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Ventilation for Buildings — Performance testing of components for residential buildings — Multifunctional balanced ventilation units for single family dwellings, including heat pumps

bsi.

National foreword

This British Standard is the UK implementation of EN 16573:2017.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Ventilation for Buildings - Performance testing of components for residential buildings - Multifunctional balanced ventilation units for single family dwellings, including heat pumps

Ventilation des bâtiments - Essais de performance des composants pour les bâtiments résidentiels - Centrales de ventilation double flux multifonctions pour les logements individuels, comprenant des pompes à chaleur

Lüftung von Gebäuden - Leistungsprüfung von Bauteilen für Wohnbauten - Multifunktionale Zu-/Abluft-Lüftungseinheiten für Einzelwohnungen, einschließlich Wärmepumpen

This European Standard was approved by CEN on 22 July 2016.

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European foreword

This document (EN 16573:2017) has been prepared by Technical Committee CEN/TC 156 “Ventilation for buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2017, and conflicting national standards shall be withdrawn at the latest by August 2017.

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1 Scope

This European Standard specifies the laboratory test methods and test requirements for aerodynamic, energy rating and acoustic performance, of multifunctional balanced units intended for use in a single dwelling.

In the case of units consisting of several parts, this standard applies only to those designed and supplied as a complete package with the mount instructions.

It covers units that contain at least, within one or more casing:

— supply and exhaust air fans;

— air filters

— common control system;

and one or more of the additional components:

— air to water heat pump;

— air to air heat pump;

— air-to-air heat exchanger.

Units including only an air to air heat exchanger and/or an exhaust air to supply air heat pump are covered by EN 13141-7.

A non-exhaustive list of possible configurations of multifunctional units covered by this standard is given in Clause 5.

The standard does not cover the thermal aspects of humidity transfer in the air-to-air heat exchanger.

This standard does not deal with non-ducted units on supply and extract air side.

This standard does not deal with collective units (centralized or semi-centralized systems)

These multifunctional balanced units can be connected to ground heat exchanger for air preheating, solar collector or other heating systems. This standard does not cover the testing with these additional components.

This standard does not cover units including combustion engine driven compression heat pumps and sorption heat pump.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12102, *Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling - Measurement of airborne noise - Determination of the sound power level*

EN 12792, *Ventilation for buildings - Symbols, terminology and graphical symbols*

EN 13141-7:2010, *Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings*

EN 14511 (all parts), *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*

EN 16147, *Heat pumps with electrically driven compressors - Testing and requirements for marking of domestic hot water units*

EN ISO 5135, *Acoustics - Determination of sound power levels of noise from air-terminal devices, air-terminal units, dampers and valves by measurement in a reverberation room (ISO 5135)*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12792, EN 13141-7, EN 14511-1 and EN 16147, and the following apply.

3.1.1
declared maximum air volume flow
maximum of the removed or fresh air volume flow corresponding to the declared total pressure of the unit at the maximum setting, without any recirculation, for standard air conditions (20 °C, 101 325 Pa)

[SOURCE: EN 13141-7:2010, 3.1.4, modified — The beginning of the definition has been redrafted and the expression "without any recirculation" has been added.]

3.1.2
declared total pressure difference
total pressure difference between the outlet and the inlet of the unit, without any recirculation, declared by the manufacturer, and corresponding to 100 Pa or to a lower total pressure if the intended use declared by the manufacturer is less than 100 Pa

[SOURCE: EN 13141-7:2010, 3.1.6, modified — The original term was "Ptud/2" and it was defined with the beginning of the present definition.]

3.1.3
multifunctional balanced ventilation unit
unit intended for use in a single family dwelling to primary provide balanced ventilation and in addition heating and/or cooling and/or hot water production and contains at least, within one or more modular casing supply and exhaust air fans, air filters, common control system and one more of the additional components, air to water heat pump, air to air heat pump, air-to-air heat exchanger

3.1.4
hydronic heating/cooling
heating or cooling supplied by a water or brine circuit

3.1.5
air heating/cooling
heating or cooling supplied by an air stream

3.1.6
air supply free cooling
recovering of cooling energy produced by the heat pump while producing hot water

Note 1 to entry: Hot water has priority.

3.1.7
reference fresh air volume flow
fresh air volume flow $q_{V,ref,fresh}$ at the reference point defined at $p_{tUd/2}$ and 70 % of declared maximum air volume flow

3.2 Symbols

ODA, 21	Outdoor Air
SUP, 22	Supply Air
RCA,	Recirculation air (additional airflow for example for air heating or air cooling function)
ETA, 11	Extract Air
EHA, 12	Exhaust Air
OEA	Outdoor to Exhaust Air (additional airflow for example to raise the thermal capacity of the heat pump)

List of symbols

P	capacity or power input, in kW
p_{tUd}	declared total pressure, in Pa
Q	thermal energy, in kWh
t	time duration, in s or in h
W	electrical work, in kWh
h	specific enthalpy in kJ/kg
q_{m}	mass flow rate, in kg/s
q_{v}	volume flow rate, in m³/h
T	temperature in °C

List of indices used for the individual and combined functions in the symbols:

AC	supply Air Cooling
AH	supply Air Heating
AFC	supply air free cooling
C	cooling
WH	(Domestic) hot water production
el	electric
H	heating
HC	Hydronic Cooling
HH	Hydronic Heating
HR	heat recovery
V	Ventilation
es	stand by

The combination of indices indicates simultaneous operation of the corresponding functions.

4 Functions

A multifunctional ventilation unit provides ventilation for single dwelling as a leading function. This means, that all additional functions:

— hydronic heating/air heating;

— hydronic cooling/air cooling;

— hot water production;

shall be operating only when ventilation is operating.

The multifunctional ventilation unit shall be designed and controlled to provide the hygienic ventilation rate for a dwelling or part of a dwelling. That means for example, that the ventilation rate shall not be controlled according to the hydronic heating demand.

If specified by the manufacturer, the unit may use an additional outdoor air volume flow, to provide a higher thermal capacity if needed. This leads to two alternatives:

1) The higher outdoor air volume flow (outdoor exhaust air) does not affect the ventilation function (fresh air and removed air).

   Additional tests shall be performed according to the declaration of manufacturer. No further correction needed

2) The air volume flows for ventilation (fresh air and/or removed air) increase. In this case the air volume flows shall be measured and documented as a percentage of reference air volume flow.

NOTE This may be needed to allow a correction of system performance according to the EPBD calculation.

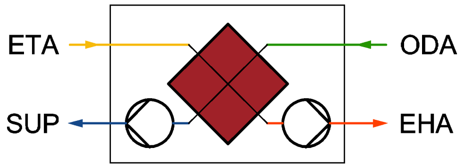
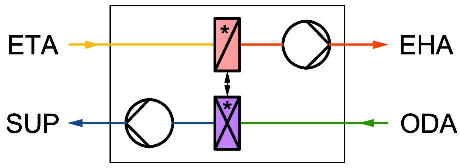
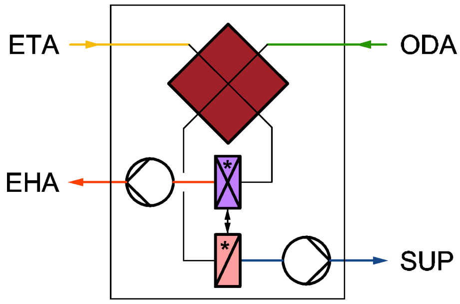
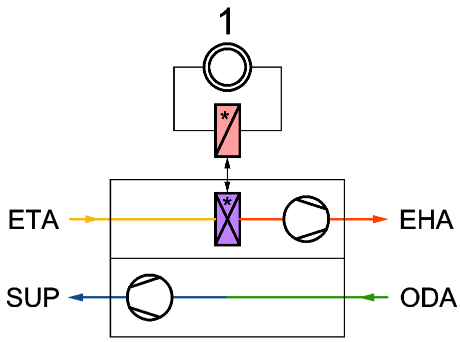
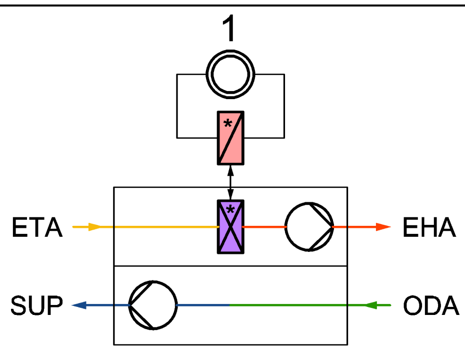
5 Description and testing of multifunctional units

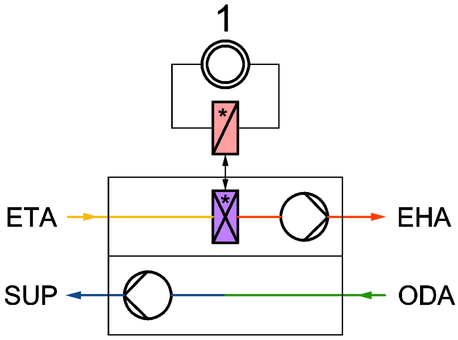
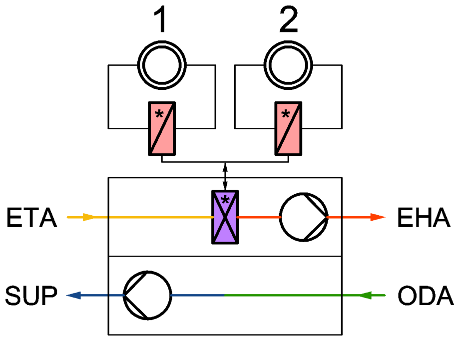
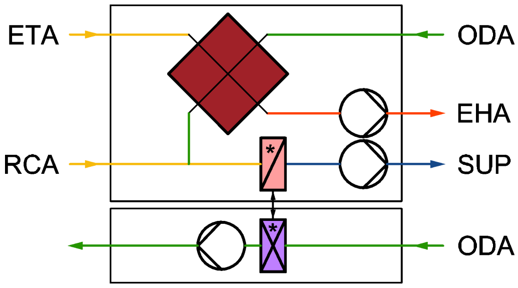
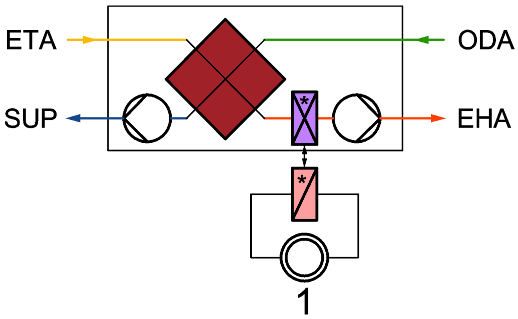
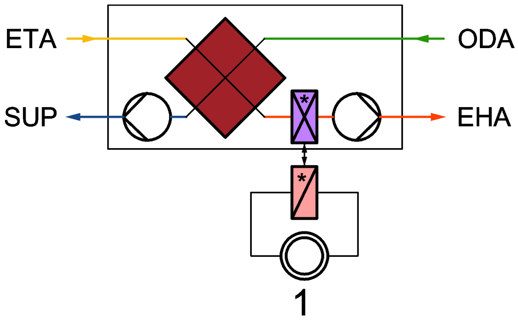
Table 1 shows a non-exhaustive list of relevant combinations of multifunctional units with the corresponding applicable test procedures according to Clause 6, 7 and 8 for thermal and acoustic performance.

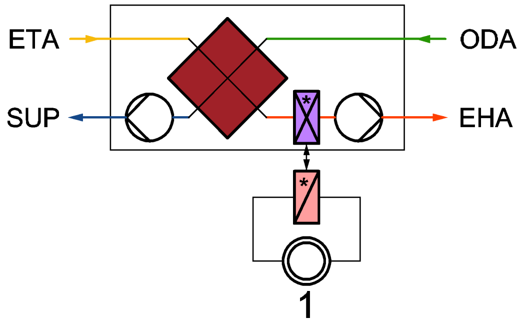
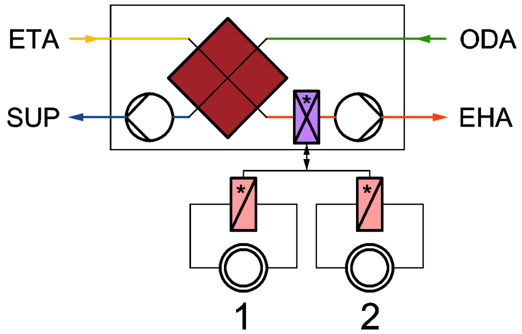
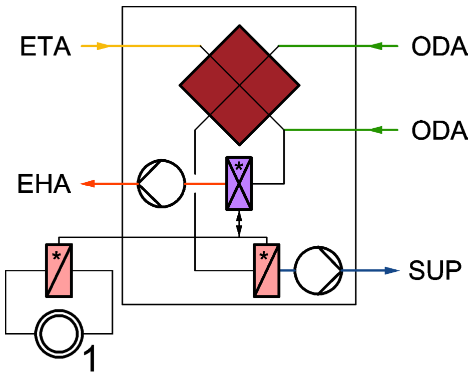
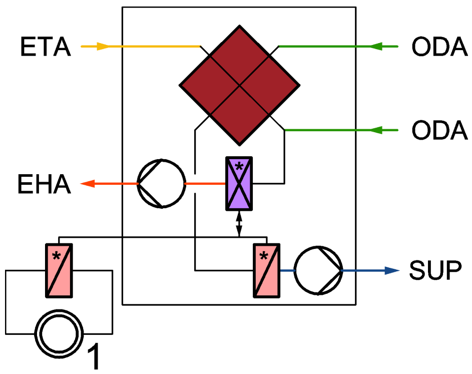
The leading function is ventilation at reference air volume flow. The heat pump can use any air source: outdoor air, exhaust air, recirculation air or any mixture of these.

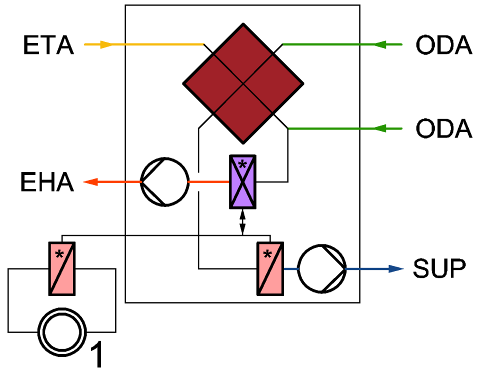
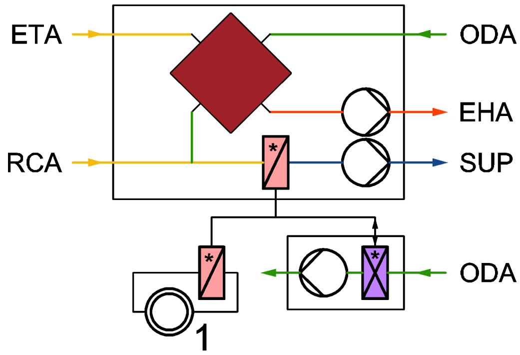
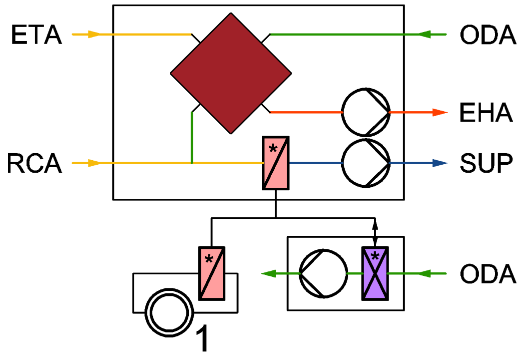
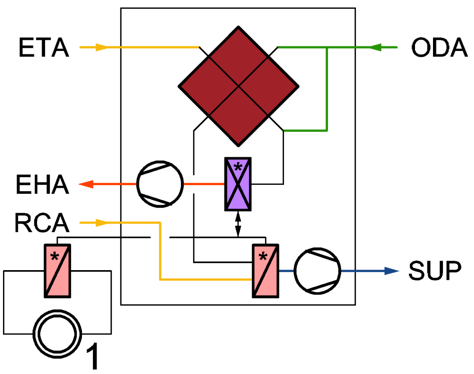
For testing the unit shall be installed according to the manufacturer instructions given in the installation manuals unless otherwise specified in the referred standards for specific tests.

Table 1 — Units and test procedures

	Description Balanced ventilation including:	**Function scheme**	**Test procedure (sub)clause:**
1.	+ Air to air heat exchanger		Fully covered by EN 13141–7
2.	+ Air to air heat pump		Fully covered by EN 13141–7
3.	+ Air to air heat exchanger + Air to supply air heat pump		Fully covered by EN 13141–7
4.	+ Air to water heat pump for the domestic hot water production		Clause 6 7.4 8.3 8.7 **Key** 1 domestic hot water
5.	+ Air to water heat pump for hydronic heating or cooling		Clause 6 7.5 8.3 8.4 **Key** 1 water heating or cooling

	Description Balanced ventilation including:	**Function scheme**	**Test procedure (sub)clause:**
6.	+ Air to water heat pump for alternative: – hydronic heating and cooling – domestic hot water production		Clause 6 7.4 7.5 8.3 8.4 **Key** 1 water heating or cooling/domestic hot water
7.	+ Air to water heat pump for simultaneous: – hydronic heating or cooling – domestic hot water		Clause 6 7.8 8.3 8.6 **Key** 1 water heating or cooling 2 domestic hot water
8.	+ air to air heat exchanger + Air source heat pump for heating or cooling with recirculating air		Clause 6 7.3 7.6 8.3 8.5
9.	+ air to air heat exchanger + Air to water heat pump for domestic hot water production		Clause 6 7.3 7.4 8.3 8.7 **Key** 1 domestic hot water
10.	+ air to air heat exchanger + Air to water heat pump for hydronic heating or cooling		Clause 6 7.3 7.5 8.3 8.4 **Key** 1 water heating or cooling

	Description Balanced ventilation including:	**Function scheme**	**Test procedure (sub)clause:**
11.	+ air to air heat exchanger + Air to water heat pump for alternative: – hydronic heating or cooling – domestic hot water production		Clause 6 7.3 7.4 7.5 8.3 8.4 **Key** 1 water heating or cooling/domestic hot water
12.	+ air to air heat exchanger + air to water heat pump for simultaneous: – hydronic heating or cooling – domestic hot water production		Clause 6 7.3 7.8 8.3 8.4 **Key** 1 water heating or cooling 2 domestic hot water
13.	+ air to air heat exchanger + Air source heat pump for: – supply air heating or cooling – for alternative: – hydronic heating or cooling – domestic hot water production		Clause 6 7.3 7.6 7.7 7.8 8.3 8.6 **Key** 1 water heating or cooling/ domestic hot water
14.	+ air to air heat exchanger + Air source heat pump for: – supply air heating or cooling – domestic hot water production		Clause 6 7.3 7.8 8.3 8.5 **Key** 1 domestic hot water

	Description Balanced ventilation including:	**Function scheme**	**Test procedure (sub)clause:**
15.	+ air to air heat exchanger + Air source heat pump for: – supply air heating or cooling – for simultaneous: – hydronic heating – domestic hot water production		Clause 6 7.3 7.6. 7.7 7.8 8.3 8.6 **Key** 1 water heating/ domestic hot water
16.	+ air to air heat exchanger + Air source heat pump for: – supply air heating or cooling – domestic hot water production With recirculation air		Clause 6 7.3 7.7 7.8 8.3 8.5 **Key** 1 domestic hot water
17.	+ air to air heat exchanger + Air source heat pump for: – supply air heating or cooling – for alternative: – domestic hot water production – hydronic heating or cooling With recirculation air		Clause 6 7.3 7.6 7.7 7.8 8.3 8.6 **Key** 1 water heating or cooling/Domestic hot water
18.	+ air to air heat exchanger + Air source heat pump for: – supply air heating or cooling and simultaneous or alternative domestic hot water production With recirculation air		Clause 6 7.3 7.4 7.6 7.9 8.3 8.5 **Key** 1 domestic hot water

NOTE EHA – Exhaust air, ETA – Extract air, ODA - Outdoor air, RCA – Recirculation air, SUP – Supply air.

6 Performance testing of aerodynamic characteristics

6.1 Leakages

6.1.1 Test method

Pressure testing method applies to classify leakages of the unit as defined in EN 13141-7.

For internal leakage, if the pressure method is not applicable, e.g. units using recirculation air, the unit shall be tested as category 2 heat exchanger (tracer gas method) in accordance with EN 13141-7.

6.1.2 Requirements

To set the declared maximum air volume flow, the declared total pressure shall correspond to 100 Pa, or to a lower total pressure if the intended use declared by the manufacturer is less than 100 Pa.

The declared maximum air volume flow shall be equal to the smaller in case the supply and extract air volume flows are different.

In addition, to assess correctly the thermal performance, aerodynamic characteristics shall be tested before or together with any thermal characteristics testing.

Aerodynamic characteristics shall include:

— external leakage or total recirculated fraction in supply air;

— internal leakage or recirculated fraction from extract to supply air or total recirculated fraction in supply air.

The tests for air flow/pressure curve and thermal performances shall not be made because of measurement uncertainty when leakages according to 6.1.1 are too high. The external and internal leakage of the unit shall comply with Class A1 or A2, B1 or B2, C1 or C2 as defined in EN 13141-7 depending on the test method.

6.2 Air flow/pressure curve

Tests shall be performed according to EN 13141-7 with the following parameters:

1) Ventilation function only:

   That means the heat pump is not operating. Any additional fan is off and any bypass damper is closed ($q_{\mathrm{V,\,OEA}}$ = 0 and $q_{\mathrm{V,\,RCA}}$ = 0) or any other recirculation air flow is off.

2) Ventilation function with additional flow rates:

   In case of additional air flow rates for the other functions the pressure curves shall be repeated with different damper positions and/or additional fans speeds (minimum 3 settings in case of stepless control). If the ventilation mode can be set independently from the recirculation mode, then the ventilation setting is the intermediate setting as defined in EN 13141-7 (see Clause 1 above) During this test, pressure at each connection shall respect the repartition of 1/3 on the outside and 2/3 on the inside.

6.3 Reference point for aerodynamic conditions

For all the thermal tests of the multifunctional unit, the reference fresh air volume flow point shall be used.

In addition, if the multifunctional ventilation unit is operating with an additional outdoor air flow at the evaporator (heating mode)/condenser (cooling mode) side, this additional air flow rate shall also be specified by the manufacturer.

In addition, if the multifunctional ventilation unit is operating with an additional recirculation air flow at the condenser (heating mode)/evaporator (cooling mode) side, this additional air flow rate shall also be specified by the manufacturer. This situation is possible only if the recirculated air is separated from extract air as the following Figure 1

Extract air is coming from kitchen, toilets, bathroom and shall not be recirculated in the house for hygienic reasons

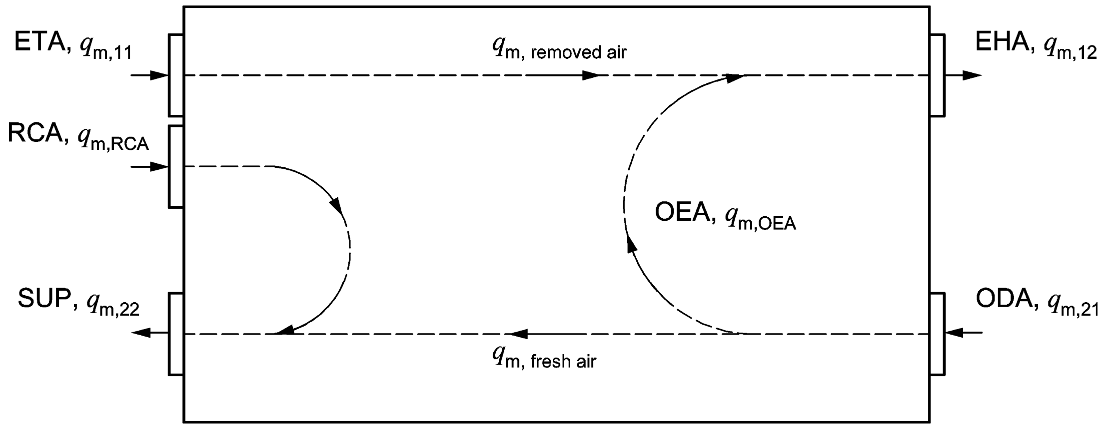


Figure 1 — Definition of reference fresh air volume flow

The reference fresh air volume flow $q_{V,\text{ ref, fresh}}$ point shall be defined at p_{tUd} /2 and 70 % of declared maximum air volume flow. If this point cannot be set, pressure shall remain at p_{tUd} /2 and airflow shall be adjusted just over (see EN 13141-7).

Depending on the configurations as descripted in Figure 2 to Figure 5 (see 7.2) the reference fresh air volume flow $q_{V,\text{ ref, fresh I}}$ is measured directly or calculated

Maximum air volume flow point shall be adjusted at p_{tUd} and declared maximum air volume flow, without any recirculation. If this point cannot be set, pressure shall be adjusted just over p_{tUd}.

Minimum air volume flow point shall be adjusted at p_{tUd} /2 and declared minimum air volume flow.

6.4 Pressure drop setting

The pressure drop is set in line with EN 13141-7. Assuming a quadratic relation between volume flow and pressure drop, the ductwork is designed for a pressure drop of p_{tUd} at $q_{V\max}$. This approximately results in a pressure drop of p_{tUd} /2 at 0,7 * $q_{V\max}$. This pressure is applied 1/3 on the outside and 2/3 on the inside.

Adapted to the described cases, it has to be regarded that there can be varying volume flows coming from the recycling air circuits. In order to compare results with EN 13141-7 and assuming that ductwork is designed for maximum recycling volume flows, pressure at each connection shall be set at the same value with or without recirculation, . An example is given in Table 2.

Table 2 —Pressure drop settings for each connection, example with p_{tud} = 100 Pa

Connection	Pressure at maximum air volume flow	Pressure at maximum air volume flow without recycling	Pressure at reference air volume flow with recycling	Pressure at reference air volume flow without recycling
ETA	66 Pa at $q_{m1,1\ max,w/recyc}$	66 Pa x $\left(\frac{q_{m1,1\ max,w/o\ recyc}}{q_{m1,1\ max,w/\ recyc}}\right)^2$	33 Pa at 0,7 * $q_{m1,1\ max,w/recyc}$	33 Pa x $\left(\frac{q_{m1,1\ max,w/o\ recyc}}{q_{m1,1\ max,w/\ recyc}}\right)^2$ at 0,7 * $q_{m1,1\ max}$
EHA	33 Pa at $q_{m,12\ max,w/recyc}$	33 Pa x $\left(\frac{q_{m1,2\ max,w/o\ recyc}}{q_{m1,2\ max,w/\ recyc}}\right)^2$	17 Pa at 0,7 * $q_{m,12\ max,w/recyc}$	17 Pa x $\left(\frac{q_{m1,2\ max,w/o\ recyc}}{q_{m1,2\ max,w/\ recyc}}\right)^2$ at 0,7 * $q_{m1,2\ max}$
ODA	33 Pa at $q_{m2,1\ max,w/recyc}$	33 Pa x $\left(\frac{q_{m2,1\ max,w/o\ recyc}}{q_{m2,1\ max,w/\ recyc}}\right)^2$	17 Pa at 0,7 * $q_{m2,1\ max,w/recyc}$	17 Pa x $\left(\frac{q_{m2,1\ max,w/o\ recyc}}{q_{m2,1\ max,w/\ recyc}}\right)^2$ at 0,7 * $q_{m2,1\ max}$
SUP	66 Pa at $q_{m2,2\ max,w/recyc}$	66 Pa x $\left(\frac{q_{m2,2\ max,w/o\ recyc}}{q_{m2,2\ max,w/\ recyc}}\right)^2$	33 Pa at 0,7 * $q_{m2,2\ max,w/recyc}$	33 Pa x $\left(\frac{q_{m2,2\ max,w/o\ recyc}}{q_{m2,2\ max,w/\ recyc}}\right)^2$ at 0,7 * $q_{m2,2\ max}$
RCA	33 Pa at $q_{mRCA\ max,w/recyc}$		17 Pa at 0,7 * $q_{m,RCA}$	

7 Performance testing of thermal characteristics

7.1 General

Measurement period and stabilization criteria for measurements on the air side shall be made according to EN 13141-7.

Measurement and stabilization criteria for any measurement when heat pump is running for hydronic heating or hydronic cooling according to EN 14511 (all parts). That means that all energy quantities are values measured over the data acquisition period.

The unit shall be tested according to the test procedure that describes the most comprehensive combination of functions provided by the unit. The overall performance and the performance of each function individually are calculated from this test.

7.2 Air flow settings and uncertainty

7.2.1 General

The removed air mass flow rate is set as the reference air volume flow as determined in 6.3.

Depending on the operation point, the fresh air mass flow can be calculated (see EN 13141-7).

Balancing between $q_{m, \text{fresh air}}$ and $q_{m, \text{removed air}}$ is conducted only once for each configuration of air flows, at the mandatory heating point (7 °C/20 °C) for all heating tests, with the heat pump out of operation.

Where applicable, balancing between $q_{m, \text{fresh air}}$ and $q_{m, \text{removed air}}$ is conducted only once for each configuration of air volume flows, at the mandatory cooling point (35 °C/27 °C) for all cooling tests, with the heat pump out of operation

Any balancing dampers are locked firmly to prevent creep during the duration of the remaining tests. At other outdoor temperatures, the balancing can be expected to deteriorate very slightly due only to changes in the density of air in the supply and extract streams.

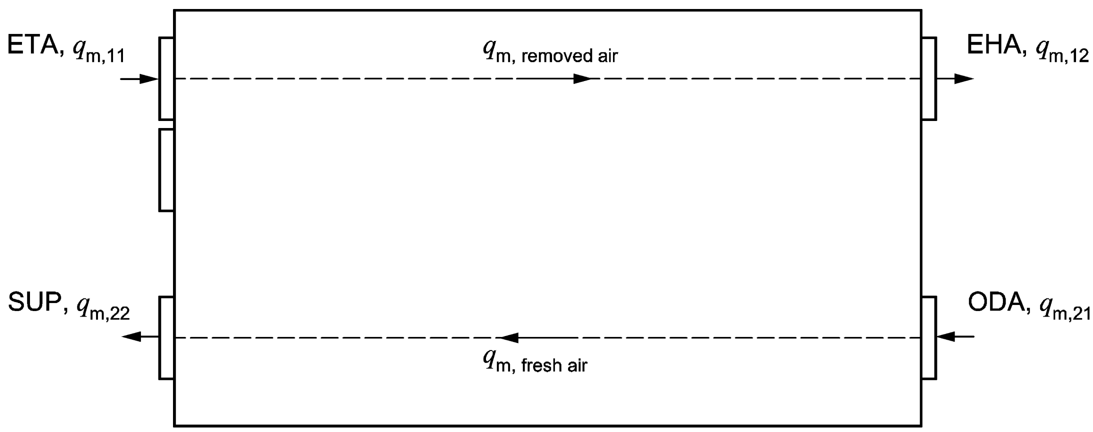
Thermal tests shall be performed with and/or without the additional outdoor air ($q_{m, \text{OEA}}$) or recirculated air ($q_{m, \text{RCA}}$) as specified by the manufacturer. The temperature conditions of recirculation air are the same as for extract air.

The total uncertainty of the airflow measurement shall not exceed ± 3 %.

The unit is declared unbalanced (see EN 13141-7) if the difference between the two air flows is greater than 10 %.

7.2.2 Configuration without any recirculation

See Figure 2:



Key

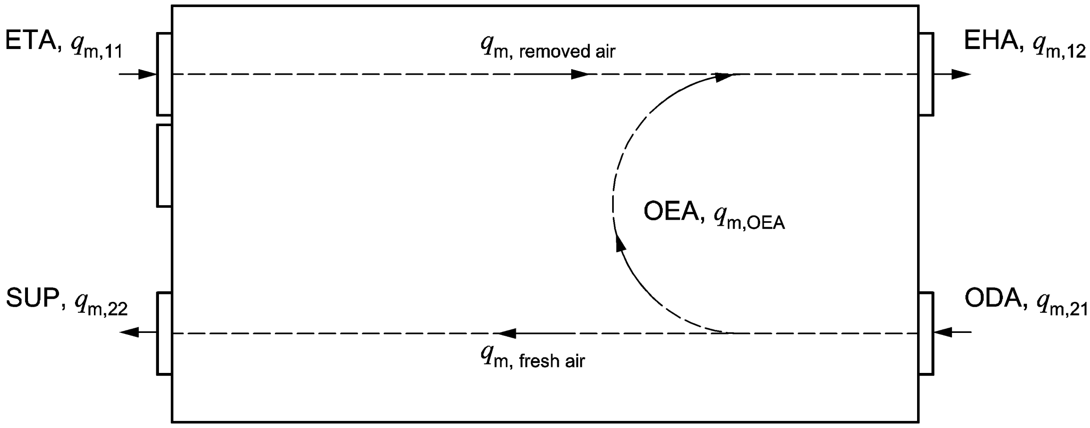
$q_{m,\text{fresh air}} = q_{m,22} = q_{m,\text{SUP}}$

$q_{m,\text{removed, air}} = q_{m,11} = q_{m,\text{ETA}}$

Figure 2 — Reference fresh/removed air volume flow without any circulation

7.2.3 Configuration with recirculation from outdoor air to exhaust air

See Figure 3:



Key

$q_{m,\text{fresh air}} = q_{m,22} = q_{m,SUP}$

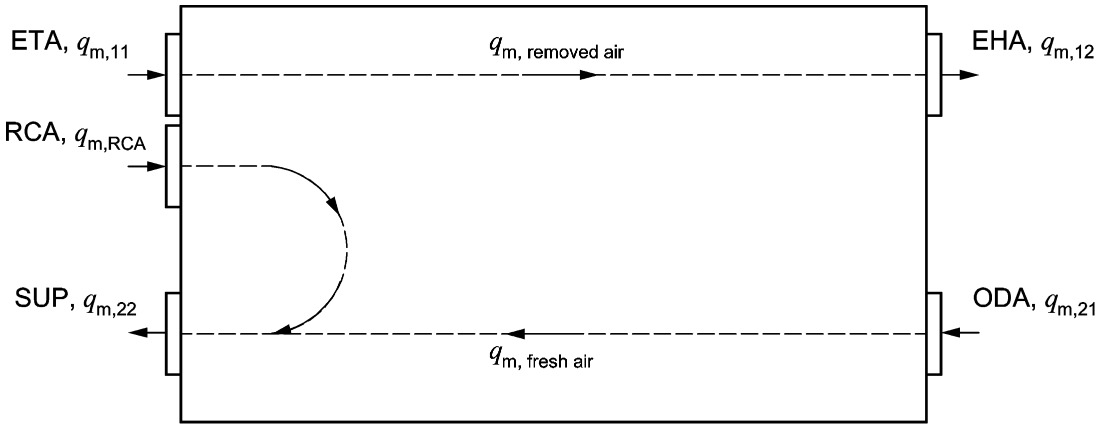
$q_{m,\text{removed, air}} = q_{m,11} = q_{m,ETA}$

$q_{m,OEA =} = q_{m,EHA} - q_{m,\text{removed air}} = q_{m,12} - q_{m,11}$

Figure 3 — Reference fresh/removed air volume flow with recirculation from outdoor air to exhaust air

7.2.4 Configuration with recirculation from extract to supply air

See Figure 4:



Key

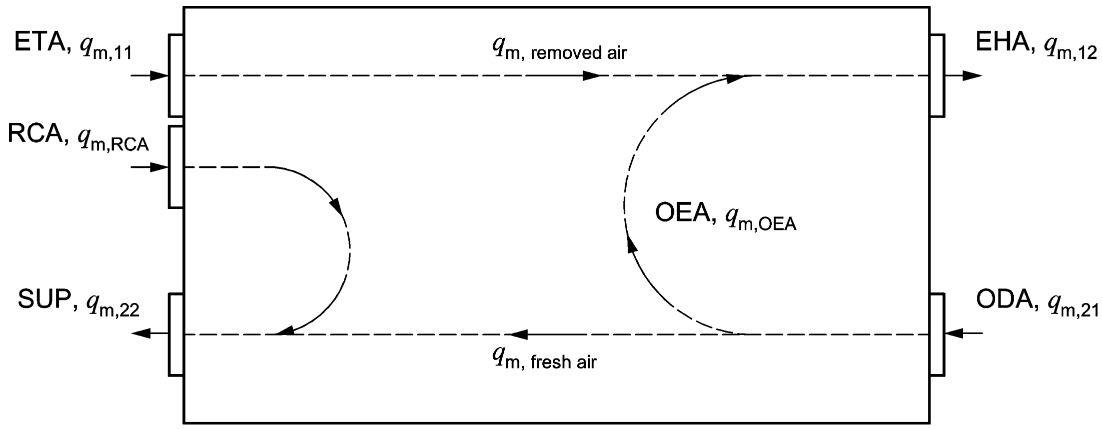
$q_{m,\text{fresh air}} = q_{m,21}$

$q_{m,\text{removed air}} = q_{m,11}$

Figure 4 — Reference fresh/removed air volume flow with recirculation from extract to supply air

7.2.5 Configuration with two recirculations

See Figure 5:



Key

$q_{m,fresh air} = q_{m,22} - q_{m,RCA}$

$q_{m,removed, air} = q_{m,11} = q_{m,ETA}$

$q_{m,OEA} = q_{m,EHA} - q_{m,removed air} = q_{m,21} - q_{m,11}$

Figure 5 — Reference fresh/removed air volume flow with two recirculations

7.3 Ventilation heat recovery performance

7.3.1 General

The tests shall be performed when the multifunctional unit is able to provide simultaneously ventilation and heat recovery by air to air heat exchanger.

7.3.2 Air flow test conditions

The extract air volume flow rate and the supply air volume flow rate are set as the reference air volume flow as determined in 6.3. Any additional fans are off and any bypass damper is closed ($q_{V,OEA}$ = 0 and $q_{V,RCA}$ = 0).

Thermal tests shall be performed at the temperature conditions accordingly to the type and use of the heat recovery device (see Table 3):

— Point 1 is a dry air test, mandatory for all units;

— Point 2 is an intermediate point, mandatory for units category II and optional for category I for condensation;

— Point 3 is an optional point intended to show extreme condensation conditions;

— Point 4 is a mandatory point for cold climate if the unit is designed to operate at outdoor temperature below –15 °C;

— Point 5 is a mandatory point if the multifunctional unit shall operate in cooling mode and the heat exchanger is not bypass;

— Point 6 and 7 are optional points according to the declaration of the manufacturer.

If condensation occurs, then the condensation test shall also be performed.

Table 3 — Temperature conditions

Test point n°	**Exhaust air and recirculation air**		**Outside air**	
	Dry bulb temp. θ_{11} °C	**Wet bulb temp.** θ_{w11} °C	**Dry bulb temp.** θ_{21} °C	**Wet bulb temp.** θ_{w21} °C
1 – mandatory	20	12	7	6
2 – optional (mandatory for category II)	20	15	2	1
3 – optional	20	12	−7	−8
4 – optional (mandatory for cold climate units)[a]	20	12	−15	–
5 – cooling mode if applicable	27	19	35	24
6 – optional for cooling mode	27	19	27	19
7 – optional for cooling mode	29	19	46	24

[a] If the unit is designed to operate at outdoor temperature below −15 °C then the cold climate test shall be performed.

Following a test for cold climates, the unit shall be visually inspected. This inspection shall be carried out immediately after defrosting or other similar action. Observations shall be noted in the test report as to the influence of freezing and condensation on the operation of the heat recovery device, and the condensation water draining.

7.3.3 Test procedure

Test procedure shall be performed according to EN 13141-7.

The heat pump is switched off and only the ventilation system is operating, i.e. fans and heat recovery heat exchanger.

Test is performed with the air flow settings defined in 7.2 and the temperatures defined in Table 3.

Once steady-state conditions are obtained, data are recorded during 15 min.

The measurements to be recorded are specified in Table 4 of 7.3.4.

7.3.4 Data to be recorded

The data to be recorded for the thermal capacity tests are given in Table 4. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 4 — Data to be recorded

Measured or calculated quantity	**Symbol**	**Unit**
Extract air (ETA)		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m³/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Dry bulb temperature	$T_{d,22}$	°C
Wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	m³/h
mass flow rate	$q_{m,22}$	kg/s
Outdoor air (ODA)		
Dry bulb temperature	$T_{d,21}$	°C
Wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m³/h
mass flow rate	$q_{m,21}$	kg/s
Exhaust air (EHA)		
Dry bulb temperature	$T_{d,12}$	°C
Wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m³/h
mass flow rate	$q_{m,12}$	kg/s
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Ventilation measurements		
Power input	$P_{el,V}$	kW
Heat recovery capacity	P_{HR}	kW
Temperature ratio (supply air)	$\eta_{\theta,su}$	–
Temperature ratio (exhaust air)	$\eta_{\theta,ex}$	–
Humidity ratio (supply air)	$\eta_{x,su}$	–

7.3.5 Calculations

Temperature and humidity ratios shall be calculated according to EN 13141-7.

In addition the energy recovery Q_{HR} shall be calculated as follows:

$$Q_{HR} = q_{m,22} \times (h_{22} - h_{21}) \tag{1}$$

in kW, with h expressed in kJ/kg.

In case of bypass of the heat exchanger then $Q_{HR} = 0$.

7.4 Ventilation and domestic hot water production

7.4.1 General

The tests shall be performed when the multifunctional ventilation unit is able to provide simultaneously ventilation and domestic hot water production.

The test shall be performed according to EN 16147 for the hot water production with the additional specifications as described in 7.3.2.

The manufacturer shall declare the tapping cycle to be used according to EN 16147.

During the whole test, the ventilation function is running at reference air volume flow according to 7.2 and 7.3.

7.4.2 Test procedure

7.4.2.1 General

The test procedure can be described as a series of phases corresponding to different measurements.

The ventilation, being the primary function of the multifunctional units, it is under operation during all phases of the test.

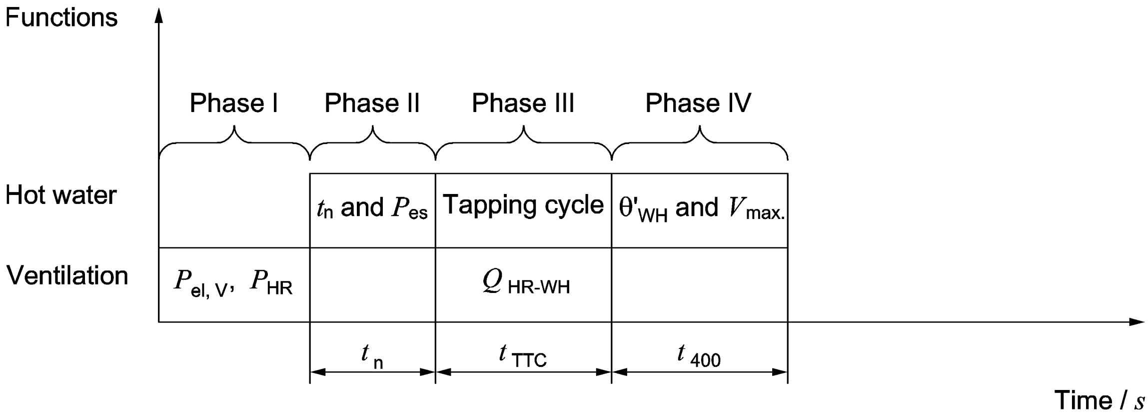


Figure 6 — Test phases for ventilation and domestic hot water production

7.4.2.2 Phase I: Starting conditions and ventilation measurements

The test is started with the ventilation only and performed as defined in 7.2 and 7.3. If the unit does not include a heat recovery heat exchanger, only the electrical power input of the unit $P_{el, V}$ is measured.

7.4.2.3 Phase II: Heating up period and stand by power measurement

The initial state for the storage tank is as defined in EN 16147.

The heating up period t_h, and the stand-by power input P_{es}, as defined in EN 16147 shall be measured.

7.4.2.4 Phase III: Hot water performances measurement

The tapping cycle test shall start directly after a shut off of the heat pump by the hot water thermostat situated in the tank.

The test is performed according to EN 16147 with the tapping cycle chosen by the manufacturer.

7.4.2.5 Phase IV: Reference hot water temperature and maximum volume of usable hot water measurements

The test is performed according to EN 16147.

The reference hot water temperature, θ'_{WH} and the maximum volume of usable water, V_{max} shall be calculated according to EN 16147.

7.4.3 Data to be recorded

The data to be recorded for the thermal capacity tests are given in Table 5. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 5 — Data to be recorded

Measured or calculated quantity	**Symbol**	**Unit**
Extract air (ETA)		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m^3/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Dry bulb temperature	$T_{d,22}$	°C
Wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	m^3/h
mass flow rate	$q_{m,22}$	kg/s
Recycled air (RCA), where applicable		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v, RCA}$	m^3/h
mass flow rate	$q_{m, RCA}$	kg/s
Outdoor air (ODA)		
Dry bulb temperature	$T_{d,21}$	°C
Wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m^3/h
mass flow rate	$q_{m,21}$	kg/s
Exhaust air (EHA)		
Dry bulb temperature	$T_{d,12}$	°C

Measured or calculated quantity	Symbol	Unit
Wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m^3/h
mass flow rate	$q_{m,12}$	kg/s
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Phase I: Ventilation measurements		
Power input	$P_{el,V}$	kW
Heat recovery capacity	P_{HR}	kW
Phase II: Heating up period and stand by power measurement		
Incoming cold water temperature	θ_{WC}	°C
Heating up period	t_h	s
Energy input	W_{es}	kWh
Test duration for Standby power input	t_{es}	s
Stand by power input	P_{es}	kW
Phase III: Hot water production performance measurements		
Incoming cold water temperature	θ_{WC}	°C
Time duration of the test cycle	t_{TTC}	h
Overall energy of the whole tapping cycle	Q_{TC}	kWh
Total energy input	$W_{el,\ V\text{-}WH}$	kWh
Energy recovery during the whole tapping cycle (when applicable)	$Q_{HR\text{-}WH}$	kWh
Phase IV: Reference hot water temperature and maximum volume of usable hot water measurements		
Incoming cold water temperature	θ_{WC}	°C
Tapping duration	t_{40}	s
Volume flow rate of hot water during tapping	V_{tap}	kg/h
Reference hot water temperature	θ'_{WH}	°C
Maximum volume of usable hot water	V_{max}	m^3

7.4.4 Performance rating calculations

7.4.4.1 Overall performance

$$COP_{V-WH} = \frac{Q_{TC} + Q_{HR-WH}}{W_{el,V-WH} + (24 - t_{TTC}).P_{es}} \tag{2}$$

Because the time span of the test cycles differs, the electrical energy for recovering the heat losses of the tank shall be corrected to a duration of 24 h, according to EN 16147;

where

$$Q_{HR-WH} = P_{HR} \times t_{TTC} \tag{3}$$

$W_{el,V\text{-}WH}$ includes electrical backup consumption as described in the EN 16147.

P_{es} calculated according to Formula (4).

7.4.4.2 Domestic hot water stand-by losses

The electrical power input due to the ventilation function $P_{el,V}$, shall be subtracted from the measured electrical energy W_{es}, to calculate the stand-by power input P_{es}.

$$P_{es} = \frac{W_{es}}{t_{es}} \times 3600 - P_{el,V} \tag{4}$$

where

P_{es} stand-by power input, in kW

W_{es} energy input during the last on/off cycle, in kWh

t_{es} duration of the last on/off cycle of the heat pump, in s

$P_{el,V}$ Power input for ventilation only, in kW

7.4.4.3 Domestic hot water performance

Because the correction due to the heat source fan is already included in the overall energy power input, the correction $W_{el\text{-}Corr}$ as defined in EN 16147 is considered equal to 0.

$$COP_{WH} = \frac{Q_{TC}}{W_{el,V-WH} - W_{el,V} + (24 - t_{TTC}).P_{es}} \tag{5}$$

where

$$W_{el,V} = P_{el,V} \times t_{TTC} \tag{6}$$

7.5 Ventilation with hydronic space heating/cooling

7.5.1 General

The tests shall be performed when the multifunctional ventilation unit is able to provide simultaneously either:

— both ventilation and hydronic heating; or

— both ventilation and hydronic cooling.

The unit shall be installed as specified in EN 14511 (all parts) for the heating/cooling function.

The test shall be performed according to EN 14511 (all parts) with the additional specifications as described in 7.5.2.

During the whole test, the ventilation function is running at reference air volume flow according to 7.2 and 7.3.

7.5.2 Temperature test conditions

The test conditions are derived from those applicable to exhaust air-to-water heat pumps as defined in EN 14511-2.

Heating performance tests shall be made according to Table 6. In addition the manufacturer may declare other water temperature conditions of the hydronic heating system according to the Tables 7 to 9.

If applicable cooling performance tests shall be made according to Table 10. In addition the manufacturer may declare an other water temperature conditions of the hydronic cooling system according to the Table 11.

For each declared temperature conditions the mandatory test point shall at least be measured.

Table 6 — Heating mode for low temperature applications

Test point n°	**Extract air and recirculation air**		**Outdoor air**		**Water**	
	Dry bulb temp. °C	Wet bulb temp. °C	Dry bulb temp. °C	Wet bulb temp. °C	Inlet temp. °C	Outlet temp. °C
1 – mandatory	20	12	7	6	30	35
2 – optional	20	12	2	1	[a]	35
3 – optional	20	12	–7	–8	[a]	35
4 – optional	20	12	12	11	[a]	35
5 – optional	20	12	–15	–	[a]	35

[a] The test is performed with the water flow rate as determined during the mandatory rating test.

Table 7 — Heating mode for medium temperature applications

Test point n°	**Extract air and recirculation air**		**Outdoor air**		**Water**	
	Dry bulb temp. °C	Wet bulb temp. °C	Dry bulb temp. °C	Wet bulb temp. °C	Inlet temp. °C	Outlet temp. °C
1 – mandatory	20	12	7	6	40	45
2 – optional	20	12	2	1	[a]	45
3 – optional	20	12	–7	–8	[a]	45
4 – optional	20	12	12	11	[a]	45
5 – optional	20	12	–15	–	[a]	45

[a] The test is performed with the water flow rate as determined during the mandatory rating test.

Table 8 — Heating mode for high temperature applications

Test point n°	**Extract air and recirculation air**		**Outdoor air**		**Water**	
	Dry bulb temp. °C	Wet bulb temp. °C	Dry bulb temp. °C	Wet bulb temp. °C	Inlet temp. °C	Outlet temp. °C
1 – mandatory	20	12	7	6	47	55
2 – optional	20	12	2	1	[a]	55
3 – optional	20	12	−7	−8	[a]	55
4 – optional	20	12	12	11	[a]	55
5 – optional	20	12	−15	–	[a]	55

[a] The test is performed with the water flow rate as determined during the mandatory rating test.

Table 9 — Heating mode for very high temperature applications

Test point n°	**Extract air and recirculation air**		**Outdoor air**		**Water**	
	Dry bulb temp. °C	Wet bulb temp. °C	Dry bulb temp °C	Wet bulb temp. °C	Inlet temp. °C	Outlet temp. °C
1 – mandatory	20	12	7	6	55	65
2 – optional	20	12	2	1	[a]	65
3 – optional	20	12	−7	−8	[a]	65
4 – optional	20	12	12	11	[a]	65
5 – optional	20	12	−15	–	[a]	65

[a] The test is performed with the water flow rate as determined during the mandatory rating test.

Table 10 — Cooling mode for medium temperature heating applications

Test point n°	**Extract air and recirculation air**		**Outdoor air**		**Water**	
	Dry bulb temp. °C	Wet bulb temp. °C	Dry bulb temp. °C	Wet bulb temp. °C	Inlet temp. °C	Outlet temp. °C
1 – mandatory	27	19	35	24	23	18
2 – optional	27	19	27	19	[a]	18
3 – optional	27	19	46	24	[a]	18

[a] The test is performed with the water flow rate as determined during the mandatory rating test.

Table 11 — Cooling mode for low temperature heating applications

Test point n°	Extract air and recirculation air		Outdoor air		Water	
	Dry bulb temp. °C	Wet bulb temp. °C	Dry bulb temp. °C	Wet bulb temp. °C	Inlet temp. °C	Outlet temp. °C
1 – mandatory	27	19	35	24	12	7
2 – optional	27	19	27	19	[a]	7
3 – optional	27	19	46	24	[a]	7

[a] The test is performed with the water flow rate as determined during the mandatory rating test.

7.5.3 Test procedure

7.5.3.1 General

The test procedure can be described as a series of phases corresponding to different measurements.

The ventilation, being the primary function of the multifunctional units, it is under operation during all phases of the test.

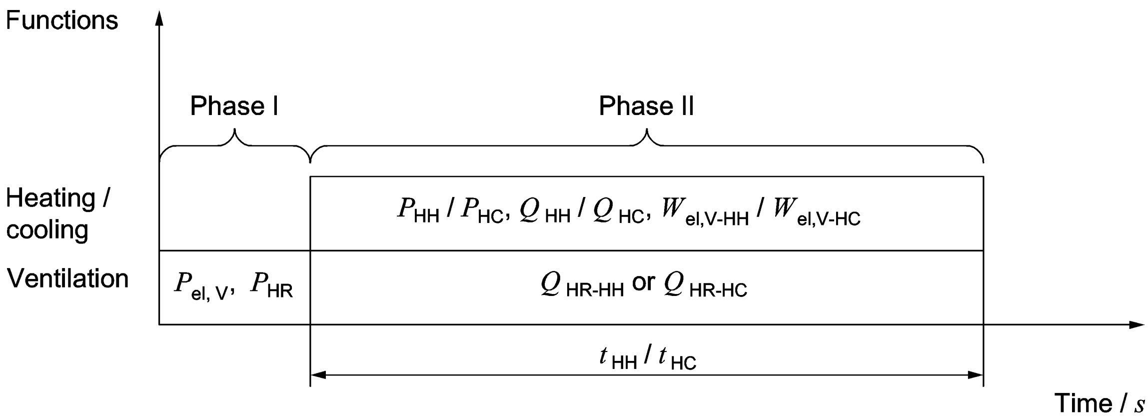


Figure 7 — Test phases for ventilation and hydronic space heating and/or cooling

7.5.3.2 Phase I: Starting conditions and ventilation measurements

The test is started with the ventilation only and performed as defined in 7.2 and 7.3. If the unit does not include a heat recovery heat exchanger, only the electrical power input of the unit $P_{el,V}$ is measured.

7.5.3.3 Phase II: Heating/cooling performance measurements

The heat pump is switched on for the heating/cooling mode and the water temperature conditions given in 7.5.2 for hydronic heating/cooling shall be reached and remained constant without having to alter the set values.

Heating/cooling performance data shall be measured and recorded according to EN 14511 (all parts).

7.5.4 Data to be recorded

The data to be recorded for the thermal capacity tests are given in Table 12. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 12 — Data to be recorded

Measured or calculated quantity	Symbol	Unit
Extract air (ETA)		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m³/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Dry bulb temperature	$T_{d,22}$	°C
Wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	m³/h
mass flow rate	$q_{m,22}$	kg/s
Recycled air (RCA), where applicable		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v, RCA}$	m³/h
mass flow rate	$q_{m, RCA}$	kg/s
Outdoor air (ODA)		
Dry bulb temperature	$T_{d,21}$	°C
Wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m³/h
mass flow rate	$q_{m,21}$	kg/s
Exhaust air (EHA)		
Dry bulb temperature	$T_{d,12}$	°C
Wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m³/h
mass flow rate	$q_{m,12}$	kg/s
Hydronic heating (HH)		
Water inlet temperature	$T_{in, HH}$	°C
Water outlet temperature	$T_{out, HH}$	°C
Water mass flow rate	$q_{mHH, water}$	kg/s
Pressure difference / external static pressure	Δp_i / Δp_e	kPa
Hydronic cooling (HC)		
Water inlet temperature	$T_{in,HC}$	°C
Water outlet temperature	$T_{out,HC}$	°C

Measured or calculated quantity	**Symbol**	**Unit**
Water mass flow rate	$q_{mHC,water}$	kg/s
Pressure difference / external static pressure	Δp_i / Δp_e	kPa
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Brine concentration	–	%
Phase I – Ventilation measurements		
Power input	$P_{el,V}$	kW
Heat recovery capacity	P_{HR}	kW
Phase II – Heating performance measurements		
Heating capacity	P_{HH}	kW
Heating energy	Q_{HH}	kWh
Time duration of acquisition	t_{HH}	s
Effective energy input	$W_{el, V\text{-}HH}$	kWh
Energy recovery (where applicable)	$Q_{HR\text{-}HH}$	kWh
Phase II – Cooling performance measurements		
Cooling capacity	P_{HC}	kW
Cooling energy	Q_{HC}	kWh
Time duration of acquisition	t_{HC}	s
Effective energy input	$W_{el,V\text{-}HC}$	kWh
Energy recovery (where applicable)	$Q_{HR\text{-}HC}$	kWh

7.5.5 Performance rating calculations

7.5.5.1 General

All measured heating/cooling capacities and power input shall be corrected from the power input of liquid circulating pump according to EN 14511-3 to obtain the heating/cooling capacities and the effective power input of the unit.

Heating/cooling energies and electrical power input shall be calculated from corrected heating/cooling capacities and effective power input.

7.5.5.2 Overall performance

a) The overall performance in heating mode $COP_{V\text{-}HH}$ shall be calculated using the following formula:

$$COP_{V-HH} = \frac{Q_{HH} + Q_{HR-HH}}{W_{el,V-HH}} \quad (7)$$

where the heating energy Q_{HH} shall be calculated in Phase II using the following formula:

$$Q_{HH} = \frac{P_{HH} \times t_{HH}}{3600} \quad (8)$$

and where the energy recovery $Q_{HR\text{-}HH}$ shall be calculated in Phase I using the following formula:

$$Q_{HR-HH} = \frac{P_{HR} \times t_{HH}}{3600} \quad (9)$$

b) The overall performance in cooling mode $EER_{V\text{-}HC}$ shall be calculated using the following formula:

$$EER_{V-HC} = \frac{Q_{HC} + Q_{HR-HC}}{W_{el,V-HC}} \quad (10)$$

where the cooling energy Q_{HC} shall be calculated in Phase II using the following formula:

$$Q_{HC} = \frac{P_{HC} \times t_{HC}}{3600} \quad (11)$$

and where the energy recovery $Q_{HR\text{-}HC}$ shall be calculated in Phase I using the following formula:

$$Q_{HR-HC} = \frac{P_{HR} \times t_{HC}}{3600} \quad (12)$$

7.5.5.3 Heating performance

The hydronic heating performance COP_{HH} shall be calculated using the following formula:

$$COP_{HH} = \frac{Q_{HH}}{W_{el,V-HH} - W_{el,V}} \quad (13)$$

where the electrical energy for the ventilation $W_{el,V}$ shall be calculated using the following formula:

$$W_{el,V} = \frac{P_{el,V} \times t_{HH}}{3600} \quad (14)$$

7.5.5.4 Cooling performance

The hydronic cooling performance COP_{HC} shall be calculated using the following formula:

$$COP_{HC} = \frac{Q_{HC}}{W_{el,V-HC} - W_{el,V}} \quad (15)$$

where the electrical energy for the ventilation $W_{el,V}$ shall be calculated using the following formula:

$$W_{el,V} = \frac{P_{el,V} \times t_{HC}}{3600} \quad (16)$$

7.6 Ventilation combined with supply air heating/cooling

7.6.1 General

The tests shall be performed when the multifunctional ventilation unit is able to provide simultaneously either:

— both ventilation and air space heating; or

— both ventilation and air space cooling.

The unit shall be installed as specified in EN 14511 (all parts) for the heating/cooling function. For supply air heating/cooling, the installation shall also satisfy the requirements of EN 13141-7.

The test shall be performed according to EN 14511 (all parts) with the additional specifications as described in 7.6.2.

During the whole test, the ventilation function is running at reference air volume flow according to 7.2 and 7.3.

7.6.2 Temperature test conditions

The test conditions are derived from those defined in EN 13141-7 and EN 14511-2, with additional optional temperatures, and are specified for both heating and cooling modes, if applicable in the following tables:

Table 13 — Temperature conditions for the heating performance test

Test point n°	Extract air inlet dry bulb (wet bulb) temperature °C	Outdoor air inlet dry bulb (wet bulb) temperature °C
1 – mandatory	20 (12)	7 (6)
2 – optional	20 (12)	2 (1)
3 – optional	20 (12)	−7 (−8)
4 – optional	20 (12)	12 (11)
5 – optional	20 (12)	−15

In the case of reverse cycle heat pump, the performance in cooling mode, i.e. cooling capacity and energy efficiency ratio (EER) shall also be measured in the temperature conditions given in Table 14.

Table 14 — Temperature conditions for the cooling performance test

Test point n°	Extract air inlet dry bulb (wet bulb) temperature °C	Outdoor air inlet dry bulb (wet bulb) temperature °C
1 (mandatory)	27 (19)	35 (24)
2 (optional)	27 (19)	27 (19)

7.6.3 Test procedure

7.6.3.1 General

The test procedure can be described as a series of phases corresponding to different measurements.

The ventilation, being the primary function of the multifunctional units, it is under operation during all phases of the test. See Figure 8.

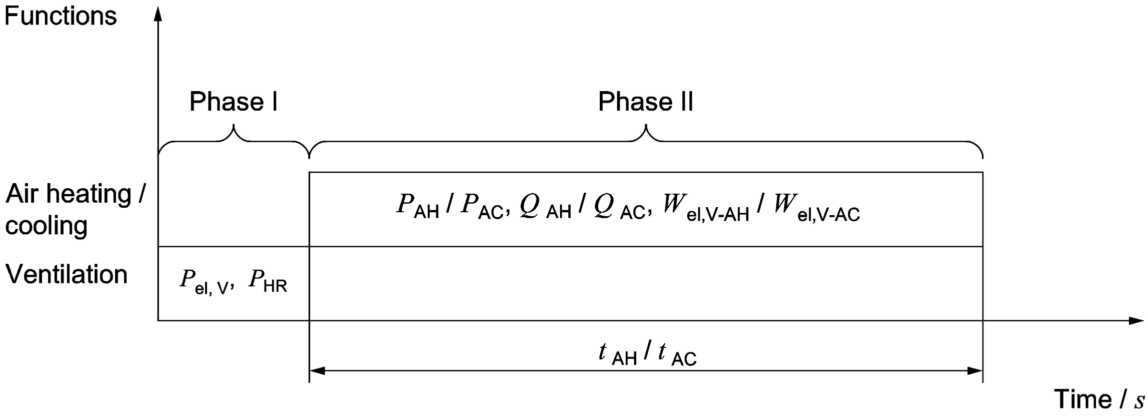


Figure 8 — Test phases for ventilation and air heating and/or cooling

7.6.3.2 Phase I: Starting conditions and ventilation measurements

The test is started with the ventilation only and performed as defined in 7.3. If the unit does not include a heat recovery heat exchanger, only the electrical power input of the unit $P_{el,V}$ is measured.

7.6.3.3 Phase II: Air heating/cooling performance measurements

The heat pump is switched on for the heating/cooling operation and the air temperature conditions given in 7.6.2 for air supply heating/cooling shall be reached and remained constant without having to alter the set values.

Heating/cooling performance data shall be measured and recorded according to EN 14511 (all parts).

7.6.4 Data to be recorded

The data to be recorded for the thermal capacity tests are given in Table 15. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 15 — Data to be recorded

Measured or calculated quantity	Symbol	Unit
Extract air (ETA)		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m³/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Dry bulb temperature	$T_{d,22}$	°C
Wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	(m³/h)
mass flow rate	$q_{m,22}$	kg/s
specific enthalpy	h_{22}	kJ/kg
Recirculation air (RCA), where applicable		
Dry bulb temperature	$T_{d,11}$	°C

Measured or calculated quantity	**Symbol**	**Unit**
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,RCA}$	m^3/h
mass flow rate	$q_{m,RCA}$	kg/s
specific enthalpy	h_{RCA}	kJ/kg
Outdoor air (ODA)		
Dry bulb temperature	$T_{d,21}$	°C
Wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m^3/h
mass flow rate	$q_{m,21}$	kg/s
specific enthalpy	h_{21}	kJ/kg
Exhaust air (EHA)		
Dry bulb temperature	$T_{d,12}$	°C
Wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m^3/h
mass flow rate	$q_{m,12}$	kg/s
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Phase I – Ventilation measurements		
Power input	$P_{el, V}$	kW
Heat recovery	P_{HR}	kW
Phase II – Air heating performance measurements		
Heating capacity	P_{AH}	kW
Heating energy	Q_{AH}	kWh
Measurement period according to EN 14511 (all parts)	t_{AH}	s
Effective energy input	$W_{el, V\text{-}AH}$	kWh
Phase II – Air cooling performance measurements		
Cooling capacity	P_{AC}	kW
Cooling energy	Q_{AC}	kWh
Measurement period according to EN 14511 (all parts)	t_{AC}	s
Effective energy input	$W_{el, V\text{-}AC}$	kWh

7.6.5 Performance rating calculations

7.6.5.1 General

Heating and cooling energies shall be calculated from corrected heating/cooling capacities and effective power input.

7.6.5.2 Overall performance

a) The overall performance in heating mode $COP_{V\text{-}AH}$ shall be calculated using the following formula:

$$COP_{V-AH} = \frac{Q_{AH}}{W_{el,V-AH}} \tag{17}$$

where the energy Q_{AH} and heating capacity P_{AH} shall be calculated using the following formulae:

$$Q_{AH} = \frac{\int_0^{t_{AH}} P_{AH} dt}{3600} \tag{18}$$

$$P_{AH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \tag{19}$$

$$P_{AH,average} = \frac{Q_{AH}}{t_{AH}} \tag{20}$$

where

$P_{AH,average}$ is the average overall heating capacity

b) The overall performance in cooling mode $EER_{V\text{-}AC}$ shall be calculated using the following formula:

$$EER_{V-AC} = \frac{Q_{AC}}{Q_{el,V-AC}} \tag{21}$$

where the energy Q_{AC} and cooling capacity P_{AC} shall be calculated using the following formulae:

$$Q_{AC} = \frac{P_{AC} \times t_{AC}}{3600} \tag{22}$$

and

$$P_{AC} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \tag{23}$$

where

P_{AC} average overall cooling capacity over the measurement period according to EN 14511 (all parts).

7.6.5.3 Air heating performance

The air heating performance COP_{AH} shall be calculated using the following formula:

$$COP_{AH} = \frac{Q_{AH} - Q_{HR-AH}}{W_{el,V-AH} - W_{el,V}} \tag{24}$$

where

$$Q_{HR-AH} = P_{HR} \times t_{AH} / 3600 \tag{25}$$

the electrical energy for the ventilation $W_{el,V}$ shall be calculated using the following formula:

$$W_{el,V} = \frac{P_{el,V} \times t_{AH}}{3600} \quad (26)$$

7.6.5.4 Air cooling performance

The air cooling performance EER_{AC} shall be calculated using the following formula:

$$EER_{AC} = \frac{Q_{AC} - Q_{HR-AC}}{W_{el,V-AC} - W_{el,V}} \quad (27)$$

where

$$Q_{HR-AC} = P_{HR} \times t_{AC} / 3600 \quad (28)$$

the electrical energy for the ventilation $W_{el,V}$ shall be calculated using the following formula:

$$W_{el,V} = \frac{P_{el,V} \times t_{AC}}{3600} \quad (29)$$

7.7 Ventilation combined with both hydronic and supply air heating/cooling

7.7.1 General

The tests shall be performed when the multifunctional ventilation unit is able to provide simultaneously either:

— both ventilation and supply air and hydronic heating; or

— both ventilation and supply air and hydronic cooling.

The unit shall be installed as specified in EN 14511 (all parts) for the heating/cooling function. For supply air heating/cooling, the installation shall also satisfy the requirements of EN 13141-7.

Air flows shall be set according to 7.2 and 7.3.

The test shall be performed according to according to EN 14511 (all parts) with the additional specifications as described in 7.7.2.

During the whole test, the ventilation function is running at reference fresh air volume flow.

7.7.2 Test procedure

7.7.2.1 General

The test procedure can be described as a series of phases corresponding to different measurements.

The ventilation, being the primary function of the multifunctional units, it is under operation during all phases of the test. See Figure 9.

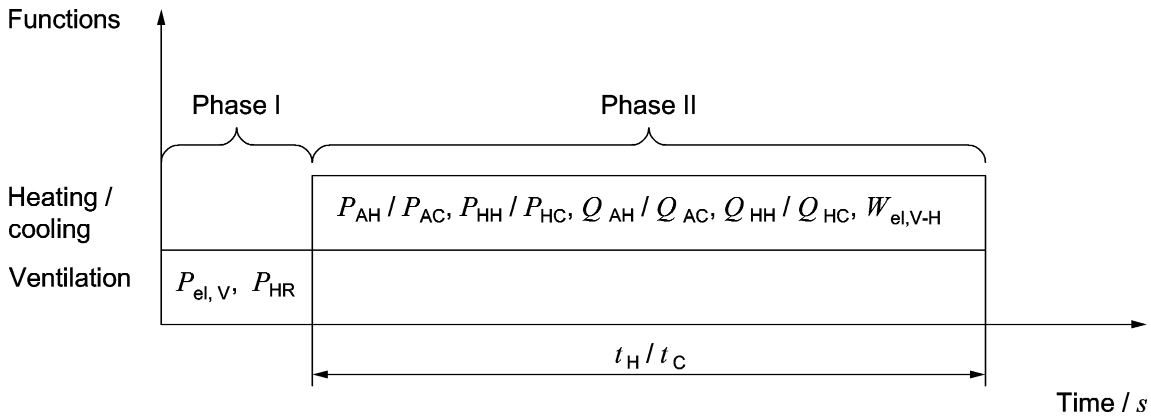


Figure 9 — Test phases for ventilation and both hydronic and air heating/cooling

7.7.2.2 Phase I: Starting conditions and ventilation measurements

The test is started with the ventilation only and performed as defined in 7.3. If the unit does not include a heat recovery heat exchanger, only the electrical power input of the unit $P_{el, V}$ is measured.

7.7.2.3 Phase II: Heating/cooling performance measurements

The heat pump is switched on for the heating/cooling operation and the water and air temperature conditions given in 7.3.2 and in 7.5.2 for hydronic and air supply heating/cooling respectively shall be reached and remained constant without having to alter the set values.

7.7.3 Data to be recorded

The data to be recorded during the tests is given in Table 16. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 16 — Data to be recorded

Measured or calculated quantity	**Symbol**	**Unit**
Extract air (ETA)		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m³/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Dry bulb temperature	$T_{d,22}$	°C
Wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	m³/h
mass flow rate	$q_{m,22}$	kg/s
specific enthalpy	h_{22}	kJ/kg
Recycled air (RCA), where applicable		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,RCA}$	m³/h
mass flow rate	$q_{m,RCA}$	kg/s
specific enthalpy	h_{RCA}	kJ/kg
Outdoor air (ODA)		
Dry bulb temperature	$T_{d,21}$	°C
Wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m³/h
mass flow rate	$q_{m,21}$	kg/s
specific enthalpy	h_{21}	kJ/kg
Exhaust air (EHA)		
Dry bulb temperature	$T_{d,12}$	°C
Wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m³/h
mass flow rate	$q_{m,12}$	kg/s
Hydronic heating (HH)		
Water inlet temperature	$T_{in, HH}$	°C
Water outlet temperature	$T_{out, HH}$	°C
Water mass flow rate	$q_{mHH, water}$	kg/s
Pressure difference / external static pressure	Δp_i / Δp_e	kPa

Measured or calculated quantity	**Symbol**	**Unit**
Hydronic cooling (HC)		
Water inlet temperature	$T_{in,HC}$	°C
Water outlet temperature	$T_{out,HC}$	°C
Water mass flow rate	$q_{mHC,water}$	kg/s
Pressure difference / external static pressure	Δp_i / Δp_e	kPa
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Brine concentration (if applicable)	–	%
Phase I: Ventilation measurements		
Power input	$P_{el,V}$	kW
Heat recovery capacity	P_{HR}	kW
Phase II: Supply air and hydronic heating performance measurements		
Heating capacity – hydronic – supply air	P_{HH} P_{AH}	kW
Heating energy – hydronic – supply air	Q_{HH} Q_{AH}	kWh
Effective energy input	$W_{el,V\text{-}H}$	kWh
Duration of acquisition	t_H	s
Phase II: Supply air and hydronic cooling performance measurements		
Cooling capacity – hydronic – supply	P_{HC} P_{AC}	kW
Cooling energy – hydronic – supply air	Q_{HC} Q_{AC}	kWh
Effective energy input	$W_{el,\,V\text{-}C}$	kWh
Duration of acquisition	t_C	s

7.7.4 Performance rating calculations

7.7.4.1 General

All measured heating/cooling capacities and power input shall be corrected from the power input of fans and liquid circulating pump according to EN 14511-3 to obtain the heating/cooling capacities and the effective power input of the unit.

Heating/cooling energies and electrical power input shall be calculated from corrected heating/cooling capacities and effective power input.

7.7.4.2 Overall performance

a) The overall performance in heating mode $COP_{V\text{-}H}$ shall be calculated using the following formula:

$$COP_{V-H} = \frac{Q_{AH} + Q_{HH}}{W_{el,V-H}} \tag{30}$$

where the energy Q_{AH} and air heating capacity P_{AH} shall be calculated using the following formulae:

$$Q_{AH} = \frac{\int_0^{t_H} P_{AH} dt}{3600} \tag{31}$$

$$P_{AH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \tag{32}$$

and the hydronic heating energy Q_{HH} shall be calculated using the following formulae:

$$Q_{HH} = \frac{P_{HH} \times t_H}{3600} \tag{33}$$

b) The overall performance in cooling mode $EER_{V\text{-}C}$ shall be calculated using the following formula:

$$EER_{V-C} = \frac{Q_{AC} + Q_{HC}}{Q_{el,V-C}} \tag{34}$$

where the energy Q_{AC} and air cooling capacity P_{AC} and the hydronic cooling capacity Q_{HC} shall be calculated using the following formulae:

$$Q_{AC} = \frac{P_{AC} \times t_C}{3600} \tag{35}$$

$$P_{AC} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \tag{36}$$

$$Q_{HC} = \frac{P_{HC} \times t_C}{3600} \tag{37}$$

7.7.4.3 Heating performance and or cooling performance

a) The heating performance COP_H shall be calculated using the following formula:

$$COP_H = \frac{Q_{AH} + Q_{HH} - Q_{HR-AH}}{W_{el,V-H} - W_{el,V}} \tag{38}$$

where

$$Q_{HR-AH} = P_{HR} \times t_C / 3600 \tag{39}$$

and the electrical energy for the ventilation $W_{el,V}$ shall be calculated using the following formula:

$$W_{el,V} = \frac{P_{el,V} \times t_H}{3600} \tag{40}$$

b) The cooling performance EER_C shall be calculated using the following formula:

$$EER_C = \frac{Q_{AC} + Q_{HC} - Q_{HR-AC}}{W_{el,V-C} - W_{el,V}} \tag{41}$$

where

$$Q_{HR-AC} = P_{HR} \times t_{AC} / 3600 \tag{42}$$

and the electrical energy for the ventilation $W_{el,V}$ shall be calculated using the following formula:

$$W_{el,V} = \frac{P_{el,V} \times t_C}{3600} \tag{43}$$

7.8 Ventilation combined with heating and hot water production

7.8.1 General

The tests shall be performed when the multifunctional ventilation unit is able to provide:

— ventilation

— domestic hot water production; and

— hydronic and/or supply air heating.

The unit shall be installed as specified in according to EN 14511 (all parts) for the heating function. For supply air heating, the installation shall also satisfy the requirements of EN 13141-7.

Air flows shall be set according to 7.2 and 7.3.

The test shall be performed according to EN 16147 for the hot water production and to according to EN 14511 (all parts) for the heating function, with the additional specifications as described in 7.8.2.

The manufacturer shall declare the tapping cycle to be used according to EN 16147.

During the whole test, the ventilation function is running at reference fresh air volume flow.

7.8.2 Test procedure

7.8.2.1 General

The test procedure can be described as a series of phases corresponding to different measurements.

The ventilation, being the primary function of the multifunctional units, it is under operation in all phases of the test. See Figure 10.

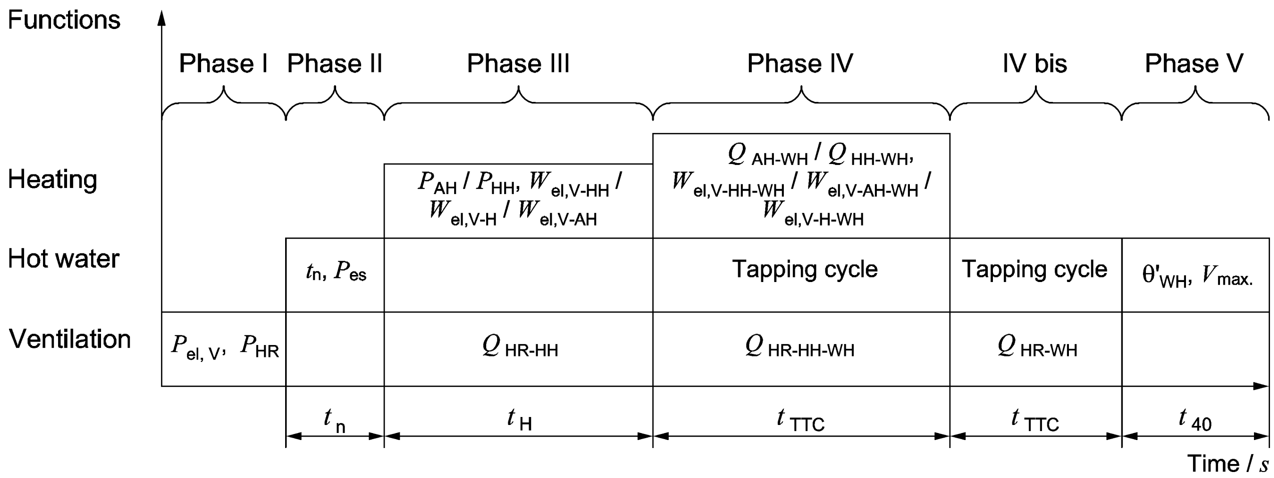


Figure 10 — Test phases for air heating plus hot water production

Phase IVbis is optional: in case the performance for domestic hot water production only without any heating is required, phase IVbis shall be performed.

7.8.2.2 Phase I: Starting conditions and ventilation measurements

The initial state for the storage tank is as defined in EN 16147.

The test is started with the ventilation only and performed as defined in 7.3.

If the unit does not include a heat recovery heat exchanger, only the electrical power input of the unit $P_{el,V}$ is measured.

7.8.2.3 Phase II: Heating up and stand-by power input measurements

The heat pump is switched on for the hot water production only and the heating up period t_h, as well as the stand-by power input P_{es}, as defined in EN 16147, are measured.

The power input due to the ventilation function $P_{el,V}$, shall be subtracted from the measured electrical energy W_{es}, to calculate the stand-by power input P_{es}.

$$P_{es} = \frac{W_{es}}{t_{es}} \times 3600 - P_{el,V} \qquad (44)$$

where

P_{es} stand-by power input, in kW

W_{es} energy input during the last on/off cycle, in kWh

t_{es} duration of the last on/off cycle of the heat pump, in s

$P_{el,V}$ power input for ventilation only, in kWh

7.8.2.4 Phase III: Hydronic and/or air heating performance measurements

The heat pump is switched on for the heating mode and the water temperature conditions given in 7.5.2 for hydronic heating and/or the air temperature conditions given in 7.6.2 for supply air heating, shall be reached and remained constant without having to alter the set values.

Heating performance data shall be measured and recorded according to EN 14511 (all parts), with the corrections for fans and liquid pump as applicable to the heating capacity and effective power input. The Phase III shall end at the shut off of the heat pump by the hot water thermostat situate in the tank.

NOTE During this phase III, the heat pump may operate to compensate for the heat losses of the tank and thus not providing any heating to the water or air. Therefore if this occurs, fluctuation on the measured heating capacity may be observed.

7.8.2.5 Phase IV: Hot water production performance measurements

The tapping cycle shall start directly after a shut off of the heat pump by the hot water thermostat situated in the tank.

The test is performed according to EN 16147 with the tapping cycle chosen by the manufacturer.

The operation of the heating function being altered by the tapping cycle, the water mass flow rate and either the inlet or outlet water temperature of the heating circuit, depending on the control strategy of the unit, shall be maintained constant and equal to the conditions defined for the Phase III.

The effective power input shall include the corrections due to fans and liquid pump as applicable.

7.8.2.6 Phase IVbis optional: Hot water production performance measurements without heating

If determination of the performance of the hot water production without operation of the heating function is required, another tapping cycle test shall be performed without operation of the heating function of the heat pump.

This additional tapping cycle shall start directly after a shut off of the heat pump by the hot water thermostat situated in the tank.

No correction for the liquid pump or fans is necessary as the heating function is not operating.

7.8.2.7 Phase V: Reference hot water temperature and maximum volume of usable hot water measurements

The heating function of the unit is switched off.

The test is performed according to EN 16147.

The reference hot water temperature θ'_{WH} and the maximum volume of usable hot water V_{max} shall be calculated according to EN 16147.

7.8.3 Data to be recorded

The data to be recorded during the tests is given in Table 17. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 17 — Data to be recorded

Measured or calculated quantity	Symbol	Unit
Extract air (ETA)		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m³/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Dry bulb temperature	$T_{d,22}$	°C
Wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	m³/h
mass flow rate	$q_{m,22}$	kg/s
specific enthalpy	h_{22}	kJ/kg
Recycled air (RCA), where applicable		
Dry bulb temperature	$T_{d,11}$	°C
Wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v, RCA}$	m³/h
mass flow rate	$q_{m, RCA}$	kg/s
specific enthalpy	h_{RCA}	kJ/kg
Outdoor air (ODA)		
Dry bulb temperature	$T_{d,21}$	°C
Wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m³/h
mass flow rate	$q_{m,21}$	kg/s
specific enthalpy	h_{21}	kJ/kg
Exhaust air (EHA)		
Dry bulb temperature	$T_{d,12}$	°C
Wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m³/h
mass flow rate	$q_{m,12}$	kg/s
Hydronic heating (HH)		
Water inlet temperature	$T_{in, HH}$	°C
Water outlet temperature	$T_{out, HH}$	°C
Water mass flow rate	$q_{mH, water}$	kg/s
Pressure difference / external static pressure	Δp_i / Δp_e	kPa

Measured or calculated quantity	**Symbol**	**Unit**
Domestic hot water production		
Incoming cold water temperature	θ_{WC}	°C
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Brine concentration	–	%
Phase I – Ventilation measurements		
Power input	$P_{el,V}$	kW
Heat recovery (where applicable)	P_{HR}	kW
Phase II – Heating up and stand-by power input measurements		
Heating up period	t_h	s
Energy input	W_{es}	kWh
Stand by power input	P_{es}	kW
Phase III – Heating performance measurements		
Heating capacity – hydronic – supply air	P_{HH} P_{AH}	kW
Heating energy – hydronic – supply air	Q_{HH} Q_{AH}	kWh
Time duration of acquisition	t_H	s
Effective energy input – hydronic – supply air – both	$W_{el,V\text{-}HH}$ $W_{el,V\text{-}AH}$ $W_{el,V\text{-}H}$	kWh
Energy recovery (where applicable) – hydronic	$Q_{HR\text{-}HH}$	kWh
Phase IV – Hot water production performance measurements		
Heating capacity – hydronic – supply air	$P_{HH\text{-}WH}$ $P_{AH\text{-}WH}$	kW
Heating energy	$Q_{HH\text{-}WH}$	kWh

Measured or calculated quantity	Symbol	Unit
– hydronic – supply air	$Q_{\text{AH-WH}}$	
Time period of the test cycle	t_{TTC}	h
Overall energy of the whole tapping cycle	Q_{TC}	kWh
Effective energy input – hydronic – supply air – both	$W_{\text{el,V-HH-WH}}$ $W_{\text{el,V-AH-WH}}$ $W_{\text{el,V-H-WH}}$	kWh
Energy recovery (where applicable) – hydronic	$Q_{\text{HR-HH-WH}}$	kWh
Phase IVbis (optional) – Hot water production performance measurements without heating		
Time period of the test cycle	t_{TTC}	h
Overall energy of the whole tapping cycle	Q_{TC}	kWh
Effective energy input, without heating	$W_{\text{el,V-WH}}$	kWh
Energy recovery (where applicable)	$Q_{\text{HR-WH}}$	kWh
Phase V – Reference hot water temperature and maximum volume of usable hot water measurements		
Tapping time	t_{40}	s
Volume flow rate of hot water during tapping	V_{tap}	kg/h
Reference hot water temperature	θ'_{WH}	°C
Maximum volume of usable hot water	V_{max}	m^3

7.8.4 Performance rating calculations

7.8.4.1 General

All measured heating capacities and power input shall be corrected from the power input of fans and liquid circulating pump according to EN 14511-3 to obtain the heating capacities and the effective power input of the unit.

Heating and electrical energies shall be calculated from corrected heating capacity and effective power input.

7.8.4.2 Overall performance

The overall COP of the unit is defined as the overall energy from ventilation, heating and hot water production divided by the total electrical energy input as follows:

a) With hydronic heating:

$$COP_{V-HH-WH} = \frac{Q_{HH-WH} + Q_{TC} + Q_{HR-HH-WH}}{W_{el,V-HH-WH} + (24 - t_{TTC}).P_{es}} \quad (45)$$

because the time span of the test cycles differs, the electrical energy for recovering the heat losses of the tank shall be corrected to a duration of 24 h, according to EN 16147;

where

$$Q_{HH-WH} = \frac{\int_0^{t_{TTC}} P_{HH-WH} dt}{3600} \quad (46)$$

and

$$Q_{HR-HH-WH} = P_{HR} \times t_{TTC} \quad (47)$$

b) With supply air heating: $$COP_{V-AH-WH} = \frac{Q_{AH-WH} + Q_{TC}}{W_{el,V-AH-WH} + (24 - t_{TTC}).P_{es}} \quad (48)$$

because the time span of the test cycles differs, the electrical energy for recovering the heat losses of the tank shall be corrected to a duration of 24 h, according to EN 16147;

where

$$Q_{AH-WH} = \frac{\int_0^{t_{TTC}} P_{AH-WH} dt}{3600} \quad (49)$$

and

$$P_{AH-WH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \quad (50)$$

c) With both supply air and hydronic heating: $$COP_{V-H-WH} = \frac{Q_{AH-WH} + Q_{HH-WH} + Q_{TC}}{W_{el,V-H-WH} + (24 - t_{TTC}).P_{es}} \quad (51)$$

because the time span of the test cycles differs, the electrical energy for recovering the heat losses of the tank shall be corrected to a duration of 24 h, according to EN 16147.

7.8.4.3 Heating performance

A COP corresponding to the heating only function can be derived from the measurements as follows:

a) For hydronic heating: $$COP_{HH} = \frac{Q_{HH}}{W_{el,V-HH} - W_{el,V}} \quad (52)$$

where

$$Q_{HH} = \frac{P_{HH} \times t_H}{3600} \quad (53)$$

$$W_{el,V} = \frac{P_{el,V} \times t_H}{3600} \quad (54)$$

b) For supply air heating: $$COP_{AH} = \frac{Q_{AH} - Q_{HR-AH}}{W_{el,V-AH} - W_{el,V}} \quad (55)$$

where

$$Q_{HR-AH} = P_{HR} \times t_H / 3600 \quad (56)$$

$$W_{el,V} = \frac{P_{el,V} \times t_H}{3600} \quad (57)$$

$$P_{AH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \quad (58)$$

$$Q_{AH} = \frac{\int_o^{t_H} P_{AH} dt_H}{3600} \quad (59)$$

c) For both supply air and hydronic heating: $$COP_H = \frac{Q_{AH} + Q_{HH} - Q_{HR-H}}{W_{el,V-H} - W_{el,V}} \quad (60)$$

where

$$Q_{HR-H} = P_{HR} \times t_H / 3600 \quad (61)$$

$$W_{el,V} = \frac{P_{el,V} \times t_H}{3600} \quad (62)$$

7.8.4.4 Hot water production performance

Because the correction due to the heat source fan is already included in the overall energy power input, the correction $W_{\text{el-Corr}}$ as defined in EN 16147 is considered equal to 0.

a) With hydronic heating: $$COP_D = \frac{Q_{TC}}{W_{el,V-HH-WH} - W'_{el,HH} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (63)$$

where

$$W'_{el,HH} = \frac{Q_{HH-D}}{COP_{HH}} \quad (64)$$

$$W'_{el,V} = P_{el,V} \times t_{TTC} \quad (65)$$

b) With supply air heating: $$COP_D = \frac{Q_{TC}}{W_{el,V-AH-WH} - W'_{el,AH} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (66)$$

where

$$W'_{el,AH} = \frac{Q_{AH-WH}}{COP_{AH}} \quad (67)$$

$$W'_{el,V} = P_{el,V} \times t_{TTC} \quad (68)$$

c) With both supply air and hydronic heating: $$COP_D = \frac{Q_{TC}}{W_{el,V-H-D} - W'_{el,H} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (69)$$

where

$$W'_{el,H} = \frac{Q_{HH-WH} + Q_{AH-WH}}{COP_H} \quad (70)$$

$$W'_{el,V} = P_{el,V} \times t_{TTC} \quad (71)$$

d) With no heating: $$COP'_{WH} = \frac{Q_{TC}}{W_{el,V-WH} - W_{el,V} + (24 - t_{TTC}).P_{es}} \quad (72)$$

where

$$W_{el,V} = P_{el,V} \times t_{TTC} \quad (73)$$

7.9 Ventilation combined with cooling and hot water production

7.9.1 General

The tests shall be performed when the multifunctional ventilation unit is able to provide simultaneously:

— ventilation;

— domestic hot water; and

— hydronic and/or supply air cooling

Regarding domestic hot water and supply air cooling, supply air cooling can be either the leading function or the secondary function. If supply air cooling is the secondary function, domestic hot water production is the leading function and supply air cooling is considered as “free” (supply air free cooling).

The unit shall be installed as specified in EN 14511 (all parts) for the cooling function. For supply air cooling, the installation shall also satisfy the requirements of EN 13141-7.

Air flows shall be set according to 7.2 and 7.3.

The test shall be performed according to EN 16147 for the hot water production and to EN 14511 (all parts) for the cooling function, with the additional specifications as described in 7.8.2.

The manufacturer shall declare the tapping cycle to be used according to EN 16147.

During the whole test, the ventilation function is running at reference fresh air volume flow.

7.9.2 Test procedure

7.9.2.1 General

The ventilation, being the primary function of the multifunctional units, it is under operation during all phases of the test. See Figure 11.

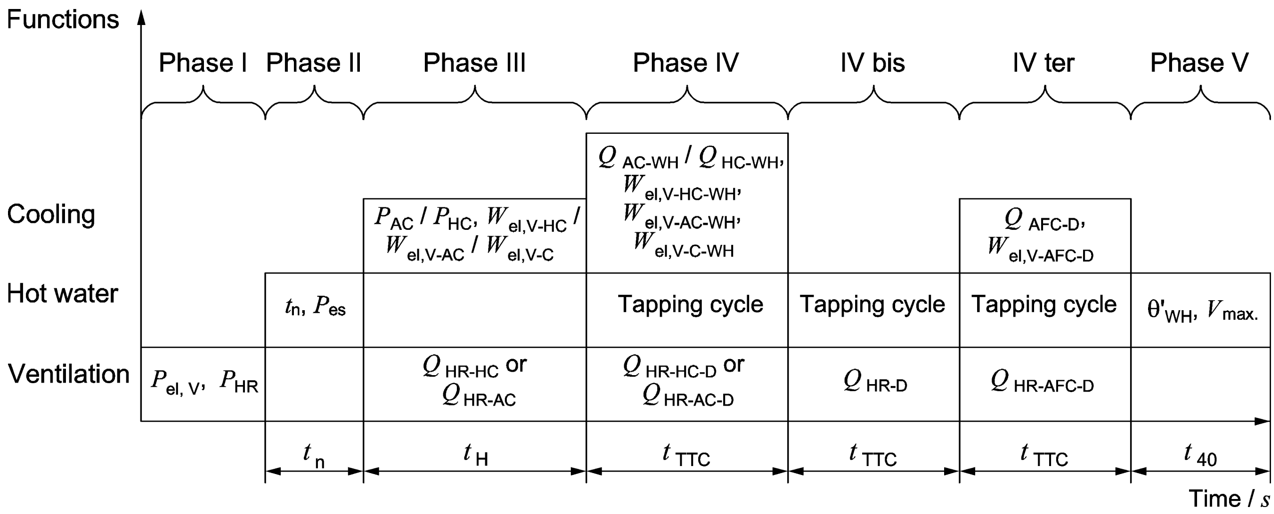


Figure 11 — Test phases for ventilation and air cooling plus hot water production

Phase IVbis is optional: in case the performance during domestic hot water production without any cooling is required, phase IVbis shall be performed.

Phase IVter is optional: in case the free supply air cooling capacity by domestic hot water production as leading function is required, phase IVter shall be performed. Phase IVter can be performed after phase IV if phase IVbis is omitted.

7.9.2.2 Phase I: Starting conditions and ventilation measurements

The initial state for the storage tank is as defined in EN 16147.

The test is started with the ventilation only and performed as defined in 7.3.

If the unit does not include a heat recovery heat exchanger, only the electrical power input of the unit $P_{el,v}$ is measured.

7.9.2.3 Phase II: Heating up and stand-by power input measurements

The heat pump is switched on for the hot water production only. The heating up period t_h, and the stand-by power input P_{es}, as defined in EN 16147 respectively, are measured.

The power input due to the ventilation operation $P_{el,V}$, shall be subtracted from the measured electrical energy W_{es}, to calculate the stand-by power input P_{es}.

$$P_{es} = \frac{W_{es}}{t_{es}} x\, 3\,600 - P_{el,V} \tag{74}$$

where

P_{es} stand-by power input, in kW

W_{es} energy input during the last on/off cycle, in kWh

t_{es} duration of the last on/off cycle of the heat pump, in s

$P_{el,V}$ power input for ventilation only, in kW

7.9.2.4 Phase III: Cooling performance measurements

The heat pump is switched on for the cooling mode and the water temperature conditions given in 7.5.2 for hydronic cooling and/or the air temperature conditions given in 7.6.2 for supply air cooling, shall be reached and remained constant without having to alter the set values.

Cooling performance data shall be measured and recorded according to EN 14511 (all parts), with the correction for fans and liquid pump as applicable to the cooling capacity and effective power input.

The Phase III shall end at the shut off of the heat pump by the hot water thermostat situate in the tank.

NOTE During this phase III, the heat pump may operate to compensate for the heat losses of the tank and thus not providing any heating to the water or air. Therefore if this occurs, fluctuation on the measured heating capacity may be observed.

7.9.2.5 Phase IV: Hot water production performance measurements

The tapping cycle shall start directly after a shut off of the heat pump by the hot water thermostat situated in the tank.

The test is performed according to EN 16147 with the tapping cycle chosen by the manufacturer.

The operation of the cooling function may be altered by the tapping cycle; the water mass flow rate and either the inlet or outlet water temperature of the heating circuit, depending on the control strategy of the unit, shall be maintained constant and equal to the conditions defined for the Phase III.

The effective power input shall include the correction due to fans and liquid pump.

7.9.2.6 Phase IVbis optional: Hot water production performance measurements without cooling

If determination of the performance of the hot water production without operation of the cooling function is required, another tapping cycle test shall be performed without operation of the cooling function of the heat pump.

This additional tapping cycle shall start directly after a shut off of the heat pump by the hot water thermostat situated in the tank.

No correction for liquid pump or fans is necessary as the cooling function is not operating.

7.9.2.7 Phase IVter optional: Hot water production performance measurements with supply air free cooling

If determination of the performance of hot water production with operation of the air supply free cooling function is required (hot water production is leading), another tapping cycle test shall be performed.

The tapping cycle shall start directly after a shut off of the heat pump by the hot water thermostat situated in the tank.

The test is performed according to EN 16147 with the tapping cycle chosen by the manufacturer.

7.9.2.8 Phase V: Reference hot water temperature and maximum volume of usable hot water measurements

The cooling function of the unit is switched off.

The test is performed according to EN 16147.

The reference hot water temperature θ'_{WH} and V_{max} shall be calculated according to EN 16147.

7.9.3 Data to be recorded

The data to be recorded during the tests is given in Table 18. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 18 — Data to be recorded

Measured or calculated quantity	Symbol	Unit
Extract air (ETA)		
Inlet dry bulb temperature	$T_{d,11}$	°C
Inlet wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v,11}$	m³/h
mass flow rate	$q_{m,11}$	kg/s
Supply air (SUP)		
Outlet dry bulb temperature	$T_{d,22}$	°C
Outlet wet bulb temperature	$T_{w,22}$	°C
volume flow rate (at standard air conditions)	$q_{v,22}$	m³/h
mass flow rate	$q_{m,22}$	kg/s
specific enthalpy	h_{22}	kJ/kg
Recycled air (RCA), where applicable		
Inlet dry bulb temperature	$T_{d,11}$	°C
Inlet wet bulb temperature	$T_{w,11}$	°C
volume flow rate (at standard air conditions)	$q_{v, RCA}$	m³/h
mass flow rate	$q_{m, RCA}$	kg/s
specific enthalpy	h_{RCA}	kJ/kg
Outdoor air (ODA)		
Inlet dry bulb temperature	$T_{d,21}$	°C
Inlet wet bulb temperature	$T_{w,21}$	°C
volume flow rate (at standard air conditions)	$q_{v,21}$	m³/h
mass flow rate	$q_{m,21}$	kg/s
specific enthalpy	h_{21}	kJ/kg
Exhaust air (EHA)		
Outlet dry bulb temperature	$T_{d,12}$	°C
Outlet wet bulb temperature	$T_{w,12}$	°C
volume flow rate (at standard air conditions)	$q_{v,12}$	m³/h
mass flow rate	$q_{m,12}$	kg/s
Hydronic cooling (HC)		
Water inlet temperature	$T_{in, HC}$	°C
Water outlet temperature	$T_{out, HC}$	°C
Water mass flow rate	$q_{mC, water}$	kg/s
Pressure difference / external static pressure	Δp_i / Δp_e	kPa

Measured or calculated quantity	Symbol	Unit
Domestic hot water production		
Incoming cold water temperature	θ_{WC}	°C
Electrical quantities		
Frequency	–	Hz
Voltage	–	V
Total current	–	A
Others		
Atmospheric pressure	–	Pa
Fan(s) speed setting, if applicable	–	–
Brine concentration	–	%
Phase I – Ventilation measurements		
Power input	$P_{el,V}$	kW
Heat recovery capacity (where applicable)	P_{HR}	kWh
Phase II – Heating up and stand-by power input measurements		
Heating up period	t_h	s
Energy input	W_{es}	kWh
Stand by power input	P_{es}	kW
Phase III – Cooling performance measurements		
Cooling capacity – hydronic – supply air	P_{HC} P_{AC}	kW
Cooling energy – hydronic – supply air	Q_{HC} Q_{AC}	kWh
Duration of acquisition	t_C	s
Effective energy input – hydronic – supply air – both	$W_{el,V\text{-}HC}$ $W_{el,V\text{-}AC}$ $W_{el,V\text{-}C}$	kWh
Energy recovery (when applicable) – hydronic	$Q_{HR\text{-}HC}$	kWh
Phase IV – Hot water production measurements		
Cooling capacity – hydronic – supply air	$P_{HC\text{-}WH}$ $P_{AC\text{-}WH}$	kW
Cooling energy	$Q_{HC\text{-}WH}$	kWh

Measured or calculated quantity	**Symbol**	**Unit**
– hydronic – supply air	$Q_{AC\text{-}WH}$	
Energy recovery (where applicable) – hydronic	$Q_{HR\text{-}HC\text{-}WH}$	kWh
Time period of the test cycle	t_{TTC}	h
Overall energy of the whole tapping cycle	Q_{TC}	kWh
Effective energy input – hydronic – supply air – both	$W_{el,V\text{-}HC\text{-}WH}$ $W_{el,V\text{-}AC\text{-}WH}$ $W_{el,V\text{-}C\text{-}WH}$	kWh
Phase IVbis (optional) – Hot water production measurements without cooling		
Time period of the test cycle	t_{TTC}	h
Overall energy recovery of the whole tapping cycle	Q_{TC}	kWh
Effective energy input, without cooling	$W_{el,VD}$	kWh
Energy recovery (where applicable)	$Q_{HR\text{-}WH}$	kWh
Phase IVter (optional) – Hot water production and air supply free cooling		
Cooling capacity – supply air	$P_{AFC\text{-}WH}$	kW
Cooling energy – supply air	$Q_{AFC\text{-}WH}$	kWh
Time period of the test cycle	t_{TTC}	h
Overall energy recovery of the whole tapping cycle	Q_{TC}	kWh
Effective energy input	$W_{el,V\text{-}AFC\text{-}WH}$	kWh
Phase V – Reference hot water temperature and maximum volume of usable hot water measurements		
Tapping time	t_{40}	s
Volume flow rate of hot water during tapping	V_{tap}	kg/h
Reference hot water temperature	θ'_{WH}	°C
Maximum volume of usable hot water	V_{max}	m³

7.9.4 Performance rating calculations

7.9.4.1 General

All measured cooling capacity and power input shall be corrected from the power input of fans and liquid circulating pump according to EN 14511-3 to obtain the cooling capacity and the effective power input of the unit.

Cooling and electrical energies shall be calculated from corrected cooling capacity and effective power input.

7.9.4.2 Overall performance

The overall *EER* of the unit is defined as the overall energy from ventilation, cooling and hot water production divided by the total electrical energy input as follows:

a) With hydronic cooling: $$EER_{V-HC-WH} = \frac{Q_{HC-WH} + Q_{TC} + Q_{HR-HC-WH}}{W_{el,V-HC-WH} + (24 - t_{TTC}).P_{es}} \quad (75)$$

because the time span of the test cycles differs, the electrical energy for recovering the heat losses of the tank shall be corrected to a duration of 24 h, according to EN 16147;

where

$$Q_{HC-WH} = \frac{\int_0^{t_{TTC}} P_{HC-WH} dt}{3600} \quad (76)$$

$$Q_{HR-HC-WH} = \frac{P_{HR} \times t_{TTC}}{3600} \quad (77)$$

b) With supply air cooling leading: $$EER_{V-AC-WH} = \frac{Q_{AC-WH} + Q_{TC}}{W_{el,V-AC-WH} + (24 - t_{TTC}).P_{es}} \quad (78)$$

because the time span of the test cycles differs, the electrical energy for recovering the heat losses of the tank shall be corrected to a duration of 24 h, according to EN 16147;

where

$$Q_{AC-WH} = \frac{\int_0^{t_{TTC}} P_{AC-WH} dt}{3600} \quad (79)$$

$$P_{AC-WH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \quad (80)$$

c) With supply free cooling: $$EER_{V-AFC-WH} = \frac{Q_{AFC-WH} + Q_{TC}}{W_{el,V-AFC-WH} + (24 - t_{TTC}).P_{es}} \quad (81)$$

where

$$Q_{AC-WH} = \frac{\int_0^{t_{TTC}} P_{AFC-WH} dt}{3600} \quad (82)$$

$$P_{AFC-WH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \quad (83)$$

d) With both supply air and hydronic cooling: $$EER_{V-C-WH} = \frac{Q_{AC-WH} + Q_{HC-WH} + Q_{TC}}{W_{el,V-C-WH} + (24 - t_{TTC}).P_{es}} \quad (84)$$

7.9.4.3 Cooling performance

An *EER* corresponding to the cooling only function can be derived from the measurements as follows:

a) With hydronic cooling: $$EER_{HC} = \frac{Q_{HC}}{W_{el,V-HC} - W_{el,V}} \quad (85)$$

where

$$Q_{HC} = \frac{P_{HC} \times t_C}{3600} \quad (86)$$

$$W_{el,V} = \frac{P_{el,V} \times t_C}{3600} \quad (87)$$

b) With supply air cooling leading: $$EER_{AC} = \frac{Q_{AC} - Q_{HR-AC}}{W_{el,V-AC} - W_{el,V}} \quad (88)$$

where

$$Q_{HR-AC} = P_{HR} \times t_C / 3600 \quad (89)$$

$$W_{el,V} = \frac{P_{el,V} \times t_C}{3600} \quad (90)$$

$$Q_{AC-WH} = \frac{P_{AC-WH} \times t_C}{3600} \quad (91)$$

$$P_{AC-WH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \quad (92)$$

c) With supply air free cooling: $$Q_{AFC-WH} = \frac{\int_0^{t_{TTC}} P_{AFC-WH} dt}{3600} \quad (93)$$

where

$$P_{AFC-WH} = q_{m,21} \times (h_{22} - h_{21}) + q_{m,RCA} \times (h_{22} - h_{RCA}) \quad (94)$$

d) With both supply air and hydronic cooling: $$EER_C = \frac{Q_{AC} + Q_{HC}}{W_{el,V-C} - W_{el,V}} \quad (95)$$

where

$$W_{el,V} = \frac{P_{el,V} \times t_C}{3600} \quad (96)$$

7.9.4.4 Hot water production performance

Because the correction due to the heat source fan is already included in the overall energy power input, the correction $W_{el\text{-}Corr}$ as defined in EN 16147 is considered equal to 0.

a) With hydronic cooling: $$COP_{WH} = \frac{Q_{TC}}{W_{el,V-HC-WH} - W'_{el,HC} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (97)$$

where

$$W'_{el,HC} = \frac{Q_{HC-WH}}{EER_{HC}} \quad (98)$$

$$W'_{el,V} = \frac{P_{el,V} \times t_{TTC}}{3600} \quad (99)$$

b) With supply air cooling leading: $$COP_{WH} = \frac{Q_{TC}}{W-_{el,VAC-WH} - W'_{el,AC} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (100)$$

where

$$W'_{el,AC} = \frac{Q_{AC-WH}}{EER_{AC}} \quad (101)$$

$$W'_{el,V} = \frac{P_{el,V} \times t_{TTC}}{3600} \quad (102)$$

c) With supply air free cooling: $$COP_{WH} = \frac{Q_{TC}}{W-_{el,VAFC-WH} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (103)$$

where

$$W'_{el,V} = \frac{P_{el,V} \times t_{TTC}}{3600} \quad (104)$$

d) With both supply air and hydronic cooling: $$COP_{WH} = \frac{Q_{TC}}{W_{el,V-C-WH} - W'_{el,C} - W'_{el,V} + (24 - t_{TTC}).P_{es}} \quad (105)$$

where:

$$W'_{el,C} = \frac{Q_{HC-WH} + Q_{AC-WH}}{EER_{C}} \quad (106)$$

$$W'_{el,V} = \frac{P_{el,V} \times t_{TTC}}{3600} \quad (107)$$

e) With no cooling is based on phase IVbis: $$COP'_{WH} = \frac{Q_{TC}}{W_{el,V-WH} - W_{el,V} + (24 - t_{TTC}).P_{es}} \quad (108)$$

where

$$W_{el,V} = \frac{P_{el,V} \times t_{TTC}}{3600} \quad (109)$$

8 Performance testing of acoustic characteristics

8.1 General

In-duct and noise radiated by the casing shall be measured as the acoustic characteristics. The following data shall be measured

— sound power level L_W

— overall A-weighted sound power level L_{WA}

— sound power levels in octave bands between 125 Hz and 8000 Hz

— corresponding air volume flow q_v

In case of units provided in several parts tests shall be done separately for the parts of the unit where either a fan or a compressor is installed.

The air volume flows for the acoustic measurements are defined as follows:

- ventilation only: maximum declared and reference air volume flow;
- other configurations: reference fresh air volume flow.

If the unit provides additional air flow rates (RCA, OEA) the sound power levels shall be determined according to the declaration of the manufacturer at maximum RCA and/or OEA air flow rate.

8.2 Configurations to be tested

As the ventilation function is the leading function, acoustic performance shall be tested in ventilation mode only. In addition one other operating configuration for the acoustic tests is chosen to take into account the additional sound source of the compressor(s).

When the unit can provide space heating (cooling) and/or DHW production, space heating (cooling) is chosen as the other configuration for testing.

When the unit does not provide any space heating (cooling) then the DHW production is chosen as the other configuration for testing.

This additional configuration is specified in Table 1.

8.3 Performance testing ventilation only

Acoustic measurement shall be carried out according to EN 13141-7 with the heat pumps off.

8.4 Performance testing ventilation and hydronic heating

The temperature conditions for acoustic tests shall refer to the mandatory point of Table 7.

The test procedure is as described in EN 12102; however the duct end correction shall be done according to EN ISO 5135.

8.5 Performance testing ventilation and supply air heating

The temperature conditions for acoustic tests shall refer to the mandatory point of Table 13.

The test procedure is as described in EN 12102; however the duct end correction shall be done according to EN ISO 5135.

8.6 Performance testing ventilation and supply air heating and hydronic heating

The temperature conditions for acoustic tests shall refer to the mandatory point of Table 7.

The test procedure is as described in EN 12102; however the duct end correction shall be done according to EN ISO 5135.

8.7 Performance testing ventilation and domestic hot water

Any units including a heat pump for domestic hot water shall be tested in a heating up period of the heat pump. That means the water in the storage tank at the beginning has approx. room temperature (20 °C).

The acoustic tests shall be done in the range of the tapping hot water temperature between 35 °C to 45 °C.

The test procedure is as described in EN 12102; however the duct end correction shall be done according to EN ISO 5135.

9 Test report

9.1 General information

The test report shall at least contain:

a) date;

b) test institute;

c) test location;

d) test method;

e) test supervisor;

f) test object designation:

   1) type;

   2) serial number;

   3) description of the object and qualitative visual inspections;

   4) unique identification of report;

g) name of the manufacturer;

h) year of initial installation;

i) type of refrigerant;

j) mass of refrigerant;

k) properties of fluids;

l) reference to this European Standard.

9.2 Additional information

Additional information given on the rating plate shall be noted and any other information relevant for the test. Particularly, it shall be stated whether the test is performed on a unit new or not. In the case of a test performed on a unit in use, information relative to the year of installation and heat exchange tubes cleaning shall be given.

9.3 Rating test results

9.3.1 Product specifications

The equipment specification shall be given as follows:

- declared maximum air volume flow: q_{vd} in l·s^{-1};
- reference air volume flow: q_{vn} in l·s^{-1};
- declared total pressure: p_{tUd} in Pa.
- filter class.

9.3.2 Leakages

The equipment leakages established shall be given in accordance with EN 13141-7.

9.3.3 Air flow/pressure curve

The air flow/pressure characteristic shall be given in accordance with EN 13141-7.

9.3.4 Temperature ratios of ventilation function

The temperature ratios (7.3.5) shall be reported at every mandatory and optional operating point in accordance with EN 13141-7.

9.3.5 Performance data of ventilation and domestic hot water functions

The performance data shall be reported according to 7.4.4 at every mandatory and optional point.

9.3.6 Performance data of ventilation and hydronic space heating and/or cooling

The performance data shall be reported according to 7.5.5 at every mandatory and optional point.

9.3.7 Performance data of ventilation and air heating and/or cooling

The performance data shall be reported according to 7.6.5 at every mandatory and optional point.

9.3.8 Performance data of ventilation with both hydronic and air heating/cooling

The performance data shall be reported according to 7.7.4 at every mandatory and optional point.

9.3.9 Performance data of ventilation with heating and hot water production

The performance data shall be reported according to 7.8.4 at every mandatory and optional point.

9.3.10 Performance data of ventilation with cooling and hot water production

The performance data shall be reported according to 7.9.4 at every mandatory and optional point.

9.4 Acoustic characteristics

For the measurement of noise radiated by the casing of the unit in accordance with Clause 8, the presentation of the results shall include:

- test method;
- corresponding air volume flow: q_v in l.s^{-1};
- corresponding pressure: p in Pa;
- sound power levels in octave band: L_W in dB between 125 Hz and 8 000 Hz;
- overall A-weighted sound power level: L_{WA} in dB(A).

For the sound power level at the duct connections of the unit in accordance with Clause 8, the presentation of the results shall include:

- test method;
- corresponding air volume flow: q_v in l.s^{-1};
- corresponding pressure: p in Pa;

and for each type of duct connection:

- sound power levels in octave band: L_W in dB between 125 Hz and 8 000 Hz;
- overall A-weighted sound power level: L_{WA} in dB(A).

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