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Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems for Certification as “Passive House suitable component”

For the certification of a ventilation unit as a “Passive House suitable component” by the Passive House Institute, at least the following measurements should be commissioned to a PHI-approved independent inspecting authority. All measured data and documentation of that authority must be made available to the PHI.
The manufacturer must provide the independent authority with a serial unit for testing. Specially prepared appliances will not be accepted for testing and must be taken back at the cost of the manufacturer. The inspecting authority must guarantee a testing procedure in accordance with these testing regulations.

1. Experiment set-up

The siphon of the condensate drain is to be filled with water and the ventilation unit is to be installed and started according to the manufacturer’s instructions.

The fine filter

Before the start of the testing the type and model of the built-in filters should be checked. On the outdoor air side a Class F7 filter, on the extract air side a Class G4 filter is to be inserted. If it is not possible to insert an F7 filter, an external filter box with an F7 filter is to be specified and delivered by the manufacturer and integrated into the experiment. Any integrated outdoor air filter of lesser quality can then be removed.
An external filter unit is attached to the nozzles of the unit and treated as part of the apparatus for all tests. The decrease in pressure of the external filter unit, its leakages and heat flow through the filter housing all contribute to the experimental data for the unit: air conditions and flow rate are thus measured before entering the external additional attachment.

Anti-freeze protection of the heat exchanger

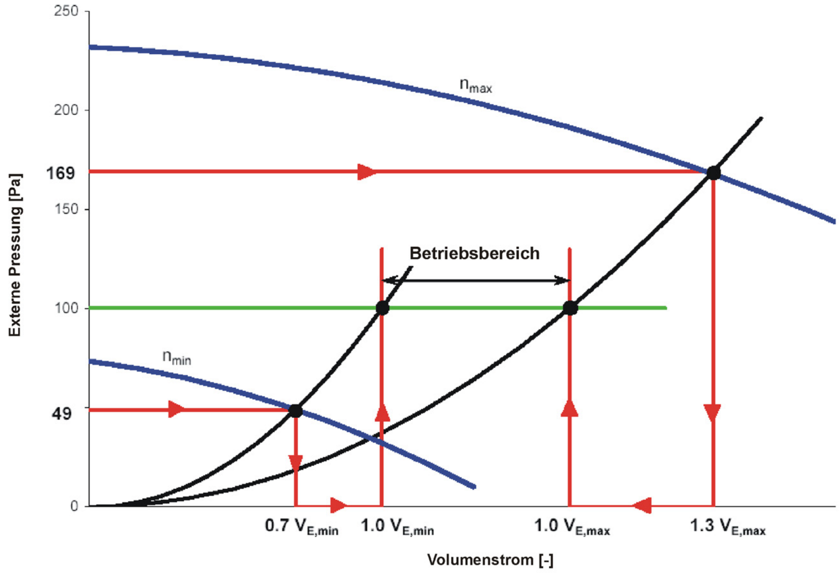
It should be checked that a frost protection device for the heat exchanger (i.e. heater coils) is installed. If this is not the case, an external frost protection with all relevant controls is to be specified and delivered by the manufacturer and integrated into the experiment set-up. An external unit is attached to the nozzles of the unit and treated as part of the apparatus for all tests. The decrease in pressure of the external frost protection unit, as well as its air leakage and heat flow through the housing all contribute to the performance of the apparatus: air conditions and flow rate are thus measured before entering the external additional attachment.

Emergency shutdown for frost protection

Likewise it should be checked that the ventilation unit has an integrated emergency shutdown for critically low supply air temperatures (to protect the heater coils from freezing up). If not, then an external appliance with its factory setting is to be delivered by the manufacturer, and this will be a part of the experimental set-up. If the emergency shutdown is only possible through an external device, it should be clearly and visibly set out in the assembly instructions that its use is compulsory for Passive Houses with hydraulic supply air heater coils.

2. Operational range and flow rates for the test

The limits of the operational range are defined with the experimental set-up according to 1 as follows:



a) The unit is operated at full speed with an external pressure of 100 Pa x 1,3² = 169 Pa. The flow rate measured divided by 1.3 gives the upper limit of the operational range.
b) The unit is operated with an external pressure of 100 Pa x 0,7² = 49 Pa at the lowest fan speed. The measured flow rate divided by 0.7 gives the lower limit of the operational range.
c) The flow rate for the test is computed from the average value of the upper and lower limits of the operational area.
d) If the proportion of the upper and lower limits is greater than 1.6:1, several test series are to be taken. The total operational range is divided up into equal parts which must be proportionally less than 1.6:1. Within these partial areas measurements should be made using mid flow rate values.

The rated flow rate in all cases is the supply air flow rate. The external pressure to be applied for the measurements is to be distributed evenly (i.e. 50% at a time) across the suction side and pressure side.

3. Testing of airtightness

The experiment set-up follows the Nordtest method [NT VVS 022 HEATRECOVERY Units, internal Leakage; NT VVS 023 HEATRECOVERY Units, external Leakage]. The internal and external airtightness of the test object is to be investigated. The airtightness test for negative pressure as well as for over-pressure is to be carried out before starting the thermo-dynamical testing. The measurements should be made for at least four testing pressures at a time in the range between 50 Pa and 300 Pa.

a) External leakage: the air flow rate which is necessary to maintain the static pressure difference between the apparatus interior and the surroundings is determined.
b) Internal leakage: The air flow rate between the extract air/exhaust air side and outdoor air/supply air side is ascertained by sealing the extract air/exhaust air side and putting it under negative/over-pressure. Between the surrounding air and the outdoor air/supply air side a pressure difference of 0 Pa is adjusted using an auxiliary fan. The internal leakage flow rate is represented by the input and discharge flow rates which are necessary for adjustment of the pressure difference of 0 Pa.

The leakage for both the over-pressure and negative pressure is given as standardised for 100 Pa by using the regression line computed from the measurement readings. As a result of the airtightness test the respective average value is calculated from the over-pressure and negative pressure tests. All readings are to be documented in the test report.
The leakages determined should not be greater than 3 % of the mid flow rate of the operational range of the ventilation equipment as defined in paragraph 2. The rated flow rate is the supply air flow rate.

4. Thermo-dynamical testing

The external pressure for the measurements is generally 100 Pa. The applied external pressure decrease should be evenly distributed (i.e. 50 % at a time) across the suction side and pressure side.

a) The mass flows of the outdoor air and exhaust air are to be balanced within the precision of the measurements by adjustment of the fans (except for automatically balanced fans).
b) All flow rates (outdoor air /exhaust air and supply air/extract air) are measured and logged.
c) The air temperature and humidity is measured and logged for all flows (outdoor air /exhaust air and supply air/extract air).
d) The outdoor air temperature is to be set as low as possible, but sufficiently high enough to ensure that no condensation can occur in the heat exchanger due to the humidity present in the outdoor air and extract air.
e) During the measurements the total electrical power consumption of the apparatus (including the controls and also of any necessary external systems etc) should be ascertained and logged.

The air flow rate/rates for the measurement(s) should be assessed according to the instructions in paragraph 2. The rated flow rate is the supply air flow rate. It should be ensured and substantiated through the recorded measurement data for all series of measurements that the whole experimental set-up has achieved a steady state.

Apparatus with manual mass flow balance

The effective dry heat recovery rate must be higher than 75 % with balanced mass flows of the outdoor air and exhaust air, at outdoor air temperatures between – 15 and + 10 °C and dry extract air (ca. 20 °C).

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO}) + \dfrac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})} \qquad [1]$$

From the documentation of the apparatus it should be clearly identifiable how the adjustment of fans for establishing the outdoor air/exhaust air side mass flow balance and the adjustment to the loss of pressure of a given duct system can take place.

Apparatus with constant flow rate fans

The mass flow balance for ventilation units with constant flow rate fans is automatically achieved on the outdoor air/exhaust air side, but there is a deviation of some per cent. An imbalance of less than 10% is acceptable. If the possibility of manual readjustment of the balance is available, this should be done before the start of the measurements.

The remaining imbalance should be dealt with in the following manner: In the case of an excess of outdoor air the exhaust air temperature is to be mathematically corrected by admixture at extract air temperature as follows:

$$\vartheta_{FO,korr} = \frac{(\dot{m}_{Dis} \cdot \vartheta_{AB} + \dot{m}_{FO} \cdot \vartheta_{FO})}{\dot{m}_{AU}} \qquad [2] \qquad \text{with} \qquad \dot{m}_{Dis} = \dot{m}_{AU} - \dot{m}_{FO} \qquad [3]$$

It applies that:

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO,korr}) + \dfrac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})} \qquad [4]$$

From the documentation of the unit it must be clearly identifiable, if necessary, how the readjustment of the fans to optimise the outdoor air/ exhaust air side mass flow balance and the adjustment to the loss of pressure of a given duct system can take place.

5. Electrical efficiency

The total electrical power consumption of the ventilation apparatus (all fans, controls, and any essential external systems) should at the upper limit of the operational range not exceed 0.45 W/(m³/h) for transported supply air flow. The freeze protection for the heat exchanger remains disabled. The test is carried out at external pressure of 100 Pa (see paragraph 2).

6. Acoustical testing

Emission spectrum

The measurement of the acoustic power emitted by the ventilation unit takes place according to DIN EN ISO 3743-1 (positioning of the unit in the testing room according to manufacturer's instructions). Additionally the acoustic power in the outdoor/exhaust/supply and extract air ducts is measured according to DIN EN ISO 5136 (Oct. 2003). The measurement readings are given in third octave bands (31.5 Hz – 8000 Hz). All tests are carried out at an external pressure of 100 Pa and using the upper limit of the operational range as the flow rate (see paragraph 2).

Sound emission of the apparatus

Entirely Passive House-suitable units have a noise level of ≤ 35 dB(A) in a room with an equivalent absorption area of 4 m². They can thus be operated without further measures in any functional room (e.g. kitchen, bathroom). If this value is exceeded, a certificate can only be issued with the restriction that the device should be installed in a separate utility room or the like.

Recommendation for silencers

Suggestions for appropriate silencers for the supply air and extract air ducts are to be made by the manufacturer on the basis of the measured emissions. Because the duct systems in Passive Houses are optimised and may be very short, silencers are to be dimensioned without accounting for a damping action by the duct system. The adoption of the damping action of a standard supply air or extract air outlet is tolerable.

In living areas (supply air) a noise level of ≤ 25 dB(A), while in functional rooms (extract air) a noise level of ≤ 30 dB(A) is stipulated.
If there is no recommendation by the manufacturer, exemplary guidelines on the basis of standard values of typical silencers are provided by the PHI.

7. Frost protection shutdown for hydraulic heater coils in the supply air

In order to avoid frost damage to any downstream hydraulic heater coils (Passive House supply air heating) the apparatus must have an emergency shutdown if the supply air temperature falls below +5°C (e.g. malfunction of exhaust air fan). For the user a clearly perceptible corresponding error message should be issued at the control unit.

The testing involves the closing of the extract air duct and parallel decrease in the outdoor air temperature. The temperature profile of the air flows, the development of the flow rates and the electrical power consumption of the apparatus are to be described in the test report.

8. Checking of the frost protection for the heat exchanger

Switching threshold of the factory setting

The frost protection of the apparatus must guarantee regular operation, that is, with mass flow balance on the outdoor air/ exhaust air side and undiminished mass flow, at all times. For this a suitable preheater is necessary (cf. 1).
This should be operated in the factory setting as delivered by the manufacturer. The outdoor air temperature at which the pre-heating is activated should be ascertained by measurement, with a standardised extract air condition of 21°C /50 % rH. The switching threshold for the frost protection must be –3°C or less. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

The effectiveness of the freeze-protection

The effectiveness of the freeze-protection is to be proved in a twelve-hour long-term test with an external air temperature of –15°C and standardised extract air condition of 21°C /50% rH. A visual inspection of the heat exchanger for ice deposits ends this part of the examination. The test is to be carried out using the flow rate of the upper limit of the operational range. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

Measurement of the critical temperature

The temperature at which the exhaust air temperature reaches the frost limit should be determined with deactivated pre-heating. This critical temperature for the inside positioning of the apparatus should be documented. The test is carried out using the mid flow rate of the operational range. The temperature profiles of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.
For a minimised frost protection energy demand it should be possible to set the limit temperature so that no frost can occur in the heat exchanger.

The approach for the manual readjustment of the frost protection limit temperature must be clearly described in the assembly instructions supplied with the apparatus. The factory setting must, however, guarantee the maximum temperature of –3°C.

9. Comfort criterion

The observation of a minimal supply air temperature of 16.5 °C at –10 °C outdoor air temperature is to be proved by measurement. A frost protection unit for the heat exchanger is active with its factory setting in this test. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

10. Ascertainment of the standby loss

The electrical power consumption of the ventilation unit (including controls, also any essential external systems) is to be ascertained for the purely stand-by operation of the apparatus. In the stand-by mode a consumption of 1 W should not be exceeded, otherwise the manufacturer should provide the possibility of a complete disconnection from the electrical supply as a standard.

11. Restart after a power failure

It must be ensured that the apparatus automatically starts regular operation after a power failure without any user intervention. The operation must be continued at the same setting as before the power failure. The test is to be carried out by pulling out the mains plug and waiting for ten minutes.

12. Hygiene

Inspection and cleaning of the central apparatus including the heat exchanger should be easy. It must be possible for the user to change the filters himself (no expert should be required for this), a description for this procedure and suppliers for the spare filters should be documented in the handbook.
The service life of the outdoor air filter should be limited to one year (to avoid endotoxins). The manufacturer must ensure that the proliferation of microorganisms and the entry of endotoxins is prevented permanently by providing either components or obligatory attachments for the apparatus.

13. Miscellaneous

All specified test procedures apply for typical cases. For unusual construction types alternative or additional testing may be necessary. It is recommended that this is agreed at an early stage with the Passive House Institute.
If, due to the available facilities in a certain laboratory, individual air conditions cannot be achieved, after early agreement with the PHI an arrangement should be made which approximates the intentions of the requirements as much as possible.

14. Symbols and abbreviations

AU	Outdoor air	[-]
FO	Exhaust air	[-]
ZU	Supply air	[-]
AB	Extract air	[-]
ϑ_{AU}	Outdoor air temperature	[°C]
ϑ_{FO}	Exhaust air temperature	[°C]
$\vartheta_{FO,korr}$	Corrected exhaust air temperature	[°C]
ϑ_{ZU}	Supply air temperature	[°C]
ϑ_{AB}	Extract air temperature	[°C]
$\dot{m}$	Mass flow	[kg/h]
$\dot{m}_{Dis}$	Mass flow difference/disbalance	[kg/h]
$\dot{m}_{AU}$	Mass flow outdoor air	[kg/h]
$\dot{m}_{FO}$	Mass flow exhaust air	[kg/h]
c_p	Specific thermal capacity of air	[Wh/(kg K)]
P_{el}	Real electrical power	[W]
$\eta_{WRG,t,eff}$	Effective heat recovery	[%]

Passive Houses have high requirements for the quality of the applied components because they can dispense with a separate heating system. A highly efficient heat recovery apparatus is an essential component of the comfort ventilation in a Passive House.
The following requirements have been stipulated by the PHI for the certification as "Passive House suitable component – heat recovery device" (details and explanations can be found in the appendix of the certificate):

Passive House - comfort criterion	Minimum supply air temperature of 16.5°C
Efficiency criterion (Heat)	The effective dry heat recovery efficiency must be higher than 75 % with balanced mass flows at external temperatures of between – 15 and + 10 °C and dry extract air (ca. 20 °C). $\eta_{\mathbf{WRG,t,eff}} = \dfrac{(\vartheta_{Ab} - \vartheta_{Fo}) + \dfrac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{Ab} - \vartheta_{Au})}$
Electrical efficiency criterion	At the designed mass flow rate the total electrical power consumption of the ventilation device may not exceed 0.45 W per (m³/h) of transported supply air flow.
Balancing and controllability	Outdoor air and exhaust air mass flows must be balanceable for the rated air flow rate, with controllability of at least 3 levels (basic ventilation (70-80%), standard ventilation (100%), increased ventilation (130%)).
Sound absorption	Noise level in installation room < 35 dB(A), in living areas < 25 dB(A), in functional areas < 30 dB(A).
Room air hygiene	Outdoor air filter at least F7, extract air filter at least G4
Frost protection	Frost protection for heat exchanger without supply air interruption, frost protection for an air heater in case of failure of the extract air fan or frost protection heater coil