



BSI Standards Publication

## Heat exchangers — Test procedures for establishing performance of air to air heat recovery components

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## National foreword

This British Standard is the UK implementation of EN 308:2022. It supersedes BS EN 308:1997, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/30, Heat exchangers.

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

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English Version

## Heat exchangers - Test procedures for establishing performance of air to air heat recovery components

Échangeurs thermiques - Procédures d'essai pour la détermination de la performance des composants de récupération de chaleur air/air

Wärmeaustauscher - Prüfverfahren zur Bestimmung der Leistungskriterien von Luft/Luft-Wärmerückgewinnungsanlagen

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**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

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## European foreword

This document (EN 308:2022) has been prepared by Technical Committee CEN/TC 110 “Heat exchangers”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by September 2022, and conflicting national standards shall be withdrawn at the latest by September 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 308:1997.

This edition includes the following significant technical changes with respect to EN 308:1997:

- Scope: flue gas heat recovery devices are no more included.
- In addition to laboratory tests of heat recovery components (HRC), laboratory tests for HRC fitted into air handling units and on-site tests of HRC are defined.
- Different precision classes for tests are defined.
- Leakage testing has been refined. Exhaust air transfer ratio (EATR) and outdoor air correction factor (OACF) are implemented.
- Differences of the sensible and latent efficiency can occur due to leakages and bad heat balance.
- Several terms and definitions are changed, e.g. categories of heat recovery components.
- Type A test is only on the heat exchanger and does not necessarily give a representative value when it is installed, corrections may be needed.

EN 13053 refers to EN 308 regarding the test setup and the test procedure. EN 13053 is a standard harmonized with the Commission Regulation (EU) 1253/2014 [5].

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## Introduction

This document specifies methods for the performance testing of air-to-air heat recovery components (HRC) used in ventilation systems. This document does not contain any information on air handling units, ductwork and components of air distribution, which are covered by other European Standards. The document applies for laboratory and in on-site testing. Further it applies to different purposes of tests, which can be e.g. certification of products, acceptance of installed products, market surveillance or quality tests of manufacturers.

These different applications do not require the same precision of measurements results. Therefore, different precision classes are defined. Table 1 gives informative examples for the application of the different test types and precision classes. For low quality products, low quality installations and/or simplified testing, a 'not classified' precision class can occur for all test types.

**Table 1 — Examples for the application of the different test types and precision classes**

| Test Type                                                                                                                       | Precision class P1<br>(high precision)                                                     | Precision class P2<br>(medium precision)                            | Precision class P3<br>(low precision)     | not classified          |
|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------|-------------------------|
| <b>Test type A</b><br>HRC installed in a test casing or HRC-section<br>Tested in laboratory                                     | — certification or declaration of products<br>— performance test                           | — test of functionality                                             | — not intended use                        | — not intended use      |
| <b>Test type B</b><br>HRC installed in an AHU <sup>a</sup><br>Tested in laboratory                                              | — test under ideal conditions                                                              | — certification or declaration of products<br>— performance test    | — test of functionality                   | — not intended use      |
| <b>Test type C</b><br>HRC installed in an AHU <sup>a</sup> or in duct work of an installed ventilation system<br>Tested on-site | — not intended use, but possible under ideal conditions and laboratory-like test equipment | — test under ideal conditions in real systems<br>— performance test | — typical test conditions in real systems | — test of functionality |
| <sup>a</sup> The HRC is installed in an AHU (air handling unit) by the manufacturer of the AHU.                                 |                                                                                            |                                                                     |                                           |                         |

Customers and manufacturers are free to define the aspired precision class for testing of their products, but it will be taken into account that the available precision class depends on the test conditions, the HRC itself, the measurement equipment and the environment conditions.

This document is one of a series of European Standards dedicated to heat exchangers.

Note 1 Testing procedure of residential ventilation units, RVU's, is covered by EN 13141-7 and EN 13141-8.

Note 2 EN 13053 deals with non-residential ventilation units, NRVU's, specifically Air Handling Units (AHU's). For testing of the heat recovery, EN 13053 refers to EN 308.

## 1 Scope

This document specifies methods to be used for testing of air-to-air heat recovery components (HRC). The main purpose of the HRC is to exchange heat between exhaust air and supply air in order to save energy, which results in

- preheat or heat, and/or
- precool or cool

supply air in ventilation systems or air conditioning systems. Optionally HRC can exchange air humidity between exhaust and supply air. The HRC contains the heat exchangers and all necessary features and auxiliary devices for the exchange of sensible heat and (if available) air humidity between exhaust air and supply air. The HRC will be installed in casings or ducts. If fans are part of the test unit, the effect of the fan power on the measured values will be corrected.

This document specifies procedures and input criteria required for tests to determine the performance of a HRC at one or several test conditions, each of them with continuous and stationary air flows, air temperatures and humidities at both inlet sides. Three different test types are covered:

- Test type A, Laboratory testing of HRC installed in test casings (A1) or a HRC sections (A2);
- Test type B, Laboratory testing of HRC installed in non-residential ventilation units<sup>1</sup> in design configuration;
- Test type C, on-site (field) testing of HRC in non-residential ventilation units (C1) or a HRC sections (C2) in operation configuration.

This document is applicable to recuperators, regenerators, and HRC with intermediary heat transfer medium.

This document prescribes test methods for determining:

- 1) the temperature and humidity efficiency,
- 2) the pressure drop of exhaust air and supply air sides,
- 3) possible internal leakages; exhaust air transfer ratio (EATR) and outdoor air correction factor (OACF),
- 4) external leakages and
- 5) auxiliary energy used for the operation of the HRC.

HRC using heat pumps are not covered by this document.

---

<sup>1</sup> Definition according Commission Regulation (EU) No 1253/2014 [5].

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1886, *Ventilation for buildings — Air handling units — Mechanical performance*

EN 13053, *Ventilation for buildings — Air handling units — Rating and performance for units, components and sections*

JCGM 100, *Evaluation of measurement data — Guide to the expression of uncertainty in measurement*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

### 3.1 Air categories

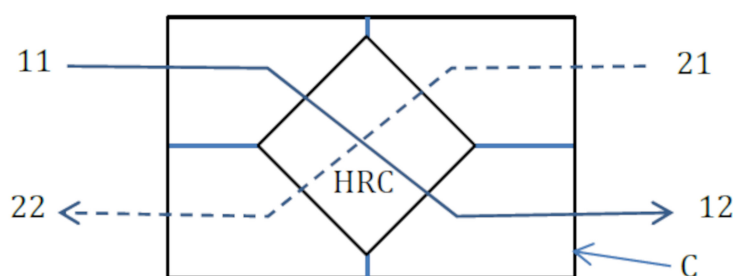
#### 3.1.1

##### exhaust air inlet

air to be exhausted from the application, before entering the HRC

Note 1 to entry: In ventilation systems, this air is usually called extract air.

Note 2 to entry: Figure 1 shows the definition of the air flow categories in heat recovery components (HRC).



#### Key

|    |                    |     |                         |
|----|--------------------|-----|-------------------------|
| 11 | Exhaust air inlet  | 22  | Supply air outlet       |
| 12 | Exhaust air outlet | HRC | Heat recovery component |
| 21 | Supply air inlet   | C   | Casing                  |

Figure 1 — Air categories

#### 3.1.2

##### exhaust air outlet

air in exhaust condition, intended to be blown back to the environment, after leaving the HRC

Note 1 to entry: In ventilation systems, this air is usually called exhaust air.

Note 2 to entry: See Figure 1.

### 3.1.3

#### **supply air inlet**

air intended for the application, before entering the HRC

Note 1 to entry: In ventilation systems, this air is usually called outdoor air. Sometimes this air does not come directly from outdoor (preheated space, ground heat exchanger, etc.)

Note 2 to entry: See Figure 1.

### 3.1.4

#### **supply air outlet**

air intended for the application, after leaving the HRC

Note 1 to entry: See Figure 1.

## 3.2 Thermal performance characteristics

### 3.2.1

#### **temperature efficiency**

$$\eta_{l,efy}$$

transfer of sensible heat from exhaust to supply air, with correction of the temperature increase of the supply air outlet caused by the EATR and a correction in case of a bad heat balance, to be used for the description of the performance characteristic of a HRC

Note 1 to entry: The determination is according to 6.1.6.

Note 2 to entry: No definitions of temperature efficiency on the exhaust-air side are included. If data on the exhaust-air side is required, conditions can be calculated by heat and mass balances, considering leakage and EATR.

Note 3 to entry: The temperature efficiency depends on the supply air mass flow and on the mass flow ratio between the supply air flow and the exhaust air flow.

### 3.2.2

#### **temperature gross efficiency**

$$\eta_{l,gro}$$

temperature difference on the supply air side divided by the temperature difference between exhaust air inlet and supply air inlet

Note 1 to entry: The determination is according to 6.1.6.

Note 2 to entry: The temperature gross efficiency does not regard internal or external leakages or heat flow through the casing. The temperatures  $\theta_{11}$ ,  $\theta_{21}$  and  $\theta_{22}$  can differ from measured values, see 6.1.6.2.

Note 3 to entry: In Regulation (EU) 1253/2014 [5], the same equation is used. There, the definition is called 'thermal efficiency of a non-residential HRS ( $\eta_{t,nrvu}$ )' and shall be measured under dry reference conditions, with balanced mass flows, an indoor-outdoor air temperature difference of 20 K, excluding thermal heat gain from fan motors and from internal leakages.

### 3.2.3 temperature net efficiency

$$\eta_{t,net}$$

net transfer of sensible heat from exhaust to supply air, with correction of the temperature change of the supply air outlet caused by the EATR

Note 1 to entry: The determination is according to 6.1.6.

Note 2 to entry: The temperature net efficiency does not regard external leakages or heat flow through the casing. The temperatures  $\theta_{11}$ ,  $\theta_{21}$  and  $\theta_{22}$  can differ from measured values, see 6.1.6.2.

Note 3 to entry: Temperature net efficiency calculation is required if EATR is determined (see 5.5.2).

### 3.2.4 temperature effectiveness

$$\varepsilon_t$$

temperature gross efficiency, multiplied with the ratio of the mass flow rate of supply air outlet to the minimum mass flow rate of supply outlet or exhaust air inlet

Note 1 to entry: The determination is according to 6.1.7.

Note 2 to entry: The temperature effectiveness describes the ratio of the effective sensible heat transfer from the exhaust air side to the supply air side compared with the theoretical possible sensible heat transfer.

Note 3 to entry: If the efficiency is very high, condensation occurs and the airflows are very unbalanced, the effectiveness value can be higher than 1.

### 3.2.5 humidity efficiency

$$\eta_{x,efy}$$

transfer of latent heat from exhaust to supply air, with correction of the humidity change of the supply air outlet caused by the EATR and a correction in case of a bad heat balance

Note 1 to entry: The humidity efficiency is determined according to 6.1.6.

Note 2 to entry: No definitions of humidity efficiency on the exhaust-air side are included. If data on the exhaust-air side is required, conditions can be calculated by heat and mass balances, considering leakage and EATR.

Note 3 to entry: The humidity efficiency depends on the supply air flow and on the mass flow ratio between the supply air flow and the exhaust air flow.

### 3.2.6 humidity gross efficiency

$$\eta_{x,gro}$$

absolute humidity difference on the supply air side divided by the absolute humidity difference between exhaust air inlet and supply air inlet

Note 1 to entry: The determination is according to 6.1.6.

Note 2 to entry: No definitions of efficiency on the exhaust-air side are included. If data on the exhaust-air side is required, conditions can be calculated by mass balances, considering leakages.

### 3.2.7

#### humidity net efficiency

$$\eta_{x, \text{net}}$$

net transfer of latent heat exhaust to supply air, with correction of the humidity change of the supply air outlet caused by the EATR

Note 1 to entry: The determination is according to 6.1.6.

Note 2 to entry: Humidity net efficiency calculation is required if EATR is determined (see 5.5.2).

### 3.2.8

#### humidity effectiveness

$$\varepsilon_x$$

humidity efficiency, multiplied with the ratio of the dry mass flow rate of supply air outlet to the minimum dry mass flow rate of supply outlet or exhaust air inlet

Note 1 to entry: The determination is according to 6.1.7.

## 3.3 Air flow and leakage

### 3.3.1

#### nominal leakage rate

ratio of the leakage (air volume flow) to the nominal air volume flow, at standard conditions

### 3.3.2

#### external leakage

$$q_{ve}$$

leakage from casing to or from the ambient air

Note 1 to entry: The external leakage is usually measured under static pressure difference. For calculations considering the impact of the external leakage on measurement uncertainty, the external leakage in operational mode has to be determined usually by calculation or estimation.

### 3.3.3

#### internal leakage

$$q_{vi}$$

umbrella term for the following definitions:

- test setup leakage;
- static internal leakage;
- dynamic internal leakage

### 3.3.4

#### test setup internal leakage

$$q_{vi, \text{setup}}$$

internal leakage of the test casing for Test Type A1, measured with static pressure difference

**3.3.5****static internal leakage** $q_{vi,stat}$ 

internal leakage of the unit under test, measured with static pressure difference

Note 1 to entry: The static internal leakage is used as quality indicator for a HRC, where EATR and OACF are not determined. This concerns constructions with no or only minor leakages, such as plate heat exchangers.

Note 2 to entry: The unit under test is defined by the test type.

**3.3.6****dynamic internal leakage**

internal leakage of the HRC, measured in operation conditions with air flow on both sides

Note 1 to entry: The dynamic internal leakage is characterized by EATR and OACF. EATR and OACF shall be declared as a pair at identical conditions.

**3.3.7****air flow**

mass flow and volume flow of air

Note 1 to entry: If a clarification (mass or volume) is necessary the term is complemented with the applicable symbol.

Note 2 to entry: Used as an umbrella term.

**3.3.8****exhaust air transfer ratio****EATR**

transfer of exhaust air into the supply air side in HRC and which provides information on the ratio of exhaust air in the supply air

Note 1 to entry: The EATR can be measured with tracer gas. The determination is according to 6.1.2.

Note 2 to entry: The subscript shows how the EATR is determined or measured respectively:

- $EATR_{A1}$ : According to Test Type A1
- $EATR_{A2}$ : According to Test Type A2
- $EATR_B$ : According to Test Type B
- $EATR_C$ : According to Test Type C

Note 3 to entry: The EATR depends on pressure difference and airflows. Therefore, the test conditions at which EATR is determined always have to be declared.

Note 4 to entry: Procedures for the estimation of the EATR for test type C are described in Annex D.

Note 5 to entry: EATR replaces the old term Carry-Over.

### 3.3.9

#### **outdoor air correction factor**

##### **OACF**

ratio of the entering supply mass airflow rate and the leaving supply mass airflow rate, which provides information about the leakages between the air flows

Note 1 to entry: The determination is according to 6.1.2.

Note 2 to entry: The OACF depends on pressure difference and airflows. Therefore, the test conditions at which OACF is determined always have to be declared.

### 3.3.10

#### **mass flow rate exhaust air inlet**

##### **$q_{m11}$**

air mass flow on the exhaust air inlet side

Note 1 to entry: This is the mass flow that leaves the application side.

### 3.3.11

#### **mass flow rate exhaust air outlet**

##### **$q_{m12}$**

air mass flow on the exhaust air outlet side

### 3.3.12

#### **mass flow rate supply air inlet**

##### **$q_{m21}$**

air mass flow on the supply air inlet side

### 3.3.13

#### **mass flow rate supply air outlet**

##### **$q_{m22}$**

air mass flow on the supply air outlet side

Note 1 to entry: This is the mass flow that enters the application side.

### 3.3.14

#### **nominal air mass flow rate**

##### **$q_{m,n}$**

declared air mass flow rate as base for testing and test results

## **3.4 Pressure**

### 3.4.1

#### **pressure difference 22–11**

##### **$\Delta p_{22-11}$**

difference in static pressure between the supply air outlet and the exhaust air inlet, measured in the casing or other connections with the same cross section area on both sides

Note to entry: The pressure difference is determined according 6.1.4.1.

**3.4.2****pressure drop** $\Delta p_{11-12}, \Delta p_{21-22}$ 

loss in static pressure between the inlet and the outlet of a HRC, measured in the casing or other connections with the same cross section area on both sides

Note to entry: The pressure drop is determined according 6.1.4.2.

**3.4.3****external static pressure difference** $\Delta p_{s,ext}$ 

difference between the static pressure at the outlet of the air handling unit and the static pressure at the inlet

[SOURCE: EN 13053]

**3.4.4****static internal leakage mass flow rate** $q_{m,il,stat}$ 

leakage, caused by a static pressure difference between exhaust air side and supply air side

Note 1 to entry: Measured by blanking off and sealing all ducts of the HRC or HRC section.

**3.5 General terms and definitions****3.5.1****standard air conditions**

relating to air with a density of 1,20 kg/m<sup>3</sup>, at a temperature of 20 °C, an atmospheric air pressure of 101 325 Pa and a relative humidity 40 %

**3.5.2****face area** $A_{f22}$ 

orthographic projection of the supply air outlet side of the HRC, which is in contact with the supply air

Note 1 to entry: The face area of HRC depends on the HRC category and construction.

**3.6 Categories of heat recovery components****3.6.1****heat recovery component****HRC**

heat exchanger or combinations of heat exchangers which transfer heat and, in some cases humidity, between exhaust and supply air flow depending on the difference of temperature and humidity levels and which are generally installed in casings or air ducts

Note 1 to entry: In the following clauses the HRC are divided into three categories and additional sub-categories. Table 2 gives an overview.

Note 2 to entry: Used as an umbrella term.

Table 2 — Category code for the principle of HRC

| Category                                                                                                                                                                                 | Description                                                                               | Detailed description in |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------|
| <b>HRC1</b>                                                                                                                                                                              | <b>Recuperative HRC (general)</b>                                                         | 3.6.2                   |
| HRC1a                                                                                                                                                                                    | Non-humidity permeable recuperative HRC                                                   | 3.6.2.1                 |
| HRC1x                                                                                                                                                                                    | Humidity permeable recuperative HRC                                                       | 3.6.2.2                 |
| <b>HRC2</b>                                                                                                                                                                              | <b>HRC with intermediary heat transfer medium (general)</b>                               | 3.6.3                   |
| HRC2a                                                                                                                                                                                    | HRC with a run around coil system, intermediary heat transfer medium without phase-change | 3.6.3.1                 |
| HRC2b                                                                                                                                                                                    | HRC with intermediary heat transfer medium with phase-change (heat pipe)                  | 3.6.3.2                 |
| <b>HRC3</b>                                                                                                                                                                              | <b>Regenerative HRC (general)</b>                                                         | 3.6.4                   |
| HRC3a                                                                                                                                                                                    | Non-hygroscopic rotary wheel                                                              | 3.6.4.2                 |
| HRC3x                                                                                                                                                                                    | Hygroscopic rotary wheel                                                                  | 3.6.4.3                 |
| HRC3b                                                                                                                                                                                    | HRC with non-hygroscopic stationary accumulator                                           | 3.6.4.5                 |
| HRC3y                                                                                                                                                                                    | HRC with hygroscopic stationary accumulator                                               | 3.6.4.6                 |
| The letters <i>a</i> and <i>b</i> are used for categories without intended humidity exchange. The letters <i>x</i> and <i>y</i> are used for categories with intended humidity exchange. |                                                                                           |                         |

**3.6.2****recuperative heat recovery component****HRC1**

heat exchangers designed to transfer energy from one air stream to another without moving parts

Note 1 to entry: Heat transfer surfaces are in form of plates or tubes. This heat exchanger can have parallel flow, cross flow or counter flow construction or a combination of these.

Note 2 to entry: Used as an umbrella term.

**3.6.2.1****non-humidity permeable recuperative heat recovery component****HRC1a**

heat exchangers of category HRC1 designed for sensible heat transfer only

**3.6.2.2****humidity permeable recuperative heat recovery component****HRC1x**

heat exchangers of category HRC1 designed for transfer of sensible heat and humidity

**3.6.3****Heat recovery component with intermediary heat transfer medium****HRC2**

HRC with heat exchangers in both air streams connected with tubes or pipes, including all necessary parts for the heat transport

Note 1 to entry: A transfer medium transports the sensible energy from one heat exchanger to the other.

Note 2 to entry: Used as an umbrella term.

### 3.6.3.1

#### **Heat recovery component with a run around coil system**

##### **HRC2a**

HRC of category HRC2 with an intermediary heat transfer medium without phase-change (liquid) used as heat transfer medium and which includes the piping, pump and transfer medium

### 3.6.3.2

#### **Heat recovery component with heat pipe**

##### **HRC2b**

HRC of category HRC2 in which the transfer medium evaporates in the heat exchanger in the warm air stream and condenses in the heat exchanger in the cold air stream

Note 1 to entry: Heat pumps are not covered by this definition.

### 3.6.4

#### **Regenerative heat recovery component**

##### **HRC3**

HRC designed for the regenerative heat transfer due to accumulation mass

Note 1 to entry: The mass is warmed up in the warm air stream and cooled down in the cold air stream. Both air streams are in alternating contact with a common surface. Due to different possible mechanisms transfer of humidity or other substances from one air stream to the other can occur.

Note 2 to entry: Used as an umbrella term.

### 3.6.4.1

#### **rotary wheel**

HRC of category HRC3 with an accumulation mass in form of a rotating cylinder which incorporates heat transfer material, a drive mechanism, a casing or frame, and includes any seals which are provided to prevent the bypassing and leakage of air from one air stream to the other

Note 1 to entry: In literature rotary wheels are sometimes also called “thermal wheels” or “heat wheels”.

### 3.6.4.2

#### **non-hygroscopic rotary wheel**

##### **HRC3a**

rotary wheel not intended for humidity exchange between the two air streams

Note 1 to entry: Humidity exchange can occur in case of condensation on the surface of the accumulator.

### 3.6.4.3

#### **hygroscopic rotary wheel**

##### **HRC3x**

rotary wheel determined for humidity exchange between the air streams without condensation

### 3.6.4.4

#### **heat recovery component with stationary accumulator**

HRC of category HRC3 with a stationary accumulation mass, where the change of the air flows is managed by reciprocating opening and closing of dampers and which incorporates heat transfer material, dampers, drive mechanism for dampers, a casing or frame, and includes any seals which are provided to retard the bypassing and leakage of air from one air stream to the other

Note 1 to entry: According this definition also mixing and air flow direction changing devices are part of the HRC.

Note 2 to entry: According to the scope only the testing of HRC with steady air flows is covered by this standard.

#### 3.6.4.5

##### **heat recovery component with non-hygroscopic stationary accumulator**

##### **HRC3b**

stationary accumulator not intended for humidity exchange between the two air streams

Note 1 to entry: Humidity exchange can occur in case of condensation on the surface of the accumulator.

#### 3.6.4.6

##### **heat recovery component with hygroscopic stationary accumulator**

##### **HRC3y**

stationary accumulator determined for humidity exchange between the air streams without condensation

### 3.7 Test types

#### 3.7.1

##### **test type A**

##### **laboratory testing of HRC and HRC sections**

tests which are carried out in a laboratory

Note 1 to entry: Used as an umbrella term.

##### 3.7.1.1

##### **test type A1**

##### **laboratory testing of HRC**

laboratory testing of a HRC integrated in a test casing or an air duct

Note 1 to entry: The HRC is tested under ideal conditions. This test type provides performance data for the HRC itself, without influences of the application. The performance data are e.g. a reliable base for a general comparison of products or a validation of software from HRC manufacturers.

Note 2 to entry: This fulfils in both cases the requirements given in 5.5.4.

##### 3.7.1.2

##### **test type A2**

##### **laboratory testing of a HRC section**

laboratory testing of a unit delivered to the laboratory, consisting only of a HRC installed in a casing or in an air duct

Note 1 to entry: According the definition no further component than the HRS is installed in the section.

Note 2 to entry: The definition deliberately leaves open whether the HRC is intended for commercial purposes or manufactured for the sole purpose of testing.

Note 3 to entry: The test item is the HRC section. The HRC section is tested under ideal conditions. The laboratory is not responsible for the casing.

**3.7.2****test type B****laboratory testing of the HRC in an AHU**

testing of a HRC is performed in a laboratory while the HRC is installed in an AHU, which is delivered to the laboratory

Note 1 to entry: The air flow rates are determined at the ducts connections of the AHU. The conditions of the inlet air (11 and 21) is also determined at the duct connection of the AHU.

Note 2 to entry: The HRC performance is tested under consideration of the installation conditions in the AHU, in particular the flow conditions and the leakages. Nevertheless, the test takes place under standardized conditions, in particular well-defined air and pressure conditions at the duct connections of the AHU.

**3.7.3****test type C****on-site testing of the HRC**

umbrella term for on-site testing of a HRC installed in an AHU, in a HRC section or in air ducts in a real ventilation system, with air flow rates and air conditions as close as possible to the design conditions

Note 1 to entry: According this definition the HRC performance is tested under consideration of the installation conditions. By definition, the pressure conditions are given by the design of the ventilation system.

Note 2 to entry: Used as an umbrella term.

**3.7.3.1****test type C1****on-site testing of the HRC in the AHU**

testing of the HRC, which is installed in the AHU, is performed on-site

Note 1 to entry: The air flow rates are determined at the duct connections of the AHU. The conditions of the inlet air (11 and 21) is also determined at the duct connection of the AHU.

Note 2 to entry: If there is no access for measurement at the duct connections of the AHU, the HRC section can be tested as Test Type C2.

**3.7.3.2****test type C2****on-site testing of the HRC section**

on-site testing of the HRC, which installed in air ducts or in a HRC section, which is not part of an AHU

Note 1 to entry: The air flow rates are determined at the duct connections of the HRC-section or the ducts belonging to the HRC. The conditions of the inlet air (11 and 21) are also determined at the duct connection of the HRC-section or the ducts belonging to the HRC.

**3.8 Uncertainty of measurement****3.8.1 Expression of uncertainty****3.8.1.1****uncertainty of measurement**

parameter, associated with the result of a measurement, that characterizes the dispersion of the values that can reasonably be attributed to the measurand

[SOURCE: JCGM 100:2008]

**3.8.1.2****standard uncertainty**

uncertainty of the result of a measurement expressed as a standard deviation

[SOURCE: JCGM 100:2008]

**3.8.1.3****combined standard uncertainty**

standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

[SOURCE: JCGM 100:2008]

**3.8.1.4****expanded uncertainty**

quantity defining an interval about the result of a measurement that can be expected to encompass a large fraction of the distribution of values that can reasonably be attributed to the measurand

[SOURCE: JCGM 100:2008]

**3.8.1.5****coverage factor****k**

numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty, corresponding to a level of confidence of 95 %

Note 1 to entry: With the given level of confidence the rounded coverage factor is 2 for a Gaussian distribution.

[SOURCE: JCGM 100:2008, modified – addition of Note 1]

**3.8.2****precision class**

class of the absolute expanded measurement uncertainty of the temperature efficiency for winter conditions or the humidity efficiency respectively

Note 1 to entry: With a class border according Table 3 under the conditions given in 5.2.

**Table 3 — Precision classes**

| Performance criteria   | Expanded measurement uncertainty of the efficiency of precision class |       |       |                |
|------------------------|-----------------------------------------------------------------------|-------|-------|----------------|
|                        | P1                                                                    | P2    | P3    | not classified |
| Temperature efficiency | 0,025                                                                 | 0,040 | 0,080 | > 0,080        |
| Humidity efficiency    | 0,060                                                                 | 0,090 | 0,160 | > 0,160        |

## 4 Symbols and abbreviations

### 4.1 Symbols

For the purposes of this document, the symbols in Table 4 apply.

**Table 4 — Symbols**

| Symbol        | Quantity                                                                                      | Unit                                           |
|---------------|-----------------------------------------------------------------------------------------------|------------------------------------------------|
| $A_f$         | face area                                                                                     | $\text{m}^2$                                   |
| $C$           | tracer gas concentration                                                                      | mol/l or ppm                                   |
| $P_E$         | electric power input                                                                          | W, kW                                          |
| $c_p$         | specific heat capacity at constant pressure                                                   | $\text{J}/(\text{K} \cdot \text{kg})$          |
| $f_E$         | conversion factor for electric power to heat                                                  | –                                              |
| $h$           | specific enthalpy                                                                             | $\text{J}/\text{kg}$                           |
| $k$           | coverage factor                                                                               | –                                              |
| $k_{hb}$      | correction of the efficiency due to bad heat balance                                          | –                                              |
| $n$           | number of revolutions                                                                         | $\text{s}^{-1}$ or rpm                         |
| $p$           | pressure                                                                                      | Pa                                             |
| $p_{11}$      | Pressure at exhaust air inlet                                                                 | Pa                                             |
| $p_{12}$      | pressure at exhaust of air outlet                                                             | Pa                                             |
| $p_{21}$      | pressure at supply of air inlet                                                               | Pa                                             |
| $p_{22}$      | pressure at supply of air outlet                                                              | Pa                                             |
| $q_{m11}$     | mass flow rate of exhaust air inlet                                                           | $\text{kg}/\text{s}$                           |
| $q_{m22}$     | mass flow rate of supply air outlet                                                           | $\text{kg}/\text{s}$                           |
| $q_{mn}$      | nominal mass flow rate                                                                        | $\text{kg}/\text{s}$                           |
| $q_{mEATR}$   | mass flow rate EATR                                                                           | $\text{kg}/\text{s}$                           |
| $q_{ve}$      | external leakage air volume flow rate                                                         | $\text{m}^3/\text{s}$ or $\text{m}^3/\text{h}$ |
| $q_{vi,stat}$ | static internal leakage air volume flow rate                                                  | $\text{m}^3/\text{s}$ or $\text{m}^3/\text{h}$ |
| $r_w$         | specific enthalpy of vaporization of water ( $2\,500 \text{ kJ}/(\text{kg} \cdot \text{K})$ ) | $\text{kJ}/(\text{kg} \cdot \text{K})$         |
| $v$           | velocity                                                                                      | $\text{m}/\text{s}$                            |
| $v_d$         | declared velocity                                                                             | $\text{m}/\text{s}$                            |
| $x$           | absolute humidity                                                                             | $\text{kg water}/\text{kg dry air}$            |
| $x_{11}$      | absolute humidity of exhaust air inlet                                                        | $\text{kg water}/\text{kg dry air}$            |
| $x_{21}$      | absolute humidity of supply air inlet                                                         | $\text{kg water}/\text{kg dry air}$            |

| Symbol                        | Quantity                                                                              | Unit                |
|-------------------------------|---------------------------------------------------------------------------------------|---------------------|
| $x_{22}$                      | absolute humidity of supply air outlet                                                | kg water/kg dry air |
| $\Delta p_{11-12}$            | pressure drop on exhaust-air side                                                     | Pa                  |
| $\Delta p_{21-22}$            | pressure drop on supply-air side                                                      | Pa                  |
| $\Delta p_{22-11}$            | difference in static pressure between the supply air outlet and the exhaust air inlet | Pa                  |
| $\Delta \theta$               | temperature difference                                                                | K                   |
| $\Delta \varphi$              | deviation of heat balance                                                             | –                   |
| $\Delta \varphi_{\text{lim}}$ | tolerance of heat balance (limits of the relative heat balance)                       | –                   |
| $\varepsilon_t$               | temperature effectiveness                                                             | –                   |
| $\varepsilon_x$               | humidity effectiveness                                                                | –                   |
| $\Phi$                        | heat flow                                                                             | W, kW               |
| $\eta_{t,\text{efy}}$         | temperature efficiency                                                                | –                   |
| $\eta_{t,\text{gro}}$         | temperature gross efficiency                                                          | –                   |
| $\eta_{t,\text{net}}$         | temperature net efficiency                                                            | –                   |
| $\eta_{x,\text{efy}}$         | humidity efficiency                                                                   | –                   |
| $\eta_{x,\text{gro}}$         | humidity gross efficiency                                                             | –                   |
| $\eta_{x,\text{net}}$         | humidity net efficiency                                                               | –                   |
| $\theta$                      | temperature                                                                           | °C, K               |
| $\theta_{11}$                 | temperature of exhaust air inlet                                                      | °C, K               |
| $\theta_{12}$                 | temperature of exhaust air outlet                                                     | °C, K               |
| $\theta_{21}$                 | temperature of supply air inlet                                                       | °C, K               |
| $\theta_{22}$                 | temperature of supply air outlet                                                      | °C, K               |
| $\rho$                        | density                                                                               | kg/m <sup>3</sup>   |
| $\rho_{\text{st}}$            | standard air density (1,20 kg/m <sup>3</sup> )                                        | kg/m <sup>3</sup>   |

## 4.2 Subscripts

|     |                                                  |
|-----|--------------------------------------------------|
| 0   | reference                                        |
| 11  | exhaust air inlet (see Figure 1)                 |
| 12  | exhaust air outlet (see Figure 1)                |
| 21  | supply air inlet (see Figure 1)                  |
| 22  | supply air outlet (see Figure 1)                 |
| A1  | determined or measured according to Test Type A1 |
| A2  | determined or measured according to Test Type A2 |
| B   | determined or measured according to Test Type B  |
| C1  | determined or measured according to Test Type C1 |
| C2  | determined or measured according to Test Type C2 |
| E   | related to electric energy                       |
| Te  | related to test conditions                       |
| a   | ambient                                          |
| dry | dry air                                          |
| ext | external                                         |
| f   | face                                             |
| gro | gross                                            |
| int | internal                                         |
| vi  | related to internal leakage volume flow rate     |
| ve  | related to external leakage volume flow rate     |
| min | minimum                                          |
| n   | nominal                                          |
| net | net                                              |
| st  | related to standard condition                    |
| w   | water                                            |

## 4.3 Abbreviations

|      |                               |
|------|-------------------------------|
| AHU  | Air Handling Unit             |
| EATR | Exhaust air transfer ratio    |
| HRC  | Heat Recovery Component(s)    |
| OACF | Outdoor air correction factor |

## 5 Test requirements

### 5.1 Specification of the-heat recovery components

The following information is required before proceeding to the test:

- Specification of the HRC category according to 3.3; this specification determines whether or not the humidity efficiency is measured.<sup>2</sup>
- Specification of the delivered HRC, that provides unambiguous identification by the testing laboratory;
- For test type A: Nominal air flow rate, as defined in 3.3.14;
- For test type A: Maximum pressure difference 22-11 (positive and negative) between supply and exhaust air side;
- For Test Type B and C: Relevant design operation conditions as given in EN 13053, at least air volume flow rate and external static pressure difference, at standard conditions. Additionally the pressure difference between the ambient pressure and the outdoor air inlet section and also the pressure difference between the ambient pressure and the exhaust air outlet can be defined;
- Clear designation of the inlet and outlet of the supply air and the exhaust air (connection of 11, 12, 21 and 22);
- For category HRC2a: The unit under test shall include the heat exchangers on both air flow sides, the piping, the pump and the fluid. The pump speed, the mass flow of the intermediary medium, the brine with the type and the concentration of the anti-freeze agent have to be defined;
- For category HRC3a and HRC3x: nominal revolutions and revolution direction of the wheel or nominal frequency of the switch of dampers respectively;
- For category HRC3a and HRC3x: Testing with/without purge sector, adjustment of the purge sector;
- Aspired precision class for the testing.

The instruction for the installation and operating of the HRC shall be delivered to the test laboratory. This shall include special settings of the control equipment for the test procedure.

### 5.2 Precision classes

#### 5.2.1 General

The aspired precision class is verified by one of the following two methods:

- a) Fulfilment of all individual requirements according 5.2.2
- b) Calculation according the principles of Annex C for temperature and humidity efficiencies, and the expanded measurement uncertainty of the efficiency is compared to the Table 3 for the equivalent precision class.

---

<sup>2</sup> This affects the measuring equipment (see Table 5), the test points and conditions (see Table 12 and Table 13) and the test report.

### 5.2.2 Verification with individual requirements

The precision class is verified if the following points are simultaneously fulfilled for the same class:

- all requirements for the uncertainties according Clause 5;
- and all test conditions according to Clause 6;
- and for humidity and temperature efficiency determination the framework conditions according 5.2.3 shall be fulfilled.

### 5.2.3 Framework conditions for efficiencies

NOTE If the achievement of a precision class is verified with a separate calculation of the measurement uncertainty, the conditions in 5.2.3 are not relevant.

For the determination of temperature efficiency, the verification of the precision class with individual requirements is only valid for the three following conditions:

- a) for P1 and P2 precision class, the temperature difference between exhaust air inlet and supply air inlet shall be at least 13 K;
- b) and the test is performed without any freezing;
- c) and the conditions on value of thermal efficiency are fulfilled:

- $\eta_{t, \text{gro}} \leq 0,85$  ;
- or for higher efficiencies, the measurement uncertainty of the term  $\theta_{11}-\theta_{22}$  is not higher than 0,2 K;
- or for higher efficiencies, the next precision class with higher uncertainty (e.g. P2 instead of P1) shall be declared.

For the determination of humidity efficiency, the verification of the precision class with individual requirements is only valid for the three following conditions:

- a) for P1 and P2 precision class, the difference of absolute humidity between exhaust air inlet and supply air inlet shall be at least 6,0 g/kg;
- b) and the test is performed with no freezing nor condensation;
- c) and the conditions on value of humidity efficiency are fulfilled:

- $\eta_{x, \text{gro}} \leq 0,85$  ;
- or for higher efficiencies, the measurement uncertainty of the term  $x_{11}-x_{22}$  is not higher than 0,3 g/kg;
- or for higher efficiencies, the next precision class with higher uncertainty (e.g. P2 instead of P1) shall be declared.

## 5.3 Measurement equipment

### 5.3.1 Uncertainties of probes and measurement instruments

The required expanded uncertainties for the measurement of single quantities for different precision classes are given in Table 5. These uncertainties are to understand as the uncertainties of the measurement instruments or the measurement chain of a quantity respectively.

**Table 5 — Required expanded uncertainties for the measurement of single quantities for different precision classes**

| Measured quantity                                                                                         | Required expanded uncertainty for the measurement of single quantities for precision class |                                            |                                            |
|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------|--------------------------------------------|
|                                                                                                           | P1                                                                                         | P2                                         | P3                                         |
| Absolute pressure at position 11 and 22, for the determination of the temperature efficiency <sup>a</sup> | 500 Pa                                                                                     | 1 000 Pa                                   | 3 000 Pa <sup>d</sup>                      |
| Absolute pressure at position 11 and 22, for the determination of the humidity efficiency <sup>a</sup>    | 100 Pa                                                                                     | 200 Pa                                     | 500 Pa                                     |
| Dry bulb temperature                                                                                      | 0,2 K                                                                                      | 0,3 K                                      | 0,5 K                                      |
| Wet bulb temperature <sup>b</sup>                                                                         | 0,3 K                                                                                      | 0,4 K                                      | 0,6 K                                      |
| Air volume flow rate                                                                                      | 3 % or 3 m <sup>3</sup> /h <sup>c</sup>                                                    | 5 % or 5 m <sup>3</sup> /h <sup>c</sup>    | 10 % or 10 m <sup>3</sup> /h <sup>c</sup>  |
| Pressure difference for the determination of the pressure drop of a HRC                                   | 1 % or 2 Pa <sup>c</sup>                                                                   | 2 % or 4 Pa <sup>c</sup>                   | 3 % or 10 Pa <sup>c</sup>                  |
| Leakage air flow                                                                                          | 5 % or 0,1 m <sup>3</sup> /h <sup>c</sup>                                                  | 10 % or 0,2 m <sup>3</sup> /h <sup>c</sup> | 20 % or 0,5 m <sup>3</sup> /h <sup>c</sup> |
| Tracer gas concentration <sup>e</sup>                                                                     |                                                                                            |                                            |                                            |
| C <sub>11</sub>                                                                                           | 0,05 (C <sub>11</sub> - C <sub>21</sub> )                                                  | 0,10 (C <sub>11</sub> - C <sub>21</sub> )  | 0,10 (C <sub>11</sub> - C <sub>21</sub> )  |
| C <sub>21</sub> and C <sub>22</sub>                                                                       | 0,006 (C <sub>11</sub> - C <sub>21</sub> )                                                 | 0,01 (C <sub>11</sub> - C <sub>21</sub> )  | 0,02 (C <sub>11</sub> - C <sub>21</sub> )  |
| For category HRC21: flow of liquid intermediary medium                                                    | 3 %                                                                                        | 5 %                                        | 10 %                                       |
| For category HRC3: revolutions of the wheel or frequency of the switch of dampers                         | 3 %                                                                                        | 5 %                                        | 10 %                                       |
| Voltage                                                                                                   | 1 %                                                                                        | 2 %                                        | 3 %                                        |
| Electric power input                                                                                      | 2 % or 1 W <sup>c</sup>                                                                    | 3 % or 2 W <sup>c</sup>                    | 5 % or 3 W <sup>c</sup>                    |

<sup>a</sup> This is to understand as combined uncertainty, which considers the uncertainty of the atmospheric pressure (of the ambient) and the pressure differences between the ambient and the pressure at the position 11 or 22 respectively.

<sup>b</sup> Approximations for the uncertainties for other methods of humidity measurement are shown in Annex B.

<sup>c</sup> The bigger of the two values is relevant.

<sup>d</sup> The atmospheric pressure can be calculated according to international standard atmosphere. The uncertainty is determined of the uncertainty of the high above sea level.

<sup>e</sup> Only for a high correlation of C<sub>21</sub>, C<sub>22</sub> and C<sub>11</sub>, which especially means measurement with the same instrument. For measurements with independent instruments, the expanded uncertainty of each value shall be 30 % lower.

### 5.3.2 Temperature measuring plane

The position of the measuring plane shall be such, that the change of the mean air temperature between the inlet or outlet respectively of the unit under test and the measured mean temperature is not greater than required in Table 6. This is to ensure by the design of the test rig or the test configuration respectively.

NOTE The relevant inlet or outlet of the unit under test is given by the test type.

In each of the air flows (ducts or casing of the test rig) to or from the HRC, a temperature measuring plane shall be arranged to determine the mean air temperature.

For the temperature measuring planes 11, 21 and 22 at least one of the following two requirements shall be met:

- Even temperature distribution: Maximum difference of the mean values of the probe with the highest temperature and the probe with the lowest temperature, according to Table 6;
- Uneven temperature distribution: Maximum difference of the mean values of neighbouring probes in a measuring plane, according to Table 6. Rules and examples for neighbouring probes are shown in A.2.

For the temperature measuring plane 12 the maximum difference of both requirements shall not exceed 1,5 times the values given in Table 6.

If the criterion for an even temperature distribution is not achieved, then the number of probes has to be increased until the criterion for an uneven is temperature distribution fulfilled. However, more than 20 probes are not required.

The temperature measurement shall not be influenced by radiation, condensation or thermal conductivity. This shall be ensured by the construction of the measuring planes, fixing of temperature probes and thermal insulation.