(hm) at 50 Pa test pressure. This achieves certification class "A+".

Table 7: Overview of the measurement results of the airtightness test

Average value of:	m³/(hm) @ 50 Pa
Timber frame in solid construction	0,00
Plastic frames in solid construction	0,00
Solid construction (total)	**0,00**
Timber frames in timber construction	0,05
Plastic frames in timber construction	0,05
Timber construction (total)	**0,05**
Total	**0,02** (±0,016)

Table 8: Achieved requirement class of the tested product for certification as an "airtight window connection system" according to the specifications of the Passive House Institute

Class	**Air permeability length-related** @ 50 Pa [m³/(hm)]	**Achieved class**
A+	**≤ 0,05**	✓
A	≤ 0,30	
B	≤ 0,50	
C	≤ 0,80	

Darmstadt, 24.04.2024

Wolfgang Hasper