Passive House Institute
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Test Report for the Certification of the Heat Recovery Device

VUT 350 VB EC A11

As a Passive House Certified Component

Client:	Private Joint Stock Company "Ventilation Systems" (Mr. Alexey Savchenko) 1, M. Kotsubynskogo str. Ukraine - 01030 Kiev
Device Under Test:	Ventilation Unit with Heat Recovery
Manufacturer:	VENTS
Identifier:	VUT 350 VB EC A11
Serial Number:	PVU07-2015 / 7441
Year Built:	2015
Author(s):	Jan Vahala
Date:	May 2016

Preface

To meet its heating demand, Passive Houses take advantage of pre-existing, in-service components in a building, effectively doing away with the need for a separate, potentially expensive, inconvenient or unnecessary heating system. A highly efficient ventilation system with heat recovery is an indispensable part of any Passive House.

To this end, the Passive House Institute has defined requirements and test criteria for ventilation units which are to be certified to be Passive House-appropriate devices. These requirements and criteria are a part of this report and are documented as an attachment.

Test Lab:	Building Research Establishment Ltd (BRE) Bucknalls Lane WD25 9XX Watford United Kingdom
Test Report:	P101556-1000
Author(s):	Michael Swainson
Date:	19.04.2016
Additional Information	./.

Table 1: Documents submitted as ancillary attachments

By the order of the manufacturer, the Passive House Institute has assessed the pre-requisites for the investigation of the aforementioned ventilation unit. Required measurements were performed by the laboratory noted in Table 1 in order to determine critical properties of the ventilation unit. All test results and corresponding test reports were provided to the Passive House Institute for further evaluation.

This presented report documents the critical results of the measurements and values which will be used in the assessment of the suitability of the device as a Passive House certified component.

1 Properties of the Air Ventilation Unit

An extensive device description is given in the unit’s technical specification manual. The datasheet and specification manual also contain a draft and/or drawing of the tested apparatus.

Dimensions (LxWxH) [mm]	610x734x758
Chassis Construction:	Metal sheet panels internally filled with mineral wool
Duct connection(s):	Ø 160 mm
Ventilator Arrangement:	Supply (SUP) / Exhaust (EHA)
Summer Bypass	Included

Operational range in accordance to the technical specifications

The operational range of this appliance results from the measurements carried out by the testing laboratory. The testing points and the results of the thermodynamic evaluation are compiled in table 2. The reference volume flow for the evaluation of the airtightness is the mean volume flow of the operational range. The evaluation of the acoustic properties is carried out at the upper limit of the operational range.

Minimum at 49 Pa ext.Pressure:	38 m³/h
Maximum at 169 Pa ext.Pressure:	363 m³/h
Operating Range	54-279 m³/h

Measured Regime	Operational Range		Average	Reference Volumetric Flow Rate
	Minimum [m³/h]	Maximum [m³/h]	(Test Points) Nominal / Actual [m³/h]	[m³/h]
1	54	111	82 / 68	167
2	111	167	139 / 102	167
3	167	223	195 / 154	167
4	223	279	251 / 232	167

Table 2: Min/Max volumetric flow rates, operational range, measuring points

Airtightness and Insulation Characterisation

The thermal bridges of this appliance could not be determined based on the measurements. Nevertheless, their impact is indirectly considered with the effective heat recovery efficiency, since it is affected by the heat bridges.

Over pressure	Pressure Difference Extract/Exhaust - Outside/Supply (nominal)	[Pa]	50	100	200	300
	Leaked airflow	[m³/h]	2.9	4.8	7.8	10.3
Under pressure	Pressure Difference Extract/Exhaust - Outside/Supply (nominal)	[Pa]	50	100	200	300
	Leaked airflow	[m³/h]	2.9	4.7	7.7	10.2

V'(L,Über) = 0.1833 * dp^(0.7073)
V'(L,Unter) = 0.1849 * dp^(0.7032)

Leakage flow at 100 Pa	Rated pressure	[Pa]	100
	Reference Volumetric Flow Rate	[m³/h]	167
	Leakage flow rate	[m³/h]	4.76 / 4.71
	Leakage Rate	–	2.84 %

Table 3: Results of testing the airtightness with respect to internal leakages

Over pressure	Pressure Difference Extract/Exhaust - Outside/Supply (nominal)	[Pa]	50	100	200	300
	Leaked airflow	[m³/h]	1.9	3.5	6.3	8.7
Under pressure	Pressure Difference Extract/Exhaust - Outside/Supply (nominal)	[Pa]	50	100	200	300
	Leaked airflow	[m³/h]	1.9	3.2	5.3	6.9

V'(L,Over) = 0.0688 * dp^(0.8507)
V'(L,Under) = 0.1135 * dp^(0.7228)

Leakage flow at 100 Pa	Rated pressure	[Pa]	100
	Reference Volumetric Flow Rate	[m³/h]	167
	Leakage flow rate	[m³/h]	3.46 / 3.17
	Leakage Rate	–	1.99 %

Table 4: Results of testing the airtightness with respect to external leakages

The results of the airtightness measurement are documented in table 3 and 4. With the measurement results the calculation of the leakage flow based on 100 Pa external pressure difference and the middle airflow rate is possible.

During the airtightness testing, the leakages maintained values lower than the mandated 3 % of the mean volume flow. This is reached, among others, by bonding the connections between a seals.

Room Air Hygiene: Equipment of Air Filter

To avoid contamination of the ventilation system, the Passive House Institute recommends equipping the ventilation appliance with internal outside air fine filters, at least of F7 class (DIN EN 779) close to the air inlet. For extract air, a G4 filter (DIN EN 779) is recommended.

This ventilation appliance during the laboratory testing was equipped with the following filters:

Outdoor air	F7
Extract air	G4

For hygienic reasons, it needs to be ensured that the relative air humidity does not exceed a value of over 80 % for more than 3 days.

Filters need to be checked regular and immediately exchanged if they are clogged. Depending on the degree of pollution, outdoor air filters should be exchanged in the interval of 6-12 months.

Comfort Criterion: Minimum Supply Air Temperature

The comfort criteria for ventilation appliances in passive houses require a minimum supply air (SUP) temperature of 16.5 °C at an outdoor air (OUT) temperature of -10.0 °C and a maximum volumetric airflow. The frost protection strategy during the test should working according to the factory settings.

At an outdoor air temperature of around -10.0 °C, the supply air temperature was 18.0 °C (measured value). The comfort criterion therefore is met.

The comfort criterion was fulfilled by use of an additional external electrical preheater NKP-160-1.7-1 with a nominal power of 1700 W. The average power of heaters during the test was ca. 1000 W.

Thermodynamical Testing: Efficiency Criterion of Heat Recovery

The thermodynamic properties are ascertained under standard testing conditions. These include: testing under an external pressure of 100 Pa, a balanced mass flow between the outer and exhaust air tracks, and no condensation in the extract and exhaust air tracks. Per the Passive House Institute’s certified component regulations, the heat recovery efficiency must be at least 75 %.

The results of these measurements are available in the test report provided by the test laboratory. The filter configuration throughout the test remained in the OEM condition. The measurement results for the determination of the dry heat recovery rate are listed in Table 5.

			Test Point 1	Test Point 2	Test Point 3	Test Point 4
Temp	ODA	°C	4.1	4.1	4.1	4.2
Temp	SUP	°C	18.8	19.1	19.2	18.9
Temp	EXT	°C	21.0	21.1	21.1	21.0
Temp	EHA	°C	7.6	7.5	7.7	8.3
Vol. Flow	ODA	m³/h	66	99	148	222
Vol. Flow	SUP	m³/h	68	102	154	232
Vol. Flow	EXT	m³/h	68	102	154	232
Vol. Flow	EHA	m³/h	66	99	149	222
rel. Humidity	ODA	%	73	74	76	80
rel. Humidity	SUP	%	28	28	28	31
rel. Humidity	EXT	%	29	27	28	29
rel. Humidity	EHA	%	70	66	67	67
Mass Flow	ODA	kg/h	84	125	187	282
Mass Flow	SUP	kg/h	82	124	186	281
Mass Flow	EXT	kg/h	81	123	185	279
Mass Flow	EHA	kg/h	82	124	187	278

Table 5: Measurement results for the determination of the dry heat recovery rate

If testing conditions are guaranteed (e.g. mass flow balance), the effective dry heat recovery rate can be calculated as follows:

$$\eta_{HR} = \frac{(\theta_{ETA} - \theta_{EHA}) + \frac{P_{el}}{\dot{m}\,.\,c_p}}{(\theta_{ETA} - \theta_{ODA})}$$

where:

η_{HR}	Heat recovery rate	[%]
θ_{ETA}	Extract air temperature	[°C[
θ_{EHA}	Exhaust air temperature	[°C]
θ_{ODA}	Outdoor air temperatur	[°C]
P_{el}	Electric power	[W]
$\dot{m}$	Mass flow	[kg/h]
c_p	Specific heat capacity	[Wh/(kg.K)]

For this appliance, the following dry heat recovery rates are calculated based on the measurements in the respective operational ranges.

Operating Range, Nominal Volumetric Flow Rate [m³/h]	Heat Recovery Efficiency η [%]
68	83 %
102	84 %
154	83 %
232	79 %

Table 6: Mean values of the heat recovery rate

Therefore an effective heat recovery rate of 79 % is achieved.

Electrical Efficiency

The overall specific electrical power input of a ventilation appliance must not exceed 0.45 W/(m³/h) within the certified range of operation. Testing demonstrated that the appliance has the following specific power consumption behaviour:

Volumetric Flow Rate [m³/h]	Power Consumption [W]	Adjusted Power Consumption [W/(m³/h)]
68	22	0.32
102	27	0.26
154	37	0.24
232	62	0.27

Table 7: Electrical power consumption

Therefore the criterion is met within the certified airflow range.

Efficiency Ratio

The efficiency ratio specifies the amount by which the energy demand caused by ventilation can be reduced through the use of a ventilation unit with heat recovery. The efficiency ratio takes into account the final energy demand for covering the ventilation heat losses and the necessary auxiliary energy for the ventilation unit and the frost protection strategy.

The efficiency ratio is calculated in accordance with the following formula:

$$\varepsilon = \frac{Q_{V,end,ref} - Q_{V,end,HR} - Q_{rv,aux} - Q_{rv,defrost}}{Q_{V,end,ref}}$$

where:

$Q_{V,end,ref}$	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]
$Q_{rv,aux}$	Energy demand of the ventilation unit in the heating period	[kWh/a]
$Q_{rv,defrost}$	Energy demand of the frost protection strategy for the heat exchanger	[kWh/a]

This unit achieves an energy ration of 0.61.

The climate data for the location Frankfurt am Main, Germany, with annual heating degree days of G_t = 79 kKh/a and with heating period length of t_H = 5136 h, were used as representative for cool-temperate climate.

Airflow Balancing and Controllability of the Device

At the PU SENS 01 control panel (A11), the user may choose between 3 standard operating modes as well as humidity control mode. The units provides also operation according to time schedule.

The airflow for each operating mode can be set as a percent ratio to the maximal fan speed. The settings is done for supply and exhaust air fan separately.

Notice: In the passive houses, the supply and exhaust airflows have to be always in balance.

The device is not equipped with constant air flow function. Setting up the device and balancing the airflow rates therefore must be carried out diligently. High pressure drop differences must be prevented by adequate measures (e.g. regular filter change).

Frost Protection of the Heat Exchanger

In order to protect the heat exchanger from freezing up the using of external preheater is recommended. The manufacturer recommends the installation of an external electrical preheater NKP-160 with a nominal power of 1700 W. The heating power of the preheater is controlled depending on outdoor air temperature. By laboratory testing, the preheater was first activated at an outdoor air temperature of ca. -3.9 °C.

The laboratory measurement has proved, that this frost protection at an upper airflow rate and an outdoor air temperature of -15 °C is sufficient. The average power of the pre-heater during the test was ca. 1200 W.

Notice: The default frost protection strategy which is based on switching off the supply air fan is not suitable for using in a passive houses.

Emergency Shutdown for Frost Protection of Hydraulic Heater Coils

In order to prevent damage to a hydraulic supply air heater coil, at least supply air fan need to be disabled if the supply air temperature drops below 5 °C.

The laboratory testing has proved, that the supply air fan is switched off in case the supply air temperature drops down to ca 8 °C. An error message was shown on the control panel.

Restart After Power Failure

In order to guarantee seamless operation and to ensure good indoor air quality, the ventilation appliance needs to utilise precautionary measures in the event of a power failure. Further, in a passive house, the supply air heating system is disrupted if the ventilation system is shut down.

Therefore, it must be guaranteed that the appliance automatically returns to its previously operating mode after a power failure.

The laboratory testing has proved, that after a power failure this appliance automatically returns into its previously operating state once the power supply is back online.

Bypass of the Heat Recovery

This version of the unit is equipped with a summer bypass which is operated automatically according to the outdoor and extract air temperature.

2 Acoustic Testing

Sound Radiated by the Unit Chassis

The measuring of acoustic power was conducted as per EN ISO 3743-1:2010. Detailed documentation is part of the testing laboratory’s report. Significant is the analysis of the sound emissions close to the upper limit of the operation range - measurement at operation point at 279 m³/h by pressure of 100 Pa was selected as the critical point.

Airflow rate [m³/h]	Sound level LW [dB]	A-weighted sound level LWA [dB(A)]
279	52.9	46.9

Table 8: Measurement results of the emission of sound from device chassis by air flow rate of 279 m³/h

The sound level of the device exceeds with 46.9 dB(A) the target value of 35 dB(A).

Please Note: The sound level of the device in an installation room with an equivalent room absorption area of 4 m² exceeds the limit value of 35 dB(A). Therefore the unit should be installed so that it is acoustically separated from living areas.

Sound Radiated by the Ducts

The testing of the sound radiated by the ventilation ducts was conducted as per EN ISO 3743-1:2010. The results are shown in Table 9.

In order to not exceed the limits of sound levels in living [25 dB(A)] and functional areas [30 dB(A)], appropriate sound silencers are required which need to be dimensioned according to site conditions. The testing has to be conducted at the highest volumetric flow rate of the operational range.

	Lw [dB(A)]	Lw [dB(A)]	Lw [dB(A)]	Lw [dB(A)]
Third Octave Mid-Band Frequency	**SUP**	**EXT**	**EHA**	**ODA**
10	0.0	0.0	0.0	0.0
12.5	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0
31.5	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0
100	43.7	36.9	42.9	41.1
125	47.4	35.9	43.1	36.6
160	50.1	38.5	42.7	38.7
200	52.4	39.2	46.3	38.7
250	58.9	43.8	54.3	44.6
315	66.9	51.6	62.0	49.7
400	53.3	41.0	49.5	43.7
500	54.6	37.7	51.7	42.3
630	58.2	38.7	56.7	40.9
800	52.3	34.7	51.8	35.3
1000	51.6	31.6	50.5	33.4
1250	52.1	32.8	50.4	33.7
1600	53.0	34.5	49.7	39.0
2000	52.3	34.7	50.2	37.8
2500	50.3	30.1	48.7	31.3
3150	46.9	28.4	45.3	29.9
4000	42.0	21.0	39.7	23.0
5000	37.0	14.3	34.5	15.9
6300	32.7	10.6	29.6	11.3
8000	27.2	8.5	22.3	8.6
10000	18.9	7.1	13.2	7.1
Summed Acoustic Power [dB(A)]	69.2	53.7	65.3	53.7

Table 9: Sound power levels of the ventilation ducts at 279 m³/h.

Canal Acoustic Silencers

In order to not exceed the limits of sound levels in living [25 dB(A)] and functional areas [30 dB(A)], appropriate canal acoustic silencers are required. These silencers must be dimensioned project-specifically.

On the base of manufacturer-provided product information for a recommended acoustic silencer, the dimensioning for extract and supply air ducts are given below. By using of 3 pieces of silencer model VENTS SRF 160/600 (160 mm diameter, 600 mm length and 50 mm insulation thickness) a sound level of ca. 24 dB(A) in supply air rooms (SUP) at an airflow rate of 279 m³/h could be achieved. On the extract air rooms (EXT) at the same airflow rate, a sound level of ca. 30 dB(A) could be achieved with 2 pieces of silencer model VENTS SR 160/600 (160 mm diameter, 600 mm length and 50 mm insulation thickness).

The silencer’s specifics are documented in Table 10.

Sound Silencer	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**	**8 kHz**
VENTS SRF 160/600	3 dB	7 dB	12 dB	20 dB	25 dB	24 dB	10 dB	12 dB
VENTS SR 160/600	2 dB	4 dB	8 dB	17 dB	33 dB	11 dB	7 dB	7 dB

Table 10: Power response at various frequencies with manufacturer recommended acoustic silencer

Appropriate acoustic silencers for the outdoor air and exhaust air sides must be dimensioned according to local requirements.

3 Summary of the Essential Energetic Properties of the Tested Appliance

The appliance features an effective heat recovery rate of 79 %.

The airtightness testing demonstrated that internal and external leakages of the appliance fulfil the limit of 3 % of the nominal volumetric airflow.

With an electrical efficiency of 0.27 W/(m³/h) (mean value), the appliance does not exceed the PHI mandated limit of 0.45 Wh/m³.

The measured standby power consumption of this appliance is 5.3 W and therefore does not comply with the target value of 1 W. In order to avoid electrical power consumption in times when the unit is switched off, an additional switch could be installed, to separate the unit from the power supply completely.

The measurement of frost protection was carried out at the upper airflow range and at an outdoor air temperature of -15 °C. The measurement shows, that by using of an additional exnternal electrical preheater NKP-160-1.7-1 with a nominal power of 1700 W as a frost protection, the heat exchanger and all other functions are not affected by freezing.

At an outdoor air temperature of -10.0 °C, the supply air temperature was 18.0 °C (measured value) and the comfort criterion is therefore met. An additional external electrical preheater was used during testing in order to meet this criterion.

The sound level of the device in an installation room with an equivalent room absorption area of 4 m² was 46.9 dB(A) at an airflow rate of 279 m³/h and exceeds the limit value of 35 dB(A). Therefore the unit should be installed so that it is acoustically separated from living areas.