Information. Criteria and Algorithms for Certified Passive House Components: Ventilation systems with heat recovery (capacity < 600 m³/h)

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Certificate: approved thermal quality

The market for highly energy-efficient buildings is expanding rapidly, and the demand for reliable high-performance components is growing. However, requirements and possibilities for achieving this are often unclear with some manufacturers specifying characteristic values which they cannot guarantee.

The Passive House Institute certifies highly energy-efficient components according to international criteria, in order to meet the requirements for comfort, hygiene and energy efficiency. In the context of the certification process, the Institute provides advice to manufacturers in relation to the optimisation of their products. This results in improved, future-proof products and reliable thermal characteristic values for input into energy balance software programmes.

Advantages of certification:

- Consultations relating to product development for highly efficient buildings
- Access to a growing market
- Increased market visibility and product recognition
- Independently tested & certified: use of the Passive House Component Seal
- Inclusion in the Component Database of the Passive House Institute
- Incorporation into the PHPP energy balance software programme for buildings

Passive House Institute

The **Passive House Institute** (PHI) is an independent research institute which has played a decisive role in the development of the Passive House concept. The Passive House Standard is the only globally recognised energy standard for buildings which stands for tangible and verifiable efficiency values.

www.passivehouse.com

All products certified by the PHI are accordingly listed in the **Passive House Component Database** and made accessible to the international public. Integrated tools and information offer a high added value for building owners, designers and manufacturers.

database.passivehouse.com

The **Passive House Planning Package (PHPP)** is a cost-saving energy balance tool for highly energy efficient buildings. It has been validated on the basis of measured projects, provides precise results and can be used reliably by all.

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iPHA, the International Passive House Association is the PHI's network of experts which is committed to the propagation of the Passive House concept and the dissemination of the relevant expertise and information. It brings together scientists and building owners as well as architects, designers and manufacturers.

https://www.passivehouse-international.org/

Contents

1 Preface

Passive House buildings provide optimal thermal comfort with minimum energy expenditure; they are within the economically profitable range with reference to their life-cycle costs. To achieve this level of comfort and low life-cycle costs, the thermal quality of the components used in Passive Houses must meet stringent requirements. These requirements are directly derived from the Passive House criteria with respect to hygiene, comfort and efficiency as well as from feasibility studies. The Passive House Institute has established component certification criteria in order to define quality standards, improve the availability of highly efficient products and promote their dissemination, and to provide planners and building owners with reliable characteristic values for input into energy balancing tools.

2 Criteria and requirements

The following paragraph describes the certification criteria and requirements for ventilation systems with heat recovery for certification as a component suitable for Passive House (unless otherwise described, the requirements apply regardless of a specific climate zone).

To assess whether a ventilation unit can be certified as a “Passive House component” by the Passive House Institute, at least the measurements listed under section 3 to sectin 6 must be carried out by an independent testing laboratory approved by the PHI. All measurement data and documentation from the testing laboratory is to be made available to the PHI in full.

The manufacturer is obliged to deliver a device from the series to the independent test laboratory for testing. Specially prepared devices will not be accepted for testing and will have to be taken back at the manufacturer's expense. The test centre shall ensure that the test is carried out in accordance with these test regulations.

The serial number must be documented in the test report. Tests on pre-series devices are only permitted after prior consultation with the Passive House Institute.

2.1 Airtightness

Requirement: Internal and external leakage at a pressure difference of 100 Pa must not exceed 3% of the average air flow rate in accordance with section 4.3

2.2 Efficiency criterion for heat recovery

For a cool-temperate climate: The effective dry heat recovery efficiency must be higher than 75 % with balanced mass flows and dry extract air.

For hot and very hot climates: The heat recovery on cooling must be at least 70% with balanced mass flows and dry outdoor air. For details, see section 4.4.

2.3 Efficiency criterion for electric power consumption

Requirement: The total electric power consumption of the ventilation device must not exceed 0.45 Wh/m³ at the upper limit of the air flow range and at an average pressure difference of 100 Pa. The quality of the fans available today allows significantly lower specific power consumption. Lower values of $P_{el} \leq 0.35$ Wh/m³ are recommended, especially for hot and very hot climates.

2.4 Moisture recovery

Moisture recovery can have a positive effect on energy consumption in both heating and cooling climates. In the heating climate this is due to the reduced evaporation from building components, while in hot and humid climates the dehumidification demand is reduced.

The humidity ratio or moisture recovery rate respectively must be determined by measurement.

Applicable for a **heating climates**: For devices with a high moisture recovery rate (>60%), humidity-controlled air-volumetric flow control is required to prevent damage to the building due to temporarily excessive indoor air humidity. The control strategy of moisture recovery must be described for certification.

For **hot and humid climates**, the moisture recovery rate should be at least 60%.

2.5 Frost protection

For proper operation of ventilation units with optional supply air heating in Passive House buildings in cool temperate climates, uninterrupted operation of the mechanical ventilation system with heat recovery is essential. The mass flows must be kept in balance even under frost conditions. The maximum permissible disbalance of mass flows at the end of the test is 10%, see section 4.6.2.

At the beginning of the test, the mass flows must be set to a balanced value. The average exhaust air temperature during the test should not be higher than 5°C, see section 4.6.

Advice for other climates:

In the context of the certification process, the frost protection strategy is not tested for colder climates (cold or arctic), because additional measures may be required for these climates, or some devices (heat exchangers) will probably not be suitable for those colder climates. The manufacturer should give information about minimum operating temperatures of devices and heat exchangers.

In milder climates (with minimum winter temperatures > -5°C), a pre-heater coil may not be necessary.
Frost protection for supply-air-post-heating coils is necessary, too in the case of failure of the exhaust air fan or the frost protection heating coil. This has to be assured by emergency shutdown of the supply air fan if the supply air temperature falls below approx. +5°C.

2.6 Comfort criterion

Requirement: A minimum supply air temperature of 16.5 °C must be kept always, even at at outdoor air temperatures of -10 °C and an extract air temperature of 20 °C. With some frost protection strategies, it may not be possible to maintain a comfortable supply air temperature at an outside air temperature of -10 °C (e.g. outside air supply air bypass, rotary heat exchanger). In this case, the manufacturer should offer compensatory measures (supply air heating coil).

2.7 Standby

In standby mode, an intput power consumption of 1 W should not be exceeded. Alternatively, the manufacturer must provide the possibility of complete disconnection from the power supply as a standard feature.

2.8 Restart after power failure

The unit's control system must ensure that the device automatically restarts to normal operation after a power failure or interruption without user intervention. Operation must continue at the setting used before the power failure.

2.9 Indoor air hygiene

The central unit, including the heat exchanger, must be easy accessible for inspection and cleaning. It must be possible for building operators/owners (not qualified staff) to change the filters themselves. The minimum filter qualities are listed in the following table.

Filter	Requirements
Outdoor air filter	Installation at the front upstream of heat exchanger and fan Filter quality according to ISO 16890: at least ISO ePM1 50%
Exhaust air filter	Filter quality in accordance with ISO 16890: at least ISO Coarse 60%

Table: 1: Requirements for filters

2.10 Summer ventilation strategy

Requirement: The device must have a summer ventilation strategy for night-time cooling which bypasses the heat recovery. Heat recovery bypass is necessary (mandatory) for certification of the ventilation unit for hot and very hot climates. The quality of the heat recovery bypass must be verified (see section 4.4.7). The temperature difference between outside air and supply air should not exceed 2 K.

2.11 Adjustment and controllability

Requirement: The device must have at least 3 preset ventilation levels (e.g. reduced-ventilation / standard-ventilation / boost-ventilation) which can be set either manually or automatically depending on the air quality.
The fans should be adjustable for the purpose of commissioning and volumetric flow rate balancing, or should have constant volumetric flow control.

2.12 Automatic volumetric flow balance

For fans with constant volumetric flow control, the quality of the constant volumetric flow control must be verified by measurement (see section 4.2). In the average air flow range, the measured value should deviate by less than 10% from the default-set target value, even with increasing differential pressure.

2.13 Sound protection

Requirements for the sound emission of the appliance: appliances unconditionally suitable for Passive House buildings must have a sound power level of ≤ 35 db(A). Those devices may be operated in a functional room (e.g. kitchen, bathroom or storage room) without any additional measures. If this value is exceeded, a certificate can only be issued with the condition that the device should be "acoustically decoupled from living areas". The noise output of the appliance must be measured according to section 6.
Requirements for the sound pressure level in the rooms:
The sound power emitted into all the 4 ducts must be determined by measurement (frequency spectrum, see section 6). The manufacturer must specify suitable silencers with which the target values for living rooms (25 dB(A)) and for functional rooms (30 dB(A)) can be achieved – without taking into account the attenuation due to the duct network.

3 Device features to be tested

3.1 Condensate drainage

Depending on the climatic conditions for which the ventilation unit is intended, the device must be equipped with a condensate drain on the exhaust air and/or supply air side. The position and type of condensate drain must be documented in the test report. The condensate drain must be positioned in such a way that the condensate can drain away completely. The installation measures to ensure this must be clearly described in the installation manual.

3.2 Filter

Before starting the test, the type and model of the installed filter must be checked and documented. The classification of the filters should follow the norm [ISO 16890]. A filter should have at least ISO ePM1 50% efficiency on the outdoor air side. On the extract air side, a filter with an efficiency of at least ISO Coarse 60% should be used.
If the device does not provide the option of using an ISO ePM1 50% fresh air filter, an external filter box with an ISO ePM1 50% filter to be specified and supplied by the manufacturer must be integrated into the test setup. A device-integrated fresh air filter of lower quality can then be removed.
An external filter box is mounted directly on the outside air connection of the appliance and is treated as part of the appliance for all tests; the pressure drop of the external filter setup, its leakages and heat flows through the filter casing are to be included in full in the device assessment. Air conditions and volumetric flows will be measured before entry into the additional external filter installation.
Each filter must be clearly labelled by the manufacturer with the exact type and efficiency.

3.3 Frost protection of heat exchanger

It must be checked whether the device (if necessary) is equipped with a suitable integrated frost protection strategy (e.g. a preheating coil), which keeps the heat exchanger ice-free in case of low ODA temperatures. Switching off the supply air fan is not a suitable approach for Passive House buildings. If an internal frost protection system does not exist, an external frost protection installation with the corresponding control system to be specified and supplied by the manufacturer must be integrated into the test setup. An external frost protection installation should be fitted directly to the connector of the device, if necessary at the front of a filter box if one is used. It will be considered a part of the device for all tests. The pressure drop of the external frost protection installation, its leakages and heat flows through the housing will therefore be included in the device assessment. The condition of the air, as well as volumetric flows will be measured before entry into the additional external device.
If no frost protection is necessary for the heat exchanger (typically in the case of rotary heat exchangers), it must be considered whether a supply air reheating coil is necessary to ensure comfortable supply air temperatures (> 16.5°C) at extreme ODA temperatures in winter (down to an outside air temperature of -10°C). As mentioned before, if a supply air reheating coil is necessary, this will be considered a part of the device for all tests.
The exact type and maximum power consumption of each additional external preheating coil must be clearly indicated by the manufacturer. In addition, the control strategy must be described.

3.4 Emergency shut-off for frost protection

It must also be checked whether the device has an integrated emergency shut-off that switches the device off if the supply air temperature falls below a certain level (approx. 5°C). If this is not the case, a suitable external device must be supplied by the manufacturer. This will constitute a part of the test setup with the provided factory settings.
If the emergency shutdown is only possible via an external device, the installation manual must clearly state that this is mandatory for Passive House buildings with a hydraulic supply air heater.

3.5 Adjustment and controllability

If the volumetric flow rate of the device is to be selected manually, at least 3 preset ventilation levels are necessary for use in Passive House buildings (e.g. reduced-ventilation / normal-ventilation / purge-ventilation). If the device is equipped as standard with automatic control of volumetric flow based on the air quality, control must be possible across the entire operating range (see section 4.1). The possibility of manual adjustment of the volumetric flows must be checked and documented. For devices with fully automatic operation, random tests must be carried out to check and document whether demand-driven control works at the limits (0/no load; 100%/heavy load) at least.
Furthermore, it must be checked whether the device has constant volumetric flow fans or whether the fans can be adjusted for the purpose of volumetric flow balancing.

3.6 Maintenance access and filter replacement

The device should have a sufficiently large maintenance opening so that all necessary components can be inspected / repaired if necessary. The central unit, including the heat exchanger, must be easy to inspect and clean.

If the appliance is equipped with a plate heat exchanger that has to be cleaned regularly, e.g. by means of a water jet, it must be possible to remove and reinstall the heat exchanger repeatedly without negatively affecting the internal leakages. A tight seal of the heat exchanger should be avoided, as this would prevent the heat exchanger from being removed.

It should also be possible for non-experts to change the filter. This should be possible without the use of special tools and without prior experience.

4 Description of the test setup for determining energy-relevant characteristics of the device

The limits of the operating range are determined by the test setup in Figure 1 as shown below:

4.1 Operating range and volumetric flows for the test

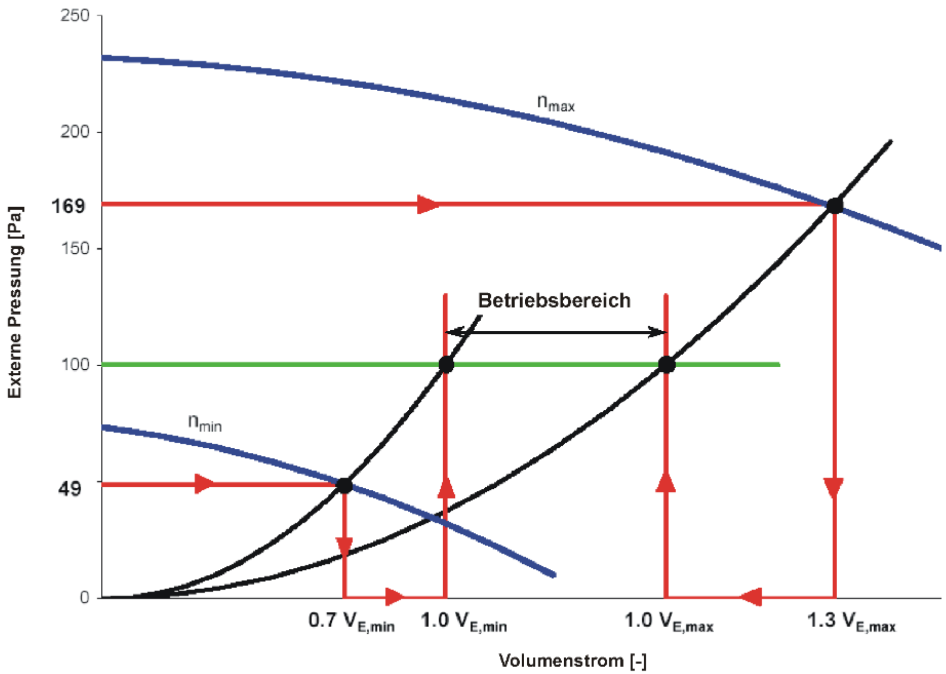

Figure 1: Graphical representation of the operating range (Betriebsbereich=operating range, Volumenstrom=volumetric flow, Externe Pressung=external pressure)

a) The appliance is operated at maximum level with an external pressure of 100 Pa x 1.3^2 = 169 Pa. The measured volumetric flow divided by 1.3 represents the upper limit of the operating range.

b) The device is operated with an external pressure of 100 Pa x 0.7^2 = 49 Pa at the lowest fan speed. The measured volumetric flow divided by 0.7 represents the lower limit of the operating range.

c) The volumetric flow for the test is determined as the average value of the upper and lower limits of the operating range.

d) If the ratio between the upper and lower limit is greater than 1.6:1, several series of measurements will be required. The entire operating range is divided into equally sized sub-ranges, which must remain in the ratio ≤ 1.6:1. Within each of these sub-ranges, measurements are made at the average volumetric flow value. The maximum number of sub-ranges is limited to 3 (maximum 3 measuring points).

In all cases, the nominal volumetric flow is the supply air volumetric flow. The differential pressure to be applied for the measurements must be realistically distributed (approx. 1/3 of the external pressure to be applied on the outside air or exhaust air side and approx. 2/3 on the supply air or extract air side).

An example calculation for determining the operating range, the sub-ranges and the measuring points is shown in Figure 2.

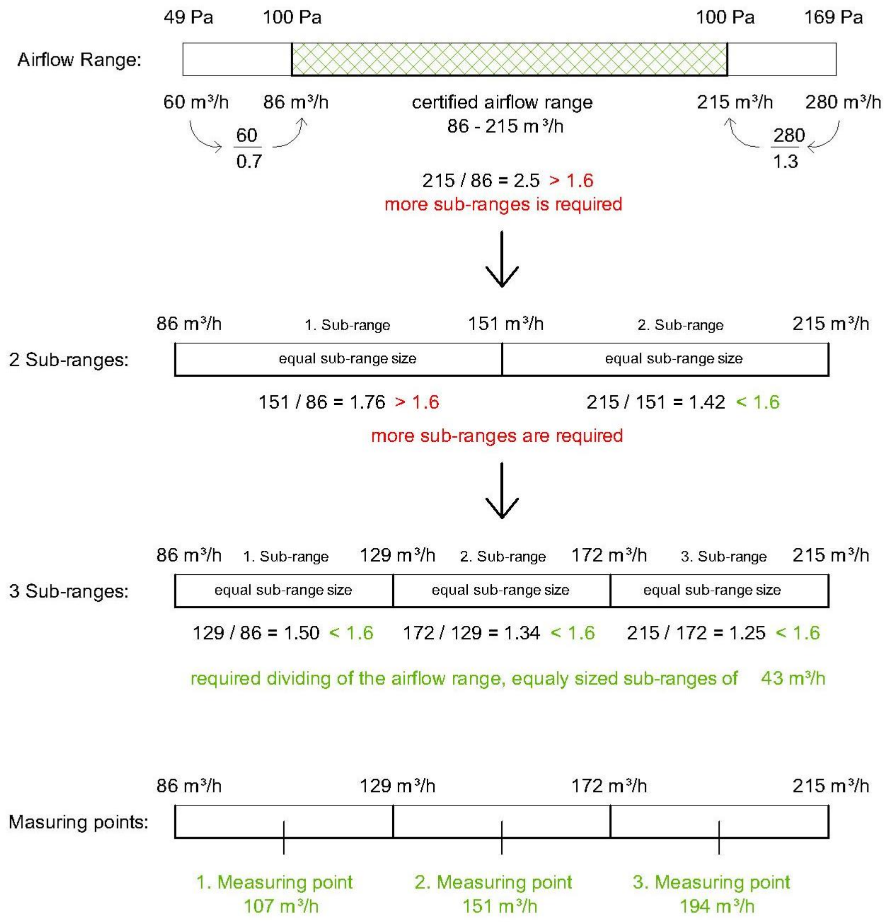

Figure 2: Example calculation: Determination of the operating range, the sub-ranges and the measuring points

4.2 Ventilation functional testing (for devices with constant volumetric flow control)

Based on the test with the air flow pressure characteristic curve according to [DIN EN 13141-7], the characteristic curve for at least 2 volumetric flow levels (average volumetric flow as well as upper operating limit according to section 4.1) must be recorded in 50 Pa steps for at least 4 differential pressures between 0 and 200 Pa.

4.3 Airtightness test

The test setup and tests are carried out in accordance with [DIN EN 13141-7]. The internal and external airtightness of the test specimen are examined. The airtightness tests should be carried out before starting thermodynamic testing. The reference volumetric flow is the average volumetric flow of the operating range determined according to section 4.1.

4.3.1 External (from inside to the outside of the unit) leakage

The test setup and tests are carried out in accordance with [DIN EN 13141-7] Appendix B1. The measurements are carried out for a minimum of four test pressures in the range between 50 Pa and 300 Pa. The air leakage rate is specified for positive pressure and negative pressure by using the regression line determined from the measured values standardised to 100 Pa. The airtightness test result is the mean value obtained from the measurement under positive pressure and the measurement under negative pressure, respectively. All measured values must be documented in the test report.

4.3.2 Internal (inside the unit between ODA-SUP and EXT-EHA) leakage

The test procedure for internal leakages depends on the type of heat recovery.

4.3.2.1 Devices with recuperative HR

For recuperative heat exchangers, the leakage rate is determined in accordance with the test setup in [DIN EN 13141-7] Appendix B2 (pressure test method). The measurements are carried out at a minimum of four test pressures in the range between 50 Pa and 300 Pa. The leakage rate is specified for positive pressure and negative pressure using the regression line determined from the measured values respectively and standardized to 100 Pa.

4.3.2.2 Device with regenerative HR

For regenerative heat exchangers, the leakage rate is determined in accordance with the test setup in [DIN EN 13141-7] Appendix C (trace gas test method).
An external pressure of 100 Pa should be set, for which a realistic static pressure distribution should be selected (approx. 1/3 of the external pressure to be set on the outside or exhaust air side and approx. 2/3 on the supply air or extract air side). The air volumetric flow during measurement corresponds to the upper limit of the operating

range. The volumetric flows must be balanced on the fresh air and exhaust air sides. For devices with discontinuous operation, the effective mean value must be determined over a sufficiently long measuring period.

4.4 Thermodynamic testing

4.4.1 General testing method for determining the heat recovery efficiency

The test regulation corresponds to measurements according to [EN 13141-7], in addition to the additional measurement technology for an optional measurement on the exhaust air side.
The differential pressure to be applied for the measurements (external pressure) is generally 100 Pa. The external pressure should be adjusted in the ratio of approx. 1/3 on the fresh air and exhaust air side and approx. 2/3 on the supply air and extract air side

- The fresh air and exhaust air mass flows are equalised by adjusting the device (if the fans are not automatically volume-flow-controlled). For devices with constant volumetric flow control, the volumetric flow is simply adjusted at the control panel.
- The volumetric flows of the measuring points determined according to section 4.1 are set at the device. The display values should correspond as closely as possible to the measured values (admissible tolerance ± 10% of the setpoint value). If larger differences occur, the volumetric flow must be adjusted.
- All 4 volumetric flows (ODA / EHA / SUP / EXT) must be measured and recorded.
- Air conditions (temperature and humidity) must be measured and recorded for all 4 volumetric flows (ODA / EHA / SUP / EXT).
- During the measurements, the total electric power consumption of the device (including control, and any necessary external systems etc.) have to be measured and recorded.
- The appliance has to be installed in the warm area (extract air conditions). The volumetric flows for the measurements can be taken from 4.1. For each measurement, it must be ensured that a steady state is reached. This must be recorded.

4.4.2 Devices with manual mass flow balancing

The effective dry heat recovery efficiency for appliances with manually adjusted mass flow balancing is determined using the following formula:

$$\eta_{HR,t,eff} = \frac{(\theta_{ETA} - \theta_{EHA}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\theta_{ETA} - \theta_{ODA})} \qquad [1]$$

with

$\eta_{HR,t,eff}$	heat recovery efficiency (dry air)	[%]
θ_{ETA}	extract air temperature	[°C]
θ_{EHA}	exhaust air temperature	[°C]
θ_{ODA}	outdoor air temperature	[°C]
P_{el}	electrical power	[W]
$\dot{m}$	mass flow rate	[kg/h]
c_p	specific heat capacity	[Wh/(kg.K)]

The outdoor air and exhaust air mass flows have to be balanced with an accuracy of +/- 3%.
The value for heat recovery efficiency will then be calculated according to formula [1]. If the mass flows were not balanced or were only inadequately balanced during measurement, the effective dry heat recovery efficiency has to be determined according to formula [4].
The certificate will state only the heat recovery efficiency value that can be guaranteed across the entire operating range. This is the smallest value out of the measurements for each range according to section 4.2.

4.4.3 Devices with constant volumetric flow fans

For devices with constant volumetric flow fans, volumetric flow adjustment on the fresh air / exhaust air side is achieved automatically, although there is a discrepancy of a few percent. A maximum imbalance of 3 % is permissible. Higher deviations must be manually readjusted before starting the measurement.
The remaining imbalance should be dealt with as follows: in the event of excess outside air, the exhaust air temperature is corrected by calculation as below:

$$\theta_{EHA,cor} = \frac{\dot{m}_{Dis} \cdot \theta_{ETA} + \dot{m}_{EHA} \cdot \theta_{EHA}}{\dot{m}_{ODA}} \qquad [2]$$

where

$$\dot{m}_{Dis} = \dot{m}_{ODA} - \dot{m}_{EHA} \qquad [3]$$

The effective dry heat recovery efficiency can then be determined as follows:

$$\eta_{HR,t,eff} = \frac{(\theta_{ETA} - \theta_{EHA,cor}) + \frac{P_{el}}{\dot{m}\cdot c_p}}{(\theta_{ETA} - \theta_{ODA})} \qquad [4]$$

with

$\theta_{EHA,cor}$	exhaust air temperature corrected	[°C]
$\dot{m}_{Dis}$	mass flow difference	[kg/h]

4.4.4 Devices with recirculated air volumetric flow (combined heat pump units)

Some combined heat pump units, in which MVHR is combined with an air-to-air heat pump (HP) for heating and cooling, require a considerable recirculated air volumetric flow in addition to the supply air volumetric flow, particularly for providing the cooling capacity in summer, similar to split unit heat pumps. This additional volumetric flow is provided by an air recirculation fan. Depending on where this recirculation fan is positioned, i.e., suction or pressure, it could affect the balance of the supply and exhaust air volumetric flows.

To ensure that the supply air / extract air balance is maintained in spite of this, appropriate precautions must be taken inside of the device and using the volumetric flow control. This is most easily done using constant volumetric flow fans in the supply air duct which will increase the speed in case of counterpressure and if the supply air volumetric flow decreases, or appropriate dampers can be used for regulation.

Testing of the balance with air recirculation operation is described in detail in the document [PH_Wärmepumpen_2025]. Only the general requirement will be discussed here in brief.

4.4.5 Regenerative heat recovery

For regenerative heat exchangers (rotors or with damper control), some special features must be taken into account with regard to determining the heat recovery efficiency.

To prevent the transfer of extract air to the supply air, the regenerator is usually partly flushed through with outside air to purge the lamella of the rotary wheel. The fresh air and exhaust air mass flows therefore differ from the supply air and exhaust air mass flows by the amount of the purge-air-flow, even with ideal airtightness of the unit. Determination of the operating range is not affected by this. The reference value here is the supply air volumetric flow. However, determination of the effective heat recovery efficiency requires consideration of the purge-air-flow amount $\dot{m}_{PA}$.

$$\dot{m}_{PA} = \dot{m}_{ODA} - \dot{m}_{SUP} \qquad [8]$$

with

$\dot{m}_{PA}$	mass flow purge air	[kg/h]
$\dot{m}_{ODA}$	mass flow outside air	[kg/h]
$\dot{m}_{SUP}$	mass flow supply air	[kg/h]

The following applies for mass flow balancing:

$$\eta_{HR,t,eff} = \frac{\dot{m}_{SUP}\cdot\theta_{ETA} + \dot{m}_{PA}\cdot\theta_{ODA} - \dot{m}_{ODA}\cdot\theta_{EHA} + \frac{P_{el}}{c_p}}{\dot{m}_{SUP}\cdot(\theta_{ETA} - \theta_{ODA})} \qquad [9]$$

A measured imbalance for constant control fans is considered by taking into account a mixed temperature of the exhaust air $\dot{\theta}_{EHA,cor}$. depending on the imbalance $\dot{m}_{DIS}$. according to the equation [3].

$$\theta_{EHA,cor} = \frac{\dot{m}_{Dis}\cdot\theta_{ETA} + \dot{m}_{EHA}\cdot\theta_{EHA}}{\dot{m}_{EHA} + \dot{m}_{DIS}} \qquad [11]$$

The effective dry heat recovery efficiency is then determined using the calculated mixed temperature:

$$\eta_{HR,t,eff} = \frac{\dot{m}_{SUP}\cdot\theta_{ETA} + \dot{m}_{PA}\cdot\theta_{ODA} - \dot{m}_{ODA}\cdot\theta_{EHA,cor} + \frac{P_{el}}{c_p}}{\dot{m}_{SUP}\cdot(\theta_{ETA} - \theta_{ODA})} \qquad [12]$$

4.4.6 Heat recovery with year-round humidity recovery

In order to be able to depict the energetically effective influence of this technology in Passive House buildings for devices with humidity recovery, which are intended for residential use among other things, the following additional stipulations have been made on the basis of extensive investigations in addition to equations [4] and [9].

For standardised conditions: the humidity ratio η_x is determined for the extract air condition 20°C / 50% rH and outdoor air condition 4°C / 80% rH.

$$\eta_x = \frac{x_{ETA} - x_{EHA}}{x_{ETA} - x_{ODA}} \qquad [13]$$

with

x_{ETA} absolute humidity extract air

x_{EHA} absolute humidity exhaust air

x_{ODA} absolute humidity outdoor air

For energy-relevant assessment the following applies for a humidity ratio $\eta_x \leq 0.6$

$$\eta_{HR,eff} = \eta_{HR,t,eff} + 0.08 \cdot \eta_X \qquad [14]$$

For a humidity ratio $\eta_x > 0.6$ this additional amount is limited to a maximum of 4.8 %.

The energy-relevant advantage of humidity recovery as an addition to the heat recovery efficiency may only be taken into account for heat exchangers with year-round humidity recovery and only for the cool, temperate climate.

For devices with a high humidity ratio $\eta_x > 0.6$, humidity-based volumetric flow control is necessary for preventing damage due to excessive indoor air humidity at times. The control strategy must be described for certification.

Furthermore, the increased air exchange necessary for limiting humidity must be taken into account in energy balance calculations: if not known exactly, this can be assumed to be

$$\dot{V}_{eff} = \dot{V}_{hyg} \cdot \frac{0.4}{1-\eta_x}$$

for residential use (35 m²/pers, humidity volumetric heat generation rate approx. 2 g/(m²h)).

4.4.7 Testing of heat recovery bypass

For the certification of ventilation units for hot and very hot climates, metrological proof of the quality of the heat recovery bypass is required. The test setup corresponds to that of the thermodynamic test according to section 4.4.1. The bypass damper must be opened (if manually operated). Automatically controlled devices remain in their standard configuration. The test criteria are summarised in section 4.4.8.

4.4.8 Test conditions

a) Winter case

Test	Temperature	Relative humidity
Thermodynamically dry	ODA = 4°C	No requirement
	ETA = 20°C	≤ 35%
Thermodynamically wet	ODA = 4°C	80%
	ETA = 20°C	50%

b) Summer case

Test	Temperature	Relative humidity
Thermodynamically dry	ODA = 35°C	≤ 50%
	ETA = 25°C	No requirement
Thermodynamically wet	ODA = 30°C	70%
	ETA = 25°C	≤ 50%
Bypass	ODA = 16°C	No requirement
	ETA = 25°C	

4.5 Electrical efficiency

In addition to the thermodynamic test, the electrical power consumption at the upper operating limit of the ventilation unit determined in accordance with 4.1 must be determined by measurement. The ventilation unit, control system and any necessary external systems must be taken into account. The frost protection for the heat exchanger should remain deactivated during the test.

The value in the certificate is the value that can be guaranteed for the entire operating range.

4.6 Effectiveness of frost protection

4.6.1 Device settings

The device settings and the settings for the frost protection strategy should take place in accordance with the manufacturer's recommendations. If changes to the factory settings are necessary to meet the requirements, these changes must be documented in the laboratory test report.

If external preheating coils are used, these should also be installed in accordance with the manufacturer's recommendations, whereby the installation situation and any necessary minimum distances between the device and the preheating coil should be documented in the laboratory test report.

4.6.2 Boundary conditions and carrying out measurements

Testing of the frost protection strategy should take place at the upper operating limit of the device based on [DIN EN 13141-7] (in accordance with 4.1) or alternatively should be carried out at a higher volumetric flow:

Outside air conditions: -15°C.

Extract air conditions: 20°C/ rH = ca 40%

Test duration once the air flows have stabilised at -15°C outside air temperature: at least 6 h.

The volumetric flows have to be balanced before or at the beginning of the test.

Starting with 0°C, the outside air temperature should gradually be decreased until the test temperature of -15°C is reached. The timepoint of activation of the frost protection strategy together with the outside air temperature and the exhaust air temperature has to be documented.

The following parameters should be recorded during the entire measurement:

- Volumetric flows (ODA, SUP, EXT, EHA)
- Temperatures (ODA, SUP, EXT, EHA)
- Electrical power consumption of the frost protection strategy or optionally that of the overall device

For a future assessment of the efficiency of the frost protection strategy, the power consumption for the frost protection strategy or optionally of the overall device should be recorded over a defined period of time.
Recording of the power consumption should begin when the outside air temperature reaches -15°C and should continue for the entire duration of the frost protection test.
At an outside air temperature of -10°C, the power consumption should also be recorded for a defined period of time (30 min).

4.6.3 Necessary data and documentation

The frost protection test must be carried out and documented as described here. The parameters recorded during the measurement must be made available to the PHI in a form suitable for evaluation (e.g. as an MS Excel file) for the purpose of evaluating the suitability of the frost protection strategy.

4.7 Testing for the comfort criterion

Verification of comfortable supply air temperatures at extreme winter temperatures must be carried out in the course of the frost protection test. When lowering the outside air temperature for the frost protection test, upon reaching -10°C the air conditions must be kept constant for some time until the air flows have stabilised (approx. 30 minutes). The supply air temperature must be documented. The outside air temperature must then be lowered further until the frost protection test temperature is reached.
As an alternative to the above procedure, the test for determining the supply air temperature at an outside air temperature of -10°C can also be carried out afterwards (the reduction of the outside air temperature during the frost protection test is carried out without interruption for this).

4.8 Deactivation of frost protection for hydraulic heating coil in supply air duct

The test is carried out by closing the extract air connection and lowering the outside air temperature at the same time. The temperature profile of the air flows, the progression of the volumetric flows and the electrical power consumption of the device must be represented in the test report of the measurement laboratory. The error message of the ventilation unit must be documented.

4.9 Determination of the efficiency indicator number

The efficiency indicator number is used for evaluation of the overall energy efficiency of a ventilation unit. It indicates the proportion by which the ventilation-related energy demand can be reduced through the use of a ventilation unit with heat recovery.
The efficiency indicator takes into account the final energy demand for covering the ventilation heat losses and the auxiliary energy required by the ventilation unit and the frost protection strategy. As the heat supply takes place via a heat pump, only electrical energy is incurred (different approaches for primary energy factors are therefore irrelevant). This indicator is determined in each case using a dataset representative of the relevant climate zone.

The efficiency indicator is calculated according to the following formula:

$$\boldsymbol{\varepsilon} = \frac{\boldsymbol{Q_{V,end,ref} - Q_{V,end,HR} - Q_{rv,aux} - Q_{rv,defrost}}}{\boldsymbol{Q_{V,end,ref}}} \qquad [15]$$

$Q_{V,end,ref}$	final energy demand for covering the ventilation heat losses of a reference system without heat recovery [kWh/a]
$Q_{V,end,HR}$	final energy demand for covering the ventilation heat losses of the ventilation system with heat recovery [kWh/a]
$Q_{rv,aux}$	final energy demand of the ventilation unit during the heating period kWh/a]
$Q_{rv,defrost}$	energy demand for the frost protection strategy of the heat exchanger [kWh/a]

With the following calculation approaches:

$$Q_{V,end,HR} = V \cdot n \cdot c \cdot (1 - \eta_{HR}) \cdot G_t \cdot e_H$$

$$Q_{V,end,Ref} = V \cdot n \cdot c \cdot G_t \cdot e_H$$

$V \cdot n = 1\, m^3/h$
$c = 0.33\, Wh/(m^3K)$

η_{HR}	calculated heat recovery efficiency (according to these test regulations) [-]
G_t	heating degree hours according to climate zone [kKh/a]
$e_H = 0.44$	efficiency ratio of the electric heat pump heating system [-]

$$Q_{rv,aux} = 0.001 \cdot V \cdot n \cdot P_{el} \cdot t_H$$

P_{el}	measured specific electrical power consumption of the ventilation unit (according to PHI test regulations) [W/(m³/h)]
t_H	duration of the heating period (of operation of the ventilation system) according to the climate zone [h]
$Q_{rv,defrost}$	energy demand for frost protection strategy [kWh/a], calculation algorithm according to [PHPP]

The frost protection strategy has some impact on the efficiency number. Depending on the foreseen frost protection strategy, the following switching points are used for the calculations.

Frost protection strategy	**Switching point outside air temperature (ODA) [°C]**
Rotor/ regenerative heat exchanger	< -15 °C
Recuperative heat exchanger with heat recovery	approx. -8 °C
Recuperative heat exchanger without heat recovery	-1.5 °C

For recuperative heat exchangers without humidity recovery, an overall switch-on temperature of -1.5°C is initially assumed; lower switch-on temperatures can be taken into account subsequently against proof. Please contact us for this.

Climate data: Climate zone: cool-temperate (representative location: Frankfurt/M): G_t = 79 kKh/a, t_H= 5136 h

4.10 Overview of measurements and test conditions

Test	**Temperature**	**Relative humidity**
Thermodynamically dry, winter case	ODA = 4°C	No requirement
	ETA = 20°C	≤ 35%
Thermodynamically wet, winter case	ODA = 4°C	80%
	ETA = 20°C	50%
Thermodynamically dry, summer case	ODA = 35°C	≤ 50%
	ETA = 25°C	No requirement
Thermodynamically wet, summer case	ODA = 30°C	70%
	ETA = 25°C	≤ 50%
Bypass	ODA = 16°C	No requirement
	ETA = 25°C	
Frost protection heat exchanger	ODA = -15°C	
	ETA = 20°C	ca. 40% (see DIN EN 13141-7)
Comfort criterion	ODA = -10°C	
	ETA = 20°C	ca. 40% (see DIN EN 13141-7)

4.11 Miscellaneous

All specified test procedures apply for typical cases. Alternative or additional testing may be necessary for unusual device configurations. Please coordinate this with the Passive House Institute at an early stage.

If air conditions cannot be achieved individually due to the facilities available in a certain laboratory, arrangements should be made in agreement with the PHI at an early stage, which approximate the intentions of the requirements as much as possible.
It is recommended that measurement details are discussed with the Passive House Institute prior to the measurements. Any deviations from the test procedures described above should be agreed with the Passive House Institute.

5 Functional tests

5.1 Determining standby losses

The electrical power consumption of the device (including controls and any necessary external systems) must be determined for purely standby operation of the device.

5.2 Restarting after a power outage

The test should be carried out after pulling out the mains plug and then waiting for 10 minutes.

6 Testing of the acoustic characteristics

6.1.1 Measurement of the noise emission spectra

The sound power emitted by the device is measured in accordance with [DIN EN ISO 3743-1] (device set up in test room according to manufacturer's instructions).
Alternatively the acoustic test can also be carried out in accordance with [DIN EN ISO 3744] or [DIN EN ISO 9614-2].

In addition, the sound power is measured in the outside air / exhaust air / supply air and extract air ducts in accordance with [DIN EN ISO 5136]. The measurement results are given in one-third octave bands (31.5 Hz - 8000 Hz). All tests are carried out at an external pressure of 100 Pa and in the upper volumetric flow operating range (see section 4.1).

7 Documents to be submitted for certification

- Laboratory test report of the tests carried out in accordance with sections 3 and 4.
- Test report relating to the acoustic tests, if not included in the laboratory test report.
- Raw measurement data for the frost protection of the heat exchanger and comfort, preferably in xls format.
- Raw measurement data for the device airtightness tests if the measured values are not included in the report.
- Technical description of the device with dimensions and duct connection pieces as well as the installation and instruction manual.
- Technical descriptions/instructions for any necessary additional components (pre-heating coil, post-heating coil).
- Description of the filter installed as standard together with the filter class and description of the filter installed for the measurement together with the filter class (if this is different from the standard case).
- Descriptions of the following functions (if not stated in the instructions):
    - Adjustment and regulation of the volumetric flows
    - For fans with constant volumetric flow control: description of the control system
    - Frost protection strategy and setting where applicable
    - Description of optional humidity-based volumetric flow control (only for devices with humidity recovery)
- Technical data about the sound absorbers recommended for the device
- Picture and sketch of the device to be published in the component database
- Designation of the device for the certificate
- Company address to be shown on the certificate
- Company logo for the component database

8 Symbols and abbreviations

$\eta_{HR,t,eff}$	heat recovery efficiency (dry air)	[%]
θ_{ETA}	extract air temperature	[°C]
θ_{EHA}	exhaust air temperature	[°C]
$\theta_{EHA,cor}$	exhaust air temperature corrected	[°C]
θ_{ODA}	outside air temperature	[°C]
P_{el}	electrical power	[W]
$\dot{m}$	mass flow	[kg/h]
$\dot{m}_{Dis}$	mass flow difference	[kg/h]
$\dot{m}_{PA}$	mass flow purge air	[kg/h]
c_p	specific heat capacity	[Wh/(kg.K)]
η_x	humidity ratio	[%]
x_{ETA}	absolute humidity extract air	[g/kg]
x_{EHA}	absolute humidity exhaust air	[g/kg]
x_{ODA}	absolute humidity outside air	[g/kg]
ε	efficiency ratio, e.g. heating system	[-]
$Q_{V,end,ref}$	final energy demand for coverage of the ventilation heat losses of a reference system without heat recovery	[kWh/a]
$Q_{V,end,HR}$	final energy demand for coverage of the ventilation heat losses of a ventilation system with heat recovery	[kWh/a]
$Q_{rv,aux}$	energy demand of the ventilation unit during the heating period	[kWh/a]
$Q_{rv,defrost}$	energy demand for the frost protection strategy of the heat exchanger	[kWh/a]

9 Reference literature

[AKKP 17]	Research Group for Cost-effective Passive Houses, Protocol Volume No. 17: Planning ventilation units for Passive Houses. Passive House Institute, Darmstadt, 1999 (7th edition 2009)
[PH_Wärmepumpen_2025]	Criteria and Algorithms for Certified Passive House Components: Heat pumps for space heating & cooling and DHW generation; Darmstadt 2025
[DIN EN 13141- 7]	DIN EN 13141- 7: 2021, Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 6: Exhaust ventilation system packages used in a single dwelling – Part 7: Performance testing of ducted mechanical supply and exhaust ventilation units (including heat recovery); December 2022
[ISO 16890]	DIN EN ISO 16890- 1: 2017-08, Air filters for general ventilation - Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM) (ISO 16890-1:2016) 2016
[DIN EN ISO 3743- 1]	DIN EN ISO 3743- 1: 2011, Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure measurements – Accuracy class 2 methods for small, movable sources in reverberant fields - Part 1: Comparison method in a test room with sound-reflective walls (ISO 3743-1:2010) (ISO 3743- 1: 2010); 2010
[DIN EN ISO 3744]	DIN EN ISO 3744: 2011, Acoustics - Determination of sound power levels of noise sources using sound pressure measurements - Methods for envelope areas with accuracy class 2 for an essentially free sound field over a reflecting plane (ISO 3744: 2010); 2010
[DIN EN ISO 9614-2]	DIN EN ISO 9614-2: 1996, Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement with continuous scanning (ISO 9614-2:1996); 1996
[DIN EN ISO 5136]	DIN EN ISO 5136: 2009, Acoustics - Determination of sound power radiated into a duct by fans and other air-moving devices - In-duct method (ISO 5136: 2003); 2009