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Test guideline for a load-based performance testing (corresponding to PythonPackage v1.0)

Hydronic heat pumps with electrically driven compressors for space heating

BAM, S.3 Ecodesign and energy labelling

Contact: Dr.-Ing. André Wachau, andre.wachau@bam.de

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1. Scope

This test guideline describes a test method for a load-based performance test of heat pumps in scope of regulation (EU) 811/2013. Not in scope are gas-fired heat pumps.

1.1 General

In accordance with EN 14511:2022 the procedures described in this test guideline apply to water-based heat pumps that are

a. air-source or ground-source;
b. water-sink or brine-sink;
c. package and single-split systems with matching assemblies;
d. intended for space-heating in buildings; and
e. rated below 70 kW heating capacity at declared design heating capacity (P_{designh})

2. Normative references

The test procedure follows the publications listed below, unless otherwise described in this document:

a. EN 14825:2022
b. EN 14511:2022

3. Terms and definitions

Terms and symbols used in this guideline in accordance with the referenced standards are listed in Table 1. Table 2 lists terms and symbols not defined in the referenced standards which are defined as follows:

$\boldsymbol{\vartheta_{\mathrm{H,calc}}}$
Temperature of mass H of the one-mass model calculated by solving equation (3) for a measured pair of supply temperature and heating capacity

$\boldsymbol{\vartheta_{\mathrm{H,in}}}$
Temperature at the mass H inlet, of the one-mass model. Calculated by solving equations (4) and (6).

$\boldsymbol{\vartheta_{\mathrm{B}}}$
Constant temperature of indoor environment equal to 20 °C.

$\boldsymbol{\vartheta_{\mathrm{R,calc}}}$
Return temperature calculated by solving equations (5) and (7), respectively, for a measured pair of supply temperature and heating capacity.

$\boldsymbol{\vartheta_{\mathrm{R,emu}}}$
Return temperature emulated by the test stand to meet the calculated temperature $\vartheta_{\mathrm{R,calc}}$.

$\boldsymbol{\Delta\vartheta_{\mathrm{BUH,calc}}(t)}$
Calculated supply temperature increase due to the virtual backup heater.

$\boldsymbol{\dot{Q}_{\mathrm{HB}}}$

Heat flux calculated between mass H and the constant indoor environment by solving equation (2) of the one-mass model.

$\dot{Q}_{\mathbf{BUH,calc}}$
Heat flux of the virtual backup heater.

$\dot{Q}_{\mathbf{BUH,real,max}}$
Maximum heat flux of the physical backup heater of the tested heat pump.

$P_{\mathbf{BUH,real,max}}$
Declared maximum electrical input power of the physical backup heater.

$UA_{\mathbf{HB}}$
Thermal conductivity of the one-mass model between mass H and B.

$\mathbf{C_H}$
Thermal capacity of mass H of the one-mass model.

$\Delta t_{\mathbf{step}}$
Time difference between each calculation step in the simulation.

$\Delta \vartheta_{\mathbf{i,cond}}$
Temperature difference between outlet and inlet of the indoor heat exchanger (condenser) of the unit under test.

$\Delta \vartheta_{\mathbf{i,cond,design}}$
Design temperature difference between outlet and inlet of the indoor heat exchanger (condenser) of the unit under test.

$\dot{m}_{\mathbf{w,H,design}}$
Design mass flow of the virtual heating system

Heating curve
Relationship between supply temperature and outdoor and/or indoor temperature to be set in the heat pump controller.

Continuous/steady state operation
No on/off cycling operation of the compressor.

Discontinuous cycling operation
Cycling between compressor on and off operation.

Table 1: Symbols, abbreviated terms, and units according to EN 14511:2022 and EN 14825:2022

Symbol and abbreviated terms	Denomination	Units
COP	Coefficient of Performance	-
DB	Dry bulb	°C
WB	Wet bulb	°C
$\dot{Q}_{\mathrm{designh}}$	Declared heating load at $T_{designh}$	kW

PLR_i	Part load ratio at test condition i	%
$P_h(T_j)$	Part-load capacity at temperature i	kW
$\dot{Q}_{\mathrm{HP}}$	Heating capacity	kW
T_{biv}	Bivalent temperature	°C
T_{designh}	Reference design temperature condition for heating	°C
TOL	Operation limit temperature	°C
$\vartheta_{i,A}$	Outdoor (ambient) temperature at test condition i	°C
$\vartheta_{\mathrm{B,set}}$	Indoor temperature set point of 20 °C	°C
ϑ_s	Indoor heat exchanger outlet water temperature (supply temperature)	°C
$\vartheta_{i,\mathrm{s,set}}$	Supply temperature set point at test condition i according to EN 14825:2022	°C
$\vartheta_{\mathrm{w,in}}$	Outdoor heat exchanger inlet water temperature (ground-source heat pumps)	°C
$\vartheta_{\mathrm{w,out}}$	Outdoor heat exchanger outlet water temperature (ground-source heat pumps)	°C

Table 2: Symbols, abbreviated terms and units introduced in this guideline

Symbol and abbreviated terms	Denomination	Units
ϑ_{B}	Constant building temperature of 20 °C	°C
$\vartheta_{\mathrm{R,calc}}$	Calculated return temperature	°C
$\vartheta_{\mathrm{R,emu}}$	Emulated return temperature (indoor heat exchanger inlet water temperature)	°C
$\Delta\vartheta_{\mathrm{BUH,calc}}(t)$	Calculated supply temperature increase due to virtual backup heater	°C
$\Delta\vartheta_{\mathrm{i,cond}}$	Temperature difference across the condenser	K
$\Delta\vartheta_{\mathrm{i,cond,design}}$	Design temperature difference across the condenser	K
$\dot{Q}_{\mathrm{BUH,calc}}$	Heat flux of the virtual backup heater.	W
$\dot{Q}_{\mathrm{BUH,real,max}}$	Maximum heat flux of the backup heater of the tested heat pump.	W
$P_{\mathrm{BUH,real,max}}$	Declared maximum electrical input power of the physical backup heater	W
$\dot{Q}_{\mathrm{HB}}$	Heat flux between mass H and mass B	W
$\dot{Q}_{\mathrm{BA}}$	Heat flux between mass B and the ambient	W
UA_{HB}	Thermal conductivity between mass H and B	W/K
C_H	Thermal capacity of mass H	J/K
$c_{\mathrm{p,w}}$	Specific heat capacity of water	J/K·kg
$\vartheta_{\mathrm{H,calc}}$	Calculated temperature of mass H	°C
$\vartheta_{\mathrm{H,in}}$	Calculated temperature at heat system's inlet	°C
Δt_{step}	Time step	s
$\dot{m}_{\mathrm{W,hp}}$	Water mass flow delivered by the heat pump	kg/s

$\dot{m}_{\mathrm{w,H,design}}$	Design mass flow of the heating system	kg/s
$m_{\mathrm{equi,w}}$	Equivalent minimum water mass declared by the manufacturer in the technical documentation	kg

4. Methodology and general requirements

During the load-based test described in this guideline, the heating circuit of the test stand is subjected to a compensation load emulating a building load. To emulate the inertia of the virtual building, the return temperature $\vartheta_{\mathrm{R,emu}}$ is controlled by the test stand according to a one-mass model. For each time step Δt_{step}, the model calculates the return temperature $\vartheta_{\mathrm{R,calc}}$ (output variable) based on the measured supply temperature ϑ_S, return temperature $\vartheta_{\mathrm{R,emu}}$, and mass flow rate $\dot{m}_{\mathrm{W,hp}}$ (input variables) of the unit under test. Thus, the test stand dynamically adapts the compensation load to match the calculated return temperature $\vartheta_{\mathrm{R,calc}}$. The heat pump responds in accordance with its heating curve as it tries to maintain the required supply temperature ϑ_s. The outdoor room shall maintain constant conditions over a temperature range associated with different climate zones for testing air-water heat pumps; for ground-sourced heat pumps the outdoor heat exchanger inlet water temperature $\vartheta_{\mathrm{w,in}}$ shall be maintained constant according to the referenced standards. All heat pumps under test (i.e., single-speed, multiple-speed, and variable-speed) shall be operated with their onboard control system (native control) active and not in a fixed-speed mode. The heat pumps are thus permitted to switch into on/off/defrost operation of the compressor.

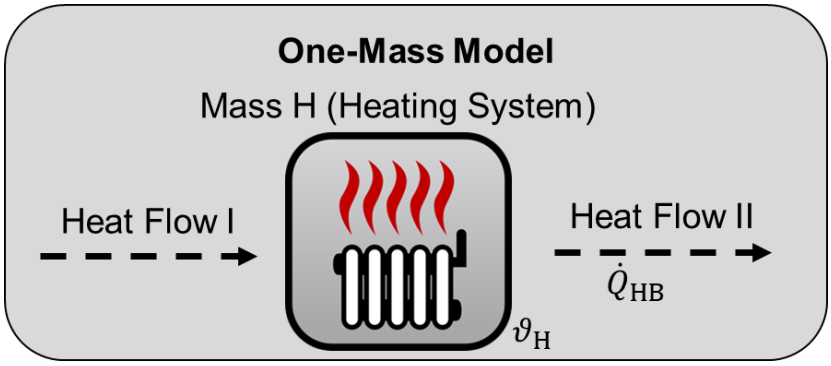


Figure 1: Schematic of the one-mass model.

The model conducts an ideal hydraulic switch that enables testing dynamic volume flows at a test point. When the mass flow of the heat pump exceeds the design mass flow, water flows through the hydraulic switch from the supply to the return pipe, leading to an increase in return temperature $\vartheta_{\mathrm{R,calc}}(t)$. If the heat pump maintains its supply temperature during this process, it indicates that the heat load aligns with the design specifications. When the mass flow from the heat pump is below design levels, the hydraulic switch enables mixing before reaching the heating system's inlet (water flows from the return to the supply pipe).

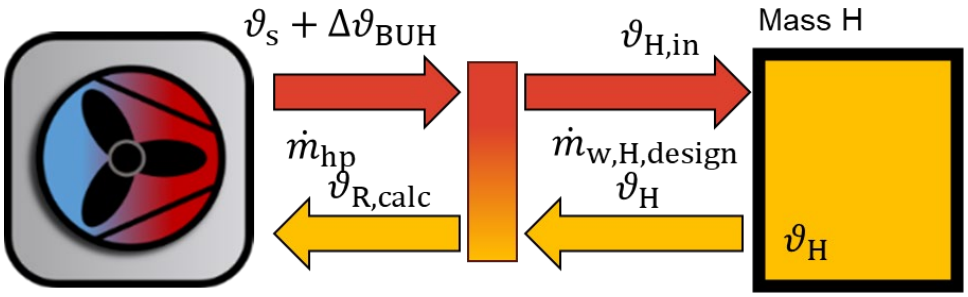


Figure 2: Simplified illustration of a hydraulic connection with a hydraulic switch

The virtual temperature at the heating system's inlet $\vartheta_{H,in}(t)$ can be used to reduce test repetitions. By emulating it and linking it back to the heat pump system, we can establish a target value for operation. If the heat pump maintains this inlet temperature, the heat load corresponds to the design load.

4.1 Installation

The units tested shall be installed in accordance with the installation manual from the manufacturer and EN14511-3:2022.

4.2 Heat pump settings

The heat pump controller shall be set by the test lab in accordance with the installation manual of the manufacturer

- for a single heating circuit without buffer or storage tank;
- with underfloor heating (low temperature application) or radiators (medium or high temperature application) enabled, depending on the temperature application;
- with the domestic hot water functions disabled (e.g. disabled three-way valve of heat pumps with integrated domestic hot water storage tank);
- with minimum damping of the outdoor temperature sensor feedback;
- with special operation modes disabled, such as night set-back, silent mode, lock times for grid operators;
- with disabled fault detection for external forced flow, if necessary and possible (see section 5.4).
- with temperature correction of the heat pump's outdoor air and supply temperature sensors, if applicable, to achieve minimum offset to the labs's corresponding temperature sensors.

Furthermore, the following information shall be provided by the manufacturer:

- the basic control strategy of the heat pump for changing the capacity (e.g. return temperature or supply temperature, fixed or variable flow, heating curve and/or indoor temperature control);
- access to the control elements which allow the adjustment of the heating curve to achieve the required supply temperature according to section 6.1;
- access to the circulation pump speed settings, if applicable.

It is not allowed to achieve the required supply temperature by setting a fixed supply temperature in the heat pump controller instead of using the heating curve.

4.3 Permissible deviations from set values

In dependence of the operating condition the following permissible deviations apply:

- During continuous/steady state and discontinuous cycling operation of the compressor the permissible deviations to be applied are shown in Table 3. Continuous operation / steady state operation starts when the permissible deviations specified in Table 3 are attained for at least 10 min.
- During off operation of the compressor the permissible deviations to be applied are shown in Table 3.
- In case of defrosting the permissible deviations according to EN14511-3:2022 Table 6 (Interval D and H) shall be applied.
- The arithmetic mean values shall be calculated by averaging complete cycles (e.g. period D plus H in case of defrost operation and on plus off periods in case of discontinuous cycling operation).

Table 3: Permissible deviations from set values during continuous/steady state and discontinuous cycling operation of the heat pump.

Measurand	Permissible deviation of the arithmetic mean values from set values	Permissible deviation of each individual measured values from set/calculated values
Outdoor heat exchanger (compressor on)		
Inlet air temperature (DB)	± 0.3K	± 1.0K
Inlet air temperature (WB)	± 0.4K	± 1.0K
Inlet water/brine temperature	± 0.2K	± 0.5K
(compressor off)		
Inlet air temperature (DB)	± 0.6K	± 2.0K
Inlet air temperature (WB)	± 0.6K	± 2.0K
Inlet water/brine temperature	-	-
Indoor heat exchanger (compressor on and off)		
Heating capacity	5 %	-
Emulated return temperature (all except period D during defrost)	-	± 0.5K*
Emulated return temperature (only period D during defrost)	-	+2/-5K
Electrical voltage (compressor on)	± 4%	± 4%*
Electrical voltage (compressor off)	± 4%	-

* Applies only when the circulation pump controlled by the heat pump is on and from 30 s after startup of the compressor.

5. Test setup

5.1 General recommendations

Brine/water and water/water heat pumps are measured on the sink and source side using the enthalpy method in accordance with EN 14511-3:2022. Air/water heat pumps are measured on the sink side using the liquid enthalpy method according to EN 14511-3:2022.

5.2 One-mass model

As outlined in section 4 the test stand shall control the return temperature $\vartheta_{\mathrm{R,emu}}$ (and the indoor temperature $\vartheta_{\mathrm{B,emu}}$, where appropriate,) based on the measured supply temperature ϑ_s and heating capacity $\dot{Q}_{\mathrm{HP}}$ of the unit under test, according to the equations (1)-(21). The calculation and recording frequency Δt_{step}shall be 1 second or lower. The following equations use values of the current time step t to calculate the values for the next time step $t + \Delta t_{step}$.

$$\dot{Q}_{\mathrm{HP}}(t) = \dot{m}_{\mathrm{W}} \cdot c_{p,\mathrm{w}} \cdot \left(\vartheta_{\mathrm{s}}(t) - \vartheta_{\mathrm{R,emu}}(t)\right) \quad (1)$$

$$\dot{Q}_{\mathrm{HB}}(t) = UA_{\mathrm{HB}}(T_i) \cdot \left(\frac{\vartheta_{\mathrm{H,in}}(t)+\vartheta_{\mathrm{H,calc}}(t)}{2} - \vartheta_{\mathrm{B}}\right) \quad (2)$$

$$\vartheta_{\mathrm{H,calc}}\left(t+\Delta t_{step}\right) = \vartheta_{\mathrm{H,calc}}(t) + \frac{\left(\dot{Q}_{\mathrm{HP}}(t)+\dot{Q}_{\mathrm{BUH,calc}}(t)-\dot{Q}_{\mathrm{HB}}(t)\right)\cdot\Delta t_{\mathrm{step}}}{c_{\mathrm{H}}} \quad (3)$$

The delivered mass flow by the heat pump and the backup heater $\dot{m}_{\mathrm{w,hp}}(t)$ with the temperature $(\vartheta_{\mathrm{s}}(t) + \Delta\vartheta_{\mathrm{BUH,calc}}(t))$ flows into the virtual hydraulic switch. Depending on the mass flow, additional water is mixed or removed reaching the heating system's inlet with the temperature $\vartheta_{\mathrm{H,in}}(t)$ and the mass flow $\dot{m}_{\mathrm{w,H,design}}$. From the outlet of the heating system, the mass flow $\dot{m}_{\mathrm{w,H,design}}$ with the temperature $\vartheta_{\mathrm{H,calc}}(t)$ flows into the hydraulic switch. Behind the switch the mass flow $\dot{m}_{\mathrm{w,hp}}(t)$ with the temperature $\vartheta_{\mathrm{R,calc}}(t)$ reaches the heat pump's inlet.

Both temperatures behind the hydraulic switch are calculated depending on the heat pump's mass flow:

If the mass flow delivered by the heat pump is lower or equal than the design mass flow of the heating system ($\dot{m}_{\mathrm{w,hp}}(t) \leq \dot{m}_{\mathrm{w,H,design}}$):

$$\vartheta_{\mathrm{H,in}}(t) = \frac{\dot{m}_{\mathrm{w,hp}}(t)\cdot(\vartheta_{\mathrm{s}}(t) + \Delta\vartheta_{\mathrm{BUH,calc}}(t)) - \left(\dot{m}_{\mathrm{w,hp}}(t) - \dot{m}_{\mathrm{w,H,design}}\right)\cdot\vartheta_{\mathrm{H,calc}}(t)}{\dot{m}_{\mathrm{w,H,design}}} \quad (4)$$

$$\vartheta_{\mathrm{R,calc}}(t) = \vartheta_{\mathrm{H,calc}}(t) \quad (5)$$

If the mass flow delivered by the heat pump is higher than the design mass flow of the heating system ($\dot{m}_{\mathrm{w,hp}}(t) > \dot{m}_{\mathrm{w,H,design}}$), the temperature at the supply line is not influenced but the return temperature at the heat pump's inlet is increased.

$$\vartheta_{\mathrm{H,in}}(t) = (\vartheta_{\mathrm{s}}(t) + \Delta\vartheta_{\mathrm{BUH,calc}}(t)) \quad (6)$$

$$\vartheta_{\mathrm{R,calc}}(t) = \frac{\dot{m}_{\mathrm{w,H,design}}\cdot\vartheta_{\mathrm{H,calc}}(t) + \left(\dot{m}_{\mathrm{w,hp}}(t) - \dot{m}_{\mathrm{w,H,design}}\right)\cdot(\vartheta_{\mathrm{s}}(t) + \Delta\vartheta_{\mathrm{BUH,calc}}(t))}{\dot{m}_{\mathrm{w,hp}}(t)} \quad (7)$$

The design mass flow of the heating system is defined depending on the temperature level:

High or medium temperature level:

$$\dot{m}_{\mathrm{w,H,design}} = \frac{Ph(PLC = E)}{c_{\mathrm{p,w}}\cdot 8\ \mathrm{K}} \quad (8)$$

Low temperature level:

$$\dot{m}_{\mathrm{w,H,design}} = \frac{Ph(PLC = E)}{c_{\mathrm{p,w}}\cdot 5\ \mathrm{K}} \quad (9)$$

The heat flux of the virtual backup heater $\dot{Q}_{\mathrm{BUH,calc}}$ is calculated as follows:

a) In case of deactivated virtual backup heater $\dot{Q}_{\mathrm{BUH,calc}} = 0$
b) In case of activated virtual backup heater (see section 6.1, option b)

$$\dot{Q}_{\mathrm{BUH,calc}}(t) = \mathrm{Ph(Tj)} - \dot{m}_{\mathrm{w}}\cdot c_{p,\mathrm{w}}\cdot\left(\vartheta_{\mathrm{s}}(t) - \vartheta_{\mathrm{r}}(t)\right) \quad (10)$$

The power $\dot{Q}_{\mathrm{BUH,calc}}$ cannot be negative. Additionally, the backup heater power is limited to a maximum power equal to the declared maximum power of the real backup heater.

$$\max\left(\dot{Q}_{\mathrm{BUH,calc}}(t)\right) = \dot{Q}_{\mathrm{BUH,real,max}} = P_{\mathrm{BUH,real,max}} \tag{11}$$

$$\min\left(\dot{Q}_{\mathrm{BUH,calc}}(t)\right) = 0 \tag{12}$$

The additional temperature lift through the backup heater $\Delta\vartheta_{\mathrm{BUH,calc}}(t)$ is considered as follows:

For $\dot{Q}_{\mathrm{BUH,calc}}(t) \leq \dot{Q}_{\mathrm{BUH,real,max}}$:

$$\Delta\vartheta_{\mathrm{BUH,calc}}(t) = \frac{\dot{Q}_{\mathrm{BUH,calc}}(t)}{\dot{m}_{\mathrm{w,hp}} \cdot c_p} \tag{13}$$

For $\dot{m}_{\mathrm{w,hp}} = 0$:

$$\Delta\vartheta_{\mathrm{BUH,calc}}(t) = 0 \tag{14}$$

The initial values at t_0 for the temperature of both masses are defined by following equations. The point in time t_0 ist defined as the end of the preconditioning phase, and the start of the measurement.[1]

- Initial transfer system mass temperature

$$\vartheta_{\mathrm{H,calc}}(t_0) = \vartheta_{i,\mathrm{s,set}} - \Delta\vartheta_{\mathrm{i,cond}} \tag{35}$$

with

$$\Delta\vartheta_{\mathrm{i,cond}} = \frac{\mathrm{Ph}(\mathrm{T_j})}{\dot{m}_{\mathrm{w,H,design}} \cdot c_{p,\mathrm{w}}} \tag{16}$$

Note: UA and C values are defined in section 6.

5.3 Circulation pump operation

For heat pumps with an integrated circulation pump, this pump shall be used for the test and controlled by the unit itself. For heat pumps without an internal circulation pump the unit's control signal shall be used to operate the circulation pump of the test stand's heating circuit.

Note: When the heat pump switches off the circulation pump during off periods of the compressor, heat can no longer be dissipated (e.g. via the heat exchanger between primary and secondary circuit of an indirect test stand), and the test stand cannot follow the calculated return temperature $\vartheta_{\mathrm{R,calc}}$anymore. Except for very fast test stands, the permissible deviations will be violated when the compressor and circulation pump turn on again. In this case it is

[1] The model has to be restarted to calculate the initial temperatures at t_0.

necessary to ensure sufficient flow in the heating circuit during off periods by an external pump.

5.4 Ambient indoor conditions

The ambient around the indoor heat exchanger shall be at (20 ± 2) °C during the test to ensure high reproducibility if the heat pump controller processes measured return temperatures during off-periods of the circulation pump (standing water).

6. Test conditions and model parameterization

6.1 Test conditions

Part load ratios are calculated according to EN 14825:2022. In accordance with the standard the part load capacities are calculated as follows.

$$\mathrm{Ph}(\mathrm{T}_i) = \dot{Q}_{\mathrm{designh}} \cdot PLR_i \tag{174}$$

For test conditions with $\vartheta_{i,A} < T_{\mathrm{biv}}$ the heating capacity and electrical power consumption of the electrical backup heater are considered as follows:

a) If the heat pump can be operated with an electrical backup heater, the backup heater shall be activated during the test.
b) If the heat pump does not allow to be operated with an electrical backup heater, a virtual electrical backup heater shall be added to the two-mass model (behind the indoor heat exchanger outlet) according to equations (3), (4), (6), (7) and (10)-14).

For ground source heat pumps only the inlet water temperature of the outdoor heat exchanger $\vartheta_{\mathrm{w,in}}$ is defined according to EN 14825:2022. The outlet temperature $\vartheta_{\mathrm{w,out}}$ is only controlled by the tested unit, prescriptions on the temperature difference between inlet and outlet water temperature or the flow rate do not apply.

During discontinuous cycling operation the set point for the supply temperature ϑ_{s} must be achieved by averaging full cycles of on and off periods. During defrost operation the set point for the supply temperature ϑ_{s} shall be reached by averaging interval H+D (whole cycles).

6.2 Model parameterization

The thermal conductivity $(UA)_{\mathrm{HB}}$ and the thermal capacity C_{H} are determined as follows:

a) For each test point, the thermal conductivity is calculated to fit the part-load capacity $\mathrm{Ph}(\mathrm{T}_i)$:
The thermal conductivity $(UA)_{\mathrm{HB}}(\mathrm{T}_i)$ is defined as follows:

$$(UA)_{\mathrm{HB}}(\mathrm{T}_i) = \frac{Ph(T_i)}{\vartheta_{i,s,\mathrm{set}} - 0.5\,\Delta\vartheta_{\mathrm{i,cond}} - \vartheta_{B,\mathrm{set}}} = \frac{Ph(T_i)}{\frac{\vartheta_{i,s,\mathrm{set}} + \vartheta_{\mathrm{H,calc}}(t_0)}{2} - \vartheta_{B,\mathrm{set}}} \tag{18}$$

b) the thermal capacity C_{H} for the equation (19) are the same for all part-load conditions $\mathrm{Ph}(\mathrm{T}_i)$. Capacity C_{H} are determined by using the full-load conitions of $\mathrm{Ph}(PLC = E)$:

$$C_{\mathrm{H}} = \tau_{\mathrm{H}} \cdot (UA)_{\mathrm{HB}}(PLC = E) \tag{19}$$

An additional water mass is necessary if the equivalent water mass is below the minimum water mass declared by the manufacture in the technical documentation. The equivalent water mass can be calculated as follow:

$$m_{\mathrm{equi,w}} = \frac{C_{\mathrm{H}}}{c_{\mathrm{p,w}}} \tag{20}$$

In this case, the thermal capacity of the heating system C_{H} has to be increased by a virtual buffer tank resulting in an additional water mass $m_{\mathrm{w,tank}}$. Therefore, the capacity is calculated by:

$$C_{\mathrm{H}} = \tau_{\mathrm{H}} \cdot (UA)_{\mathrm{HB}}(PLC = E) + m_{\mathrm{w,tank}} \cdot c_{\mathrm{p,w}} \tag{21}$$

Table 4: Time constants to be used to calculate the thermal capacity C_H for the high, medium, and low temperature applications without additional buffer tank volume.

Temperature application	**Time constant heat transfer system τ_H**
Low (Underfloor heating)	$21.38 \cdot 10^3\ s$
High and Medium (Radiator)	$2.38 \cdot 10^3\ s$

7. Test procedure

The methodology of the load-based test is described in section 4. In Figure 2 the test preparation and test procedure are shown.

7.1 Flow settings

The settings for fixed flow and variable flow units shall be done in accordance with the installation manual of the manufacturer. If no information is available on the mass flow $\dot{m}_{\mathrm{W}}$ or the temperature difference $\Delta\vartheta_{\mathrm{i,cond}}$ across the condenser, respectively, the settings shall be determined as described in EN14511-2:2022 under test condition E.

7.2 Test preparation (Pre-Conditioning phase)

Prior to each test interval, the deviation between the arithmetic mean value of the measured supply temperature ϑ_{s} and the set value $\vartheta_{i,s,\mathrm{set}}$ is checked (compare section 6.1). If the occurring deviations are within the permissible deviations of Table 3 for at least 10 minutes, the next period of the test procedure can be started.

If it is not possible to stay within the permissible deviations of the arithmetic mean values from the set values (Table 3), the control parameters of the unit under test shall be adjusted according to the installation manual of the manufacturer to utmost achieve the required supply temperature set point $\vartheta_{i,\mathrm{s,set}}$. It is permissible to set each operating point individually. In case the heat pump has a heating curve function relying on outdoor temperature it shall be used.

If a defrost process occurs during this phase the next period of the test procedure shall not be started before the end of the defrost cycle and a recovery period of 10 min.

7.3 Test procedure

A/W heat pump

Each test interval includes three major parts following EN14511-3:2022:

1) Pre-conditioning phase
   After properly setting the heating curve, a defrost process shall be initiated before the measurement starts (definitions according to EN14511-3:2022).
2) Equilibrium phase of
   a. at least 60 min if no defrost occurs or
   b. at least one complete defrost cycle. The data collection period starts immediately after the defrost process is finished.
3) Data collection period of
   a. at least 3 complete defrost cycles, if defrost operation occurs - if it takes more than 6 h to record 3 cycles the measurement can be stopped (compare section 8.1);
   b. at least 2 cycles, if continuous cycling operation;
   c. at least 3 on/off cycles, if discontinuous cycling operation.

The test intervals shall be carried out in the following order:

1. Test interval F (if applicable)
2. Test interval E
3. Test interval A
4. Test interval B
5. Test interval C
6. Test interval D

W(B)/W(B) heat pump

Each test interval includes two major parts following the EN14511-3:

1) Pre-conditioning phase
2) Data collection period of
   a. at least 35 min, if steady state operation,
   b. at least 2 cycles, if continuous cycling operation
   c. or at least 3 on/off cycles, if discontinuous cycling operation.

The test intervals shall be carried out in the following order:

1. Test interval F (if applicable)
2. Test interval E
3. Test interval A
4. Test interval B
5. Test interval C
6. Test interval D

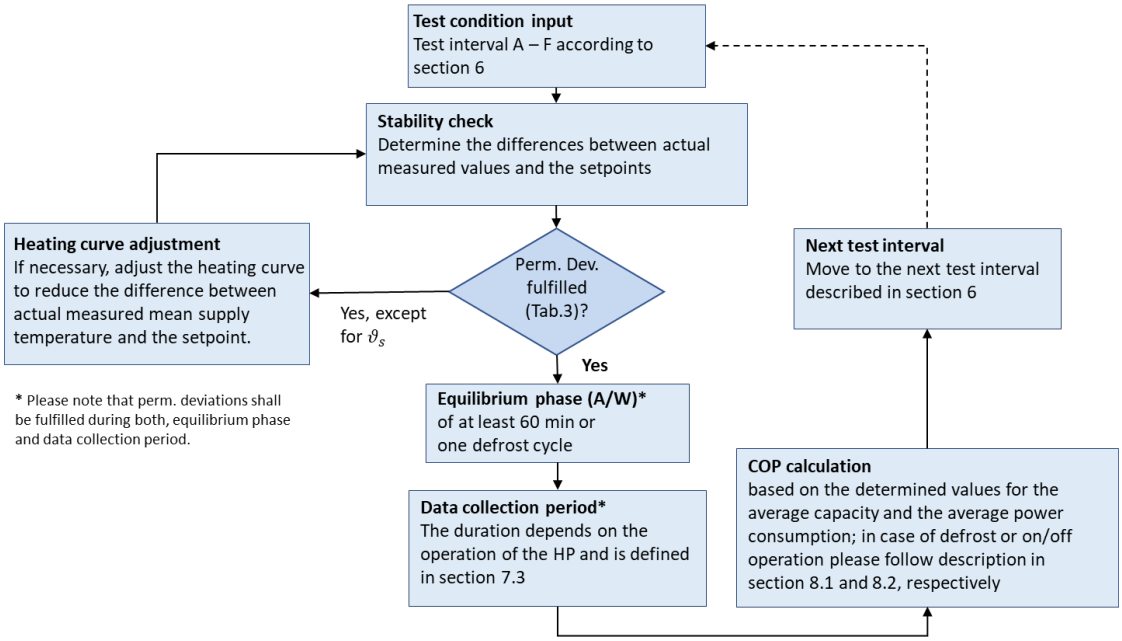


Figure 3: Test procedure

The capacity tests in each test point shall be carried out according to the prescribed procedure in Figure 2 and the test conditions according to section 6.

8. Evaluation of measurement data

Measurement data are evaluated in accordance with EN 14825:2022. The following points shall be considered.

8.1 Defrost operation

Only full defrost cycles (period H plus D according to EN 14511:2022) shall be used for COP calculation as follows:

- Use the test interval containing all complete defrost cycles which were recorded before the maximum test time of 6 hours elapsed (e.g. 2 or 1 cycles);
- Use the entire test interval of 6 hours if no defrost occurred.
- Manually initiated defrost periods shall not be considered

8.2 On/Off operation

If the heat pump switches to cyclic operation during the test, the average heating capacity and the average power consumption considering the entire test interval time (incl. off cycles of the heat pump) and at least 3 on/off cycles shall be used for the COP calculation, beginning at the start of an on-cycle and ending at the end of an off-cycle.

8.3 Pump Correction

The measured heating capacity shall be corrected for the heat from the circulating pump, in accordance with EN 14511-3:2022. The effective power input shall be obtained from the

measured power input and the corrections from the heat from the circulating pump and/or fan, if any.

9. Annex

9.1 Test setup – best practice examples

- Implement model equations in test bench control. A Python script is available at Github. Use the same version as the guideline.
- Check for delays in the setup and reduce below 30s