Criteria and algorithms for Certified Passive House Components: Drain Water Heat Recovery

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1 Criteria

Passive Houses provide optimal comfort with minimum energy costs; in addition, they are usually within the economically optimum range with reference to their life-cycle costs provided that competent planning is carried out and the necessary building components are available under functioning market conditions. Stringent criteria apply for the components used in Passive Houses. The criteria for certified Passive House components for heat recovery from shower water are derived from the following efficiency criterion:

1.1 Efficiency criterion

Under standardised boundary conditions (balanced flow, cold water temperature 10 °C, shower head temperature 40 °C, waste water temperature 35 °C, negligible pipe lengths, indoor temperature 20 °C, shower duration 6 minutes, volume flow rate 8 litres/minute), the system reduces the useful energy expenditure for shower water by at least

30 %*

* Note: Due to the temperature loss in the shower and to dynamic effects the useful energy savings typically amount to 75-80% of the stationary efficiency as defined in section 2.2.

1.2 Passive House Efficiency Classes

Systems are divided into Efficiency Classes according to the amount of useful energy saved:

Table 1: Passive House Efficiency Classes for Drain Water Heat Recovery

Shower water - useful heat saved	**Passive House Efficiency Class**	**Description**
≥ 60%	phA+	Very advanced component
≥ 50%	phA	Advanced component
≥ 40%	phB	Basic component
≥ 30%	phC	Certifiable component
< 30%		Not certifiable

2 Verification of certifiability, certificate

Evaluation of the HR systems will take place based on two parameters:

Stationary temperature ratio $\eta_{stationary}$ and effective dead time t_{dead}.

2.1 Boundary conditions

The parameters are determined under the following boundary conditions:

Volume flow rate*: 8 l/min
Temperature of cold water: 8 to 13 °C
Ambient temperature: 18 to 25 °C
Temperature of waste water: 35 to 39 °C

* Balance of waste water and cold water. Approximate conversion to disbalanced operation only takes place in the energy balance tool for buildings PHPP (Passive House Planning Package). In principle,

large devices for e.g. multi-storey buildings, swimming pools, etc. with other volume flow rates are also certifiable, in which case the nominal volume flow rate will be clearly stated on the certificate.

2.2 Stationary temperature ratio

The temperature ratio

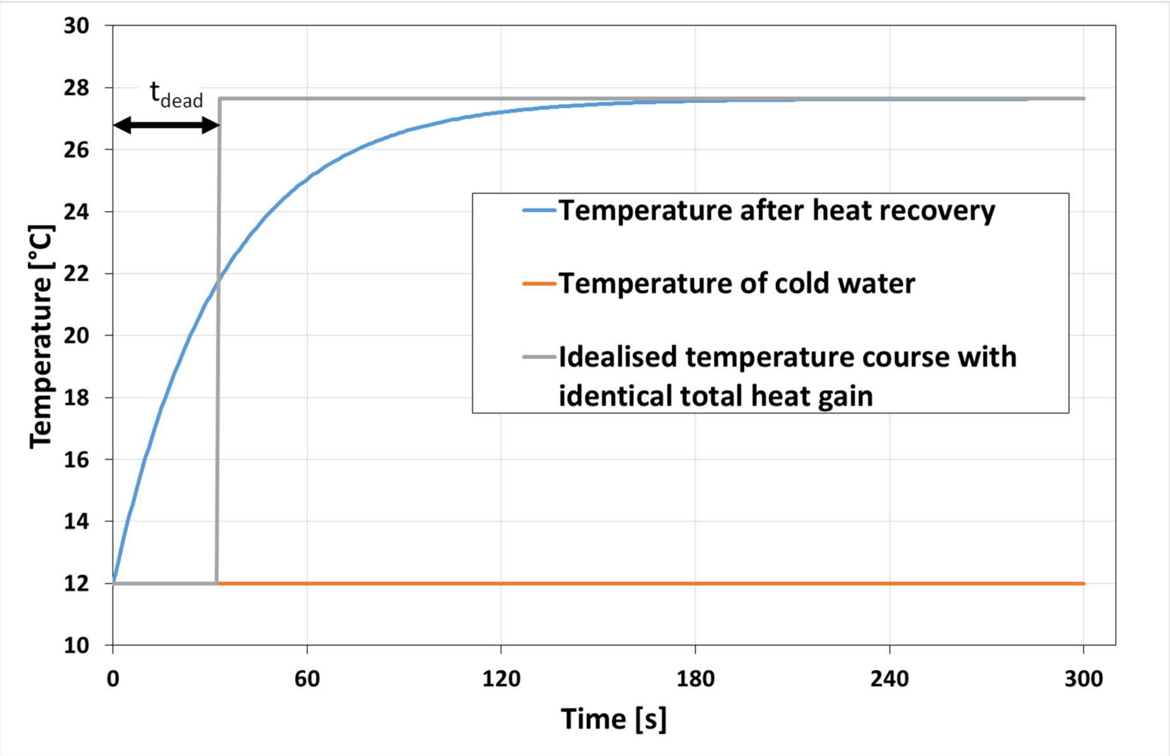
$$\eta_{stationary} = (T_{HR} - T_{cold\ water})/(T_{waste\ water} - T_{cold\ water})$$

characterises the degree of efficiency in steady-state continuous operation. Here, T_{HR} is the temperature of the cold water downstream of the heat exchanger.

2.3 Effective dead time

After the start of the shower process, temperatures will only gradually approach their values in steady state; an approximately exponential increase is typical. This is characterised as the "effective dead time" t_{dead}.

The following chart illustrates the term effective dead time for a greatly simplified case. The method for calculating the effective dead time is explained in Section 3.2.



2.4 Pressure drop

For informational purposes only, pressure drop on the fresh water side will be stated with the nominal volume flow rate (typically 8 l/min).

2.5 Connections

For informational purposes only, the sizes of the connecting pieces for waste water and fresh water will be stated.

2.6 Hygiene

Hygienic requirements are *not* tested in the certification process. However, as a prerequisite for certification, the manufacturer has to testify comprehensibly that the unit fulfils the requirement of EN 1717 for a double-wall separation of waste water and fresh water.

3 Testing method

Determination of the stationary efficiency and the effective dead time will preferably take place jointly in a single measurement with a duration of 6 to 8 minutes. In doing so, the stationary efficiency can be determined from the temperatures during the last 20 seconds of the measurements.

Tests based on CAPE/RECADO-PQE, NEN 7120 or CSA B55 can be used. In some circumstances, raw data from the measurement or additional information may be required for this. Details must be agreed with the Passive House Institute.

The measurement will take place in an independent test laboratory.

3.1 Stationary efficiency

The stationary efficiency should be measured with balanced mass flows (i.e. mass flow of waste water equal to mass flow of cold water) under the boundary conditions mentioned in Section 2.1. The measurement accuracy for the temperatures must be better than ±1 K; a maximum of ±0.2 K should be strived for. The result must be determined as an average value from at least 20 consecutive measurement points, taken during an interval of at least 20 s. Temperatures at the heat exchanger may not fluctuate more than ±1 K during the measurement period.

3.2 Effective dead time

For determining the effective dead time, the heat exchanger and the water inside it must first be brought to room temperature. For this purpose, a rest time of at least 12 hours is appropriate. Hot and cold water is passed through the heat exchanger with balanced mass flows right from the start of the measurement. The temperatures at the heat exchanger connecting pieces and the mass flows are measured at intervals of 1 s at the most. The following heat quantities are calculated from these:

$$Q_{max} = \int \dot{m} c_p (T_{waste\ water} - T_{cold\ water})\, dt$$

$$Q_{HR} = \int \dot{m} c_p (T_{HR} - T_{cold\ water})\, dt$$

Here, T_{HR} is the temperature of the cold water downstream of the heat exchanger, Q_{max} is the maximum heat quantity which can be extracted from the waste water, and Q_{HR} is the heat quantity which is actually extracted. The duration of the entire measurement should be between 6 and 8 minutes.

The effective dead time t_{dead} is defined by the following equation

$$\begin{aligned} Q_{HR} &= \eta_{stationary} \dot{m} c_p (T_{waste\ water} - T_{cold\ water})(t_{total} - t_{dead}) \\ &= \eta_{stationary} Q_{max} - \eta_{stationary} \dot{m} c_p (T_{waste\ water} - T_{cold\ water}) t_{dead} \end{aligned}$$

This results in

$$t_{dead} = \frac{Q_{max} - \frac{Q_{HR}}{\eta_{stationary}}}{\dot{m}c_p(T_{waste\ water} - T_{cold\ water})}$$

Average values for $\dot{m}$, c_p and the temperatures during the measurement period should be used for the calculation.

3.3 Pressure loss

The pressure loss is taken from measurement data, too. If no measurements at the nominal volume flow rate are available, measured values are linearly interpolated. This results in a conservative estimate for the pressure loss. Extrapolation to higher flow rates, if required, is only possible under conservative assumptions, too, i.e. assuming a fully turbulent flow ($\Delta p \sim Q^2$).

4 Services provided by the Passive House Institute

1. Calculation of the characteristic values $\eta_{stationary}$ and t_{dead} based on the data provided by the client
2. Classification into a Passive House Efficiency Class
3. Issue of the certificate including presentation of the certifiied product on the Passive House Institute website.

5 Coming into effect, transitional provisions, further development

The criteria and algorithms for certified Passive House components for Drain Water Heat Recovery come into effect in full with the publication of this document. The Passive House Institute reserves the right to make future amendments.

6 Certification procedure