
**Heat recovery ventilators and energy
recovery ventilators — Method of test
for performance —**

**Part 1:
Development of metrics for evaluation
of energy related performance**

*Ventilateurs-récupérateurs de chaleur et ventilateurs-récupérateurs
d'énergie — Méthode d'essai des performances —*

*Partie 1: Développement de paramètres pour l'évaluation des
performances énergétiques*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

This first edition of ISO 16494-1 cancels and replaces the first edition (ISO 16494:2014), which has been technically revised.

The main changes are as follows:

- consistency with terms' definition between similar group of ISO standards (ERV and HRV);
- keep editorial rules of ISO/IEC Directives Part 2 (2021);
- general test requirements, chapter 5, was added;
- test condition, T8, was added in [Table 1](#);
- maximum variations of individual readings from specified test conditions in [Table F.2](#) was deleted.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Heat recovery ventilators and energy recovery ventilators — Method of test for performance —

Part 1:

Development of metrics for evaluation of energy related performance

1 Scope

This document specifies a method of testing the ventilation and energy related performance of heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) that do not contain any supplemental heating (except for defrost), cooling, humidification, or dehumidification components.

Exchanger types of HRVs and ERVs are

- a) fixed-plate exchangers (also known as recuperators),
- b) rotary exchangers, including heat wheels and total energy wheels (also known as regenerators), and
- c) heat pipe exchangers using a heat transfer medium, excluding those using mechanical pumping,

This document does not provide a method for measuring the response of exchangers to the formation of frost.

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.

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes*

ISO 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*

ISO 5801, *Fans — Performance testing using standardized airways*

ISO 13253, *Ducted air-conditioners and air-to-air heat pumps — Testing and rating for performance*

ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*

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:

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

3.1
coefficient of energy
COE

C_{COE}
total exchanged energy between the airstreams plus the *power value of moving air* (3.22), divided by the power input

Note 1 to entry: The formula for determining the coefficient of energy (C_{COE}) is given in 9.6.

3.2
duct

insulated or uninsulated closed passage for air that is installed as part of the ventilation system in lengths determined by the needs of application, and is separate, prior to installation from exterior terminations such as weather hoods

3.3
ducted ventilator

heat recovery ventilator or energy recovery ventilator which is intended for connection of ducts to one or more of the airflow inlets or outlets and intended to address a range of static pressure differentials from the duct(s)

3.4
effective work
EW

W_{EW}
total exchanged energy between the airstreams plus the power value of moving air minus the power input

Note 1 to entry: The formula for determining the effective work (W_{EW}) is given in 9.7.

Note 2 to entry: Effective work is expressed in W.

3.5
energy recovery ventilator
ERV

ventilator which is designed to transfer both heat and moisture between two isolated airstreams

3.6
entering exhaust air

exhaust air inlet
return airflow

RA
indoor air entering the ventilator

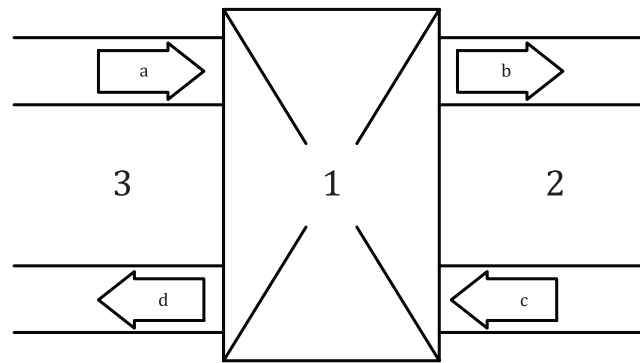
Note 1 to entry: Indicated in Figure 1 as footnote c.

3.7
entering supply air

supply air inlet
outdoor airflow

OA
outside air entering the ventilator

Note 1 to entry: Indicated in Figure 1 as footnote a.

**Key**

- 1 ventilator
- 2 indoor side
- 3 outdoor side

- a Entering supply air (OA).
- b Leaving supply air (SA).
- c Entering exhaust air (RA).
- d Leaving exhaust air (EA).

Figure 1 — Schematic numbering of airflows for heat and energy recovery ventilators

3.8**external static pressure difference**

external static pressure difference between inlet and outlet of an air stream or vi versa and is calculated as an absolute value

Note 1 to entry: The formula for absolute value is described in [6.2.2.1](#).

3.9**fixed-plate exchanger**

exchanger with multiple alternate airflow channels, separated by a heat or heat and water vapor transfer plate(s) and connected to supply and exhaust airstreams

3.10**fresh air mass flow rate**

$\dot{m}_2$

supply-mass flowrate of dry air at station 2

3.11**gross effectiveness**

measured effectiveness, not adjusted for leakage, motor heat gain, or heat transfer through the unit casing

Note 1 to entry: The sensible, latent, or total gross effectiveness of an HRV or ERV, at equal airflows, is described in [9.5](#).

3.12**heat pipe exchanger**

exchanger with an array of finned and sealed tubes that are placed in side-by-side supply and exhaust airstreams, which may include an internal wick structure in each tube and filled with a heat transfer medium

Note 1 to entry: thermosiphon exchangers are a subset (or type) of heat pipe exchanger in which the heat transfer medium moves by gravitational forces only.

3.13**heat recovery ventilator****HRV**

ventilator which is designed to transfer only heat between two isolated airstreams

3.14

leaving exhaust air

exhaust air outlet

exhaust airflow

EA

indoor air after passing through the ventilator

Note 1 to entry: Indicated in [Figure 1](#) as footnote d.

3.15

leaving supply air

supply air outlet

supply airflow

SA

outside air after passing through the ventilator

Note 1 to entry: Indicated in [Figure 1](#) as footnote b.

3.16

maximum rated airflow

largest leaving supply and entering exhaust airflows, specified by the manufacturer, at which an airflow test is performed

Note 1 to entry: For ventilators with speed control devices, different maximum rated airflows may be defined for each speed control setting at which the test is performed.

3.17

minimum rated airflow

smallest leaving supply and entering exhaust airflows, specified by the manufacturer, at which an airflow test is performed

Note 1 to entry: For ventilators with speed control devices, different minimum rated airflows may be defined for each speed control setting at which the test is performed.

3.18

model-specific exterior termination system

weather hoods, fittings and through wall penetrations designed by the ventilator manufacturer specifically for installation with a specific model of ventilator, that comprise the complete passageway connecting the ventilators outside air inlet and/or exhaust air outlet to the ventilator

3.19

net supply airflow

$Q_{2,\text{net}}$

portion of the leaving supply airflow that originated as entering supply airflow

Note 1 to entry: The net supply airflow is represented by the variable $Q_{2,\text{net}}$ measured in m³/s.

Note 2 to entry: The formulae for determining net supply airflow are given in [9.4.1](#) (ducted units) and [9.4.2](#) (unducted units).

3.20

net supply airflow ratio

ratio determined by dividing net supply airflow by supply airflow

Note 1 to entry: Expressed as a percentage and described in [9.4.1](#) (see [Formula \(3\)](#)).

3.21**net supply mass flow rate** $\dot{m}_{2,\text{net}}$

portion of the supply mass airflow rate at station 2 that originated as supply mass flow rate at station 2, accounting for R_{UEATR}

Note 1 to entry: See [Formula \(9\)](#) and [Formula \(13\)](#)

3.22**power value of moving air** P_{vma}

rate of pressure energy and kinetic energy of the air delivered by the ventilator

Note 1 to entry: The formula that determines the power value of moving air is given in [9.6.1](#).

Note 2 to entry: Power value of moving air is expressed in W for P_{vma} . (see [Formula \(10\)](#))

3.23**rating points**

sets of supply and exhaust airflows, static pressures at inlets and outlets, and speed control setting, achieved during the airflow performance measurement, at which thermal performance tests (and exhaust air transfer tests, if applicable) are performed

3.24**rotary exchanger**

exchanger with porous discs, fabricated from materials with heat or heat and water vapour retention capacity, that are regenerated by collocated supply and exhaust airstreams

3.25**speed control device**

device incorporated into the ventilator which controls the speed of the fan

3.26**station**

location in the test apparatus at which conditions such as temperature, humidity, pressure, or airflows are measured

Note 1 to entry: Indicated in [Figure 1](#) as footnotes a, b, c and d.

3.27**standard air**

dry air with a density of $1,204 \text{ kg/m}^3$ and a dynamic viscosity of $1,824 \cdot 7 \times 10^{-5} \text{ kg/(m}\cdot\text{s)}$

Note 1 to entry: These conditions approximate dry air at 20°C and $101,325 \text{ kPa}$ absolute.

3.28**static pressure differential**

static pressure at supply outlet less the static pressure at exhaust inlet

Note 1 to entry: a positive pressure differential occurs when the static pressure at *station* ([3.26](#)) 2 is higher than the static pressure at station 3. A negative pressure differential occurs when the static pressure at station 2 is lower than the static pressure at station 3.

3.29**thermal performance measurement**

test procedures which measure the temperature and humidity of the supply air when a ventilator is operating with the outside air and exhaust air at specific psychrometric conditions

3.30**unducted ventilator**

heat recovery ventilator or energy recovery ventilator which is not intended for connection of ducts to any of the airflow inlets or outlets except for model-specific exterior termination systems as defined in [3.18](#)

3.31**unit exhaust air transfer ratio****UEATR**
 R_{UEATR}

tracer gas concentration difference between the *leaving supply air* ([3.15](#)) and the *entering supply air* ([3.7](#)) divided by the tracer gas concentration difference between the *entering exhaust air* ([3.6](#)) and the *entering supply air* ([3.7](#)), at a specified airflow

Note 1 to entry: The formula for R_{UEATR} is given in [9.3](#).

3.32**ventilator**

self-contained unit that includes fans to move air through the heat/energy exchanger

4 Symbols and abbreviated terms**4.1 Symbols**

Symbol	Definition	Units
C_1	Tracer gas concentration at station 1	$\mu\text{mol/mol}$
C_2	Tracer gas concentration at station 2	$\mu\text{mol/mol}$
C_3	Tracer gas concentration at station 3	$\mu\text{mol/mol}$
C_{in}	Tracer gas concentration (indoor type)	$\mu\text{mol/mol}$
C_{out}	Tracer gas concentration (rooftop type)	$\mu\text{mol/mol}$
C_{back}	Tracer gas concentration (thru-wall type)	$\mu\text{mol/mol}$
$C_{\text{chamber},i,0}$	Tracer gas concentration in the test chamber at time zero under attempt i^{th}	$\mu\text{mol/mol}$
$C_{\text{chamber},i,t,j}$	Tracer gas concentration in the test chamber at attempt i^{th} under time t of j^{th}	$\mu\text{mol/mol}$
C_{COE}	Coefficient of energy (COE)	-
c_{p1}	Specific heat of dry air at station 1	$\text{kJ}/(\text{kg}\cdot\text{K})$
c_{p2}	Specific heat of dry air at station 2	$\text{kJ}/(\text{kg}\cdot\text{K})$
h_1	Enthalpy of the air at station 1	kJ/kg of dry air
h_2	Enthalpy of the air at station 2	kJ/kg of dry air
h_3	Enthalpy of the air at station 3	kJ/kg of dry air
$\dot{m}_2$	Mass flow rate of dry air at station 2	kg/s
$\dot{m}_{2,\text{net}}$	Net mass flow rate of dry air at station 2	kg/s
P_{aux}	Power input to any other electrical components in the ventilator	W
P_{em}	Power input to all electric motors in the ventilator	W
P_{in}	Power input to ventilator	W
P_{vma}	Power value of moving air	J/s or W
p_{si}	Static pressures at station i ($i=1,2,3,4$)	Pa
p_{vi}	Velocity pressure at station i ($i=1,2,3,4$)	Pa
Q	Airflows	m^3/s

Symbol	Definition	Units
Q_1	Average of the three calculated overall airflow rates with the unit under test in operation as described in B.2.1.1 and B.2.1.2 ; or supply airflow	m ³ /s
Q_2	Average of the three calculated natural airflow rates of the test chamber with the ventilator removed as described in B.2.2.1 and B.2.2.2 ; or supply airflow	m ³ /s
$Q_{1,2}$	Average of the three points with each three times calculated overall airflow rates with the unit under test in operation as described in B.2.1.1 and B.2.1.2	m ³ /s
$Q_{i,j}$	Airflow rate calculated using the data from a test at attempt i th under time t of j th as described in B.2.1.1 , B.2.1.2 , B.2.2.1 and B.2.2.2	m ³ /s
$Q_{2,\text{net}}$	Net supply airflow	m ³ /s
R_{NSAR}	Net supply airflow ratio (NSAR)	%
R_{UEATR}	Unit exhaust air transfer ratio (UEATR)	%
T_1	Temperature of the entering supply air at station 1 (dry bulb)	°C or K
T_2	Temperature of the leaving supply air at station 2 (dry bulb)	°C or K
T_3	Temperature of the entering exhaust air at station 3 (dry bulb)	°C or K
T_a	Ambient temperature	°C or K
T_{LAB}	Temperature lab ambient	°C or K
$T_{\text{LAB,AVE}}$	Temperature lab ambient, average	°C or K
$T_{\text{LAB,MAX}}$	Temperature lab ambient, maximum	°C or K
$T_{\text{WB},i}$	Ambient temperature at station i (wet bulb) ($i=1,2,3$)	°C or K
t	Elapsed time since the start of test unit operation	s
V_c	Air volume in the test chamber	m ³
v_2	Air velocity at PL.2 (See Figure G.1)	m/s
W_{EW}	Effective work	W
x	Dry bulb temperature (for sensible effectiveness); or absolute humidity ratio (for latent effectiveness); or total enthalpy (for total effectiveness).	°C kg water/kg dry air kJ/kg
v_s	Specific volume of the supply air (See Formula (10))	m ³ /kg
ε	Effectiveness	1
$\Delta p_{s,\text{ext}}$	External static pressure difference	Pa

4.2 Subscripts

Subscript		
a	ambient	
AVE	average	
BAR	barometric pressure	
chamber	test chamber	
I	in chamber	
i	i^{th} attempt of test	
j	j^{th} of test time	
o	in outdoor air	
LAB	lab ambient	
WB	wet bulb	

Subscript		
t	time	
0	time zero	
10	600 s	
20	1 200 s	
30	1 800 s	
12-11 or 14-31	difference between station 2 and station 1 or same as between 4 and 3	
1,2,3,4	station number, respectively	

5 General test requirements

5.1 Test apparatus

The test apparatus shall be consisted of four measurement stations (See [Figure 1](#)). Measurements shall be taken at each station of temperature (dry bulb and wet bulb), static pressure and tracer gas concentration.

5.2 Installation

Equipment to be tested shall be installed in accordance with the manufacturer's instructions.

NOTE See [Figure A.1](#), [Figure B.1](#), [Figure C.1](#), [Figure C.2](#), [Figure C.3](#), [Figure D.1](#), [Figure D.2](#) and [Figure D.3](#).

5.3 Static pressure

Static pressures shall be measured in accordance with ISO 3996, ISO 5167 (all parts), ISO 5801 or ISO 13253.

5.4 Temperature

Temperatures (dry bulb and wet bulb) shall be measured at four stations (refers of [Figure 1](#)).

5.5 Concentration

Concentration of tracer gas shall be measured at three stations (1, 2 and 3 in [Figure 1](#)).

5.6 Power input

Power input shall be measured during the test, including power input to any auxiliary items of the unit.

5.7 Instrument calibration

All measurement instruments shall be calibrated using sensors, transfer standards, and primary instruments that are traceable (see ISO/IEC 17025:2017, 6.5). Calibration shall be consistent with in ISO/IEC 17025:2017, 6.4. General requirements for the competence of testing and calibration laboratories in order to minimize the bias of the instrument. The calibration curves associated with each instrument shall be available as a permanent record.

6 Airflow tests

6.1 General conditions

6.1.1 General

All tested equipment within the scope of this document shall have the airflows determined in accordance with the following provisions.

6.1.2 Temperature conditions

When measuring airflow, the laboratory ambient conditions shall be $(20 \pm 10) ^\circ\text{C}$ and 30 % RH to 95 % RH. Laboratory ambient temperature during the test shall be recorded and reported.

6.1.3 Speed control settings

The ventilator shall be tested using the manufacturer specified speed control settings. Speed control settings shall not be adjusted during the test.

6.1.4 Unit operating voltage and frequency

The power supply voltage at the operating unit shall be within ± 2 % of the rated voltage. The power supply frequency at the operating unit shall be within ± 1 % of the rated frequency.

6.2 Ducted heat recovery ventilators and energy recovery ventilators

6.2.1 Airflows measured

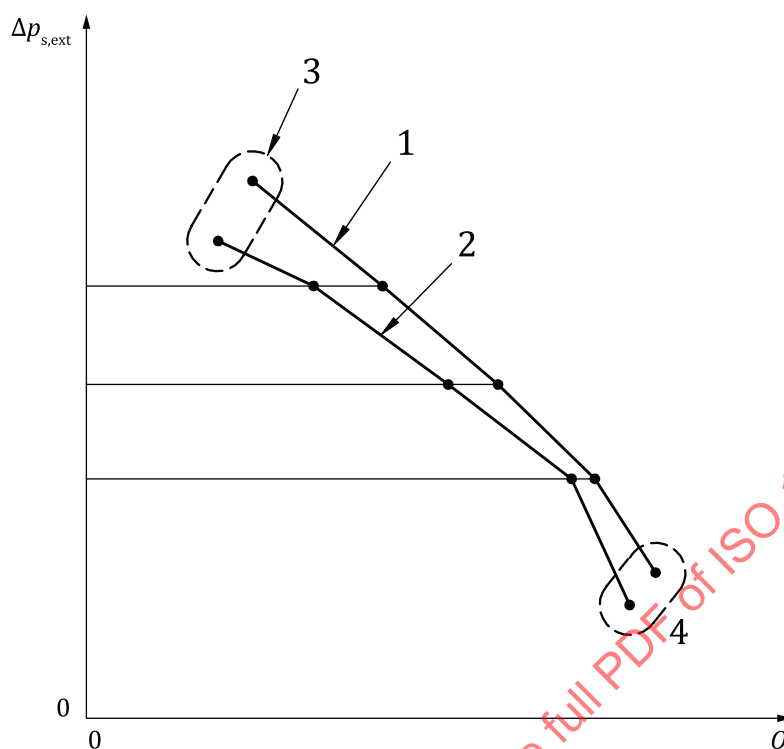
The gross airflow shall be measured and recorded at station 2 (leaving supply air) and at station 3 (entering exhaust air) as shown in [Figure 1](#), under the static pressure conditions indicated in [6.2.2](#).

6.2.2 Static pressure conditions

6.2.2.1 In order to properly characterize the performance of the unit, the ventilator shall be tested at specified maximum rated and minimum rated airflows and at a minimum of three additional, approximately evenly spaced intermediate airflows between the maximum rated airflow and minimum rated airflow. This gives a minimum of five test points as shown in [Figure 2](#). The airflow test points shall be reached by adjusting the test apparatus to change the external static pressure difference. If the ventilator is equipped with a speed control device, it shall not be adjusted during this test. Power input in watts shall be measured and recorded at each test point. The external static pressure difference is calculated by $|p_{s2} - p_{s1}|$ or $|p_{s4} - p_{s3}|$.

6.2.2.2 Any inlet or outlet which is not designed for duct connection shall be maintained at an average value of $(0 \pm 2,5)$ Pa, static pressure for all test points. However, if the ventilator is designed

for installation with model-specific exterior termination system as defined in 3.18, that system shall be installed in accordance with the manufacturer's instructions.



Key

1	$\Delta p_{s,ext}$ - Q curve (leaving supply airflow)	4	maximum rated airflow
2	$\Delta p_{s,ext}$ - Q curve (entering exhaust airflow)	$\Delta p_{s,ext}$	external static pressure difference
3	minimum rated airflow	Q	airflows

Figure 2 — Representative chart of airflow performance

6.2.2.3 When testing for airflow, the static pressure measurement requirements of 6.2.2.3a) or 6.2.2.3b) shall apply.

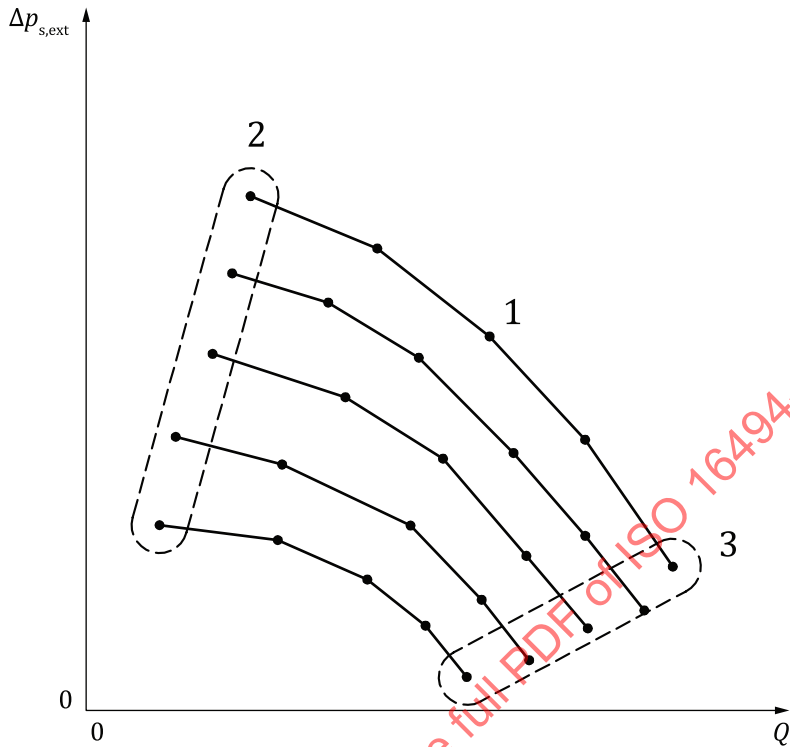
a) Only for units tested in a ducted setup:

- 1) For the maximum and minimum rated airflows, the absolute value of static pressure at inlet (p_{s1}) and outlet (p_{s2}) shall be equal within 10 Pa or 5 %, whichever is greater, of the larger of the measured values of p_{s1} or p_{s2} , except as noted in 6.2.2.2.
- 2) The absolute value of static pressure at inlet (p_{s3}) and outlet (p_{s4}) shall be equal, within 10 Pa or 5 %, whichever is greater, of the larger of the measured values of p_{s3} and p_{s4} , except as noted in 6.2.2.2.
- 3) For each intermediate test point, the absolute value of static pressures at each inlet and outlet (p_{s1} , p_{s2} , p_{s3} and p_{s4}) shall be equal within 10 Pa or 5 %, whichever is greater, of the largest of the measured value of p_{s1} , p_{s2} , p_{s3} or p_{s4} , except as noted in 6.2.2.2.

b) Only for units tested in a two-rooms setup:

- 1) For all tests the value of static pressure at inlet (p_{s1}) and inlet (p_{s3}) shall be ≤ 0 Pa, and (p_{s1}) and (p_{s3}) shall be equal within 10 Pa, or 5 %, whichever is greater, of the larger of the measured values of p_{s1} or p_{s3} .

- 2) The value of static pressure at the outlets (p_{s2}) and (p_{s4}) shall be equal, within 10 Pa, or 5 %, whichever is greater, of the larger measured value of p_{s2} or p_{s4} , except as noted in 6.2.2.2.



Key	
1	$\Delta p_{s,ext}$ - Q curves
2	minimum rated airflows
3	maximum rated airflows

NOTE Each of the individual $\Delta p_{s,ext}$ - Q curves shown here is generated at a different speed control setting. In this example, the ventilator either has just five discrete speed control settings or has a continuously variable speed control. See 6.2.2.4. For simplification, in this example only the supply air $\Delta p_{s,ext}$ - Q curves are shown.

Figure 3 — Representative chart of multispeed/variable speed ventilator airflow performance

6.2.2.4 For units with speed controls, additional airflow tests shall be performed at the alternate speed settings. If the speed control device setting is infinitely variable, the test as described in 6.2.2.1 shall be performed separately at a minimum of five speed control settings, including the highest and lowest speed control setting and a minimum of three additional approximately evenly spaced speed control settings between the highest and lowest settings.

6.2.2.5 If supply and exhaust airflows cannot be measured simultaneously, static pressures at all four stations at the time of measurement of the second airflow shall be equal within ± 10 Pa, or 5 % of the larger of the measured static pressures, whichever is greater, to the static pressures at the time of measurement of the first airflow.

6.2.3 Airflow measurement methods for ducted heat recovery and energy recovery ventilators

Airflow measurement methods are given in Annex A.

6.3 Unducted heat recovery ventilators and energy recovery ventilators

6.3.1 Airflow measured

The net supply airflow shall be determined. Power input, in watts, shall be measured and recorded.

6.3.2 Static pressure conditions

The effective/net airflow shall be determined with the static pressures at all inlets and outlets equal within $\pm 2,5$ Pa.

6.3.3 Airflow measurement methods for unducted heat recovery and energy recovery ventilators

Net supply airflow measurement of decay method is given in [Annex B](#). Alternately, the net supply airflow for unducted ventilators may be measured at points 1 and 2 in [Figure 2](#) and in [Figure 3](#), by the methods given in [Annex A](#) and [Annex C](#), and [Formulae \(4\) to \(6\)](#) in [9.4.2](#) provided that appropriate plenums are constructed around the inlets and outlets as indicated in [Annex G](#). If the ventilator is designed for installation with model-specific exterior termination systems as defined in [3.18](#), that system shall be installed in accordance with the manufacturer's instructions.

7 Tracer gas tests

7.1 General conditions

All heat recovery ventilators and energy recovery ventilators within the scope of this document shall have the unit exhaust air transfer rate and the net supply airflow rate or net supply airflow volume determined in accordance with the provisions of this clause of this document.

Tracer gas tests at other airflows and static pressure regimes may also be performed.

7.2 Temperature conditions

During tracer gas tests the laboratory ambient conditions shall be (20 ± 10) °C and 30 % RH to 95 % RH.

7.3 Preconditions

Airstreams shall be held at laboratory ambient temperature and humidity conditions and shall remain stable for the duration of the tracer gas test. Test(s) shall be performed until tracer gas levels have stabilized within ± 5 % of the mean value of tracer gas concentration variation.

7.4 Airflow conditions

Tracer gas testing shall be performed at the same static pressures, and at the same speed control setting used for the thermal performance measurement as required by [6.2.2.2](#), [6.2.2.3](#) and [6.2.2.4](#) in accordance with the setup type (ducted or two-rooms) chosen for the tracer gas testing.

7.5 Unit operating voltage and frequency

The power supply voltage at the operating unit shall be within ± 2 % of the rated voltage. The power supply frequency at the operating unit shall be within ± 1 % of the rated frequency.

7.6 Tracer gas measurement methods

Tracer gas measurement methods are given in [Annex B](#) or [Annex C](#).

8 Determination of efficiency

8.1 General conditions

All equipment within the scope of this document shall have the gross effectiveness, the coefficient of energy and the effective work determined in accordance with the provisions of this document and rated at one or more of the heating and/or cooling conditions specified in [Table 1](#) and/or [Table 2](#).

8.2 Temperature and humidity conditions: inlets to ventilator

Tests at cooling conditions shall be carried out under the conditions given in one or more of the columns T1 through T4 and T8 in [Table 1](#). Tests at heating conditions shall be carried out under the conditions given in one or more of the columns T5 through T7 in [Table 2](#).

Table 1 — Conditions of test for coefficient of energy and effective work test (cooling)

Parameter		Standard test conditions				
		T1	T2	T3	T4	T8
Temperature of entering supply air (°C)		35				
		23	24	31	24	24
Temperature of entering exhaust air (°C)		21	24	27	27	25
		15	17	20	19	18
NOTE 1 Allowable variation of readings are given in Table F.2 .						
NOTE 2 T8 is new condition.						

Table 2 — Conditions of test for coefficient of energy and effective work test (heating)

Parameter		Standard test conditions		
		T5	T6	T7
Temperature of entering supply air (°C)	dry bulb	2	5	7
	wet bulb	1	3	6
Temperature of entering exhaust air (°C)	dry bulb	21	20	20
	wet bulb	14	15	12
NOTE Allowable variation of readings are given in Table F.2 .				

8.3 Preconditions

The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained, satisfying the tolerances given in [Table F.2](#) over 30 continuous minutes. Capacity test data are taken during the last 15 min of this stability period.

8.4 Airflow conditions

8.4.1 Required rating point

Thermal performance measurements shall be performed at least at one rating point, maximum rated airflow at maximum fan speed.

8.4.2 Alternate rating points

Thermal performance measurements shall be performed with the supply airflow and return airflow volumes equal, within 0,000 6 m³/s plus 1 %, of the airflows measured during the airflow test. Alternately, if the thermal performance measurement equipment does not include airflow measurement devices, thermal performance measurements shall be performed with the inlet and outlet static pressures within 5 Pa or 2 %, whichever is greater, of those measured during the airflow test at the applicable rating point, and with the speed control at the same setting.

8.5 Static pressure conditions: ducted heat and energy recovery ventilators

Thermal performance measurements shall be performed with the static pressures at inlets and outlets controlled as required by [6.2.2.2](#), [6.2.2.3](#) and [6.2.2.4](#) in accordance with the setup type (ducted or two-room) chosen for the thermal performance measurements.

8.6 Static pressure conditions: unducted heat and energy recovery ventilators

The thermal performance measurements shall be performed with the static pressures at all inlets and outlets equal within $\pm 2,5$ Pa.

8.7 Unit operating voltage and frequency

The power supply voltage at the operating unit shall be within ± 2 % of the rated voltage. The power supply frequency at the operating unit shall be within ± 1 % of the rated frequency.

8.8 Thermal performance measurement

Thermal performance measurement methods which include unit exhaust air transfer ratio, net supply airflow, gross effectiveness, coefficient of energy and effective work are given in [Annex D](#).

9 Performance calculations

9.1 Performance calculations: ducted ventilators

Performance calculations for ducted ventilators are calculated based upon the average measured values taken during the testing period and shall include:

- a) unit exhaust air transfer ratio (see [9.3](#) and [Annex C](#));
- b) net supply airflow (see [9.4.1](#) and [Annex A](#));
- c) gross effectiveness (see [9.5](#) and [Annex D](#));
- d) coefficient of energy (see [9.6.1](#) and [Annex D](#));
- e) effective work (see [9.7.1](#) and [Annex D](#)).

9.2 Performance calculations: unducted ventilators

Performance calculations for unducted ventilators are calculated based upon the average measured values taken during the testing period and shall include:

- a) net supply airflow (see [9.4.2](#) and [Annex B](#));
- b) gross effectiveness (see [9.5](#) and [Annex D](#));
- c) coefficient of energy (see [9.6.2](#) and [Annex D](#));
- d) effective work (see [9.7.2](#) and [Annex D](#)).

9.3 Unit exhaust air transfer ratio (UEATR)

The unit exhaust air transfer ratio is given by [Formula \(1\)](#):

$$R_{\text{UEATR}} = \frac{C_2 - C_1}{C_3 - C_1} \times 100 \quad (1)$$

where

- R_{UEATR} is the unit exhaust air transfer ratio (%);
- C_2 is the tracer gas concentration at leaving supply air (station 2), ($\mu\text{mol/mol}$);
- C_1 is the tracer gas concentration at entering supply air (station 1), ($\mu\text{mol/mol}$);
- C_3 is the tracer gas concentration at entering exhaust air (station 3), ($\mu\text{mol/mol}$).

9.4 Net supply airflow

9.4.1 Net supply airflow: ducted units

Net supply airflow for ducted units shall be calculated as shown in the following [Formula \(2\)](#):

$$Q_{2,\text{net}} = \frac{R_{\text{NSAR}}}{100} \times Q_2 \quad (2)$$

where

- $Q_{2,\text{net}}$ is the net supply airflow (m^3/s);
- Q_2 is the supply airflow (m^3/s);
- R_{NSAR} is the net supply airflow ratio (%).

where

$$R_{\text{NSAR}} = 100 - R_{\text{UEATR}} \quad (3)$$

and R_{UEATR} is the unit exhaust air transfer ratio (%).

9.4.2 Net supply airflow: unducted units

Net supply airflow for unducted units as defined in [Annex B](#) shall be calculated as shown in the following [Formulae \(4\)](#) to [\(6\)](#):

$$Q_{2,\text{net}} = Q_1 - Q_2 \quad (4)$$

$$Q_{i,j} = \frac{V_c}{t_{i,j}} \ln \frac{(C_{\text{chamber},i,0} - C_{\text{OA},i,0})}{(C_{\text{chamber},i,ti,j} - C_{\text{OA},i,0})} \quad (5)$$

$$Q_{1,2} = \frac{\sum_{i=1}^3 \sum_{j=600}^{1800} \frac{V_c}{t_{i,j}} \ln \frac{(C_{\text{chamber},i,0} - C_{\text{OA},i,0})}{(C_{\text{chamber},i,ti,j} - C_{\text{OA},i,0})}}{9} \quad (6)$$

where, when corrected to standard temperature and density:

$Q_{2,\text{net}}$	is the net supply airflow (m^3/s);
Q_1	is the average of the three calculated overall airflow rates with the unit under test in operation as described in B.2.1.1 and B.2.1.2 (m^3/s);
Q_2	is the average of the three calculated natural airflow rates of the test chamber with the ventilator removed as described in B.2.2.1 and B.2.2.2 (m^3/s);
$Q_{1,2}$	is the average of the three points with each time of three attempts calculated overall airflow rates with the unit under test in operation as described in B.2.1.1 and B.2.1.2 (m^3/s);
	i represents the number of attempt (1,2,3) and j represents test times at 600 s, 12 00 s and 1 800 s of each attempt described in B.2.1.2 and B.2.2.2 ;
$Q_{i,j}$	is the airflow rate calculated using the data from attempt 'i' and time 'j' as described in B.2.1.1 , B.2.1.2 , B.2.2.1 and B.2.2.2 (m^3/s);
V_c	is the air volume in the test chamber (m^3);
$t_{i,j}$	is the elapsed time since the start (at time zero) of test unit operation at time of test in attempt (s);
$C_{\text{chamber},i,0}$	is the initial tracer gas concentration in the test chamber at time zero ($\mu\text{mol}/\text{mol}$);
$C_{\text{OA},i,0}$	is the tracer gas concentration in the air outside the chamber at time zero of test i ($\mu\text{mol}/\text{mol}$);
$C_{\text{chamber},i,t_{i,j}}$	is the tracer gas concentration in the test chamber of a test at attempt 'i' and time 'j' ($\mu\text{mol}/\text{mol}$).

9.5 Gross effectiveness, ε

The gross sensible, latent, or total effectiveness of an HRV or ERV at test conditions is described by the following [Formula \(7\)](#):

$$\varepsilon = \frac{(x_1 - x_2)}{(x_1 - x_3)} \quad (7)$$

where x equals one of the following for the test condition under consideration:

- x is the dry-bulb temperature (for sensible effectiveness), $^{\circ}\text{C}$; or
- x is the absolute humidity ratio (for latent effectiveness), $\text{kg water}/\text{kg dry air}$; or
- x is the total enthalpy (for total effectiveness), kJ/kg ;
- 1 is station 1;
- 2 is station 2;
- 3 is station 3.

9.6 Coefficient of energy (COE)

9.6.1 Coefficient of energy: ducted ventilators, $C_{\text{COE,ducted}}$

The coefficient of energy, C_{COE} , of a ducted ventilator is described by the following [Formula \(8\)](#):

$$C_{\text{COE,ducted}} = \frac{(\dot{m}_{2,\text{net}} (h_2 - h_1) \times 1\,000) + P_{\text{vma}}}{P_{\text{in}}} \quad (8)$$

where

h_1 is the enthalpy of the air at station 1 (kJ/kg of dry air);

h_2 is the enthalpy of the air at station 2 (kJ/kg of dry air);

$\dot{m}_{2,\text{net}}$ is the net supply mass flow rate at station 2 (kg/s);

P_{vma} is the power value of moving air (J/s or W);

P_{in} is the power input to ventilator (W).

and

$$\dot{m}_{2,\text{net}} = \dot{m}_2 \times \left(1 - \frac{R_{\text{UEATR}}}{100} \right) \quad (9)$$

and

$$P_{\text{vma}} = \left(\sum_1^4 |p_{si} + p_{vi}| \right) \times \dot{m}_{2,\text{net}} \times v_s \quad (10)$$

where

v_s is the specific volume of the leaving supply air (m³/kg);

p_{si} are the static pressures at the inlet(s) and outlet(s) (Pa);

p_{vi} are the dynamic pressures at the inlet(s) and outlet(s) (Pa).

and

$$P_{\text{in}} = P_{\text{em}} + P_{\text{aux}} \quad (11)$$

where

P_{in} is the power input to ventilator in operation (W);

P_{em} is the power input to all electric motors in the ventilator (W);

P_{aux} is the power input to any other electrical components in the ventilator (W).

9.6.2 Coefficient of energy: unducted ventilators, $C_{\text{COE,unducted}}$

The coefficient of energy, C_{COE} , of an unducted ventilator is described by the following [Formula \(12\)](#):

$$C_{\text{COE,unducted}} = \frac{(\dot{m}_{2,\text{net}} (h_2 - h_1) \times 1\,000)}{P_{\text{in}}} \quad (12)$$

where

- h_1 is the enthalpy of the air at station 1 (kJ/kg of dry air);
- h_2 is the enthalpy of the air at station 2 (kJ/kg of dry air);
- $\dot{m}_{2,\text{net}}$ is the net supply mass flow rate at station 2 (kg/s);
- P_{in} is the power input to ventilator in operation (W).

and

$$\dot{m}_{2,\text{net}} = \dot{m}_2 \times \left(1 - \frac{R_{\text{UEATR}}}{100} \right) \quad (13)$$

and

$$P_{\text{in}} = P_{\text{em}} + P_{\text{aux}} \quad (14)$$

where,

- P_{in} is the power input to ventilator in operation (W);
- P_{em} is the power input to all electric motors in the ventilator (W);
- P_{aux} is the power input to any other electrical components in the ventilator (W).

9.7 Effective work (EW)

9.7.1 Effective work: ducted ventilators, $W_{\text{EW,ducted}}$

The effective work, W_{EW} , of a ducted ventilator is described by the following [Formula \(15\)](#):

$$W_{\text{EW,ducted}} = P_{\text{in}} \times (C_{\text{COE,ducted}} - 1) = (|\dot{m}_{2,\text{net}} \times (h_2 - h_1)| \times 1\,000) + P_{\text{vma}} - P_{\text{in}} \quad (15)$$

9.7.2 Effective work: unducted ventilators, $W_{\text{EW,unducted}}$

The effective work, W_{EW} , of an unducted ventilator is described by the following [Formula \(16\)](#):

$$W_{\text{EW,unducted}} = P_{\text{in}} \times (C_{\text{COE,unducted}} - 1) = |\dot{m}_{2,\text{net}} \times (h_2 - h_1)| \times 1\,000 - P_{\text{in}} \quad (16)$$

9.7.3 When moisture transfer is not of interest or does not occur: the following substitution can be made in either C_{COE} or W_{EW} :

$$|h_2 - h_1| = |(c_{p2} \times T_2) - (c_{p1} \times T_1)| \quad (17)$$

where

- h_1 is the enthalpy of the air at station 1 (kJ/kg of dry air);
- h_2 is the enthalpy of the air at station 2 (kJ/kg of dry air);
- c_{p1} is the specific heat at supply airflow at station 1 (kJ/(kg·K));
- c_{p2} is the specific heat at supply airflow at station 2 (kJ/(kg·K));

T_1 is the temperature of the supply airflow at station 1 (dry bulb) (K);

T_2 is the temperature of the supply airflow at station 2 (dry bulb) (K).

10 Test results

All measurements made under this document need to be reported together to accurately characterize ventilator performance. Sample data collection and reporting worksheets are provided in [Annex E](#).

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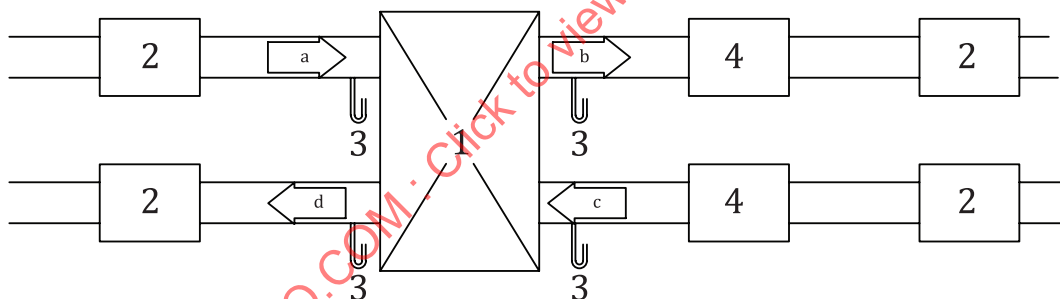
Annex A (informative)

Airflow measurement methods for both ducted and unducted ventilators — Test equipment

The test equipment shall be as follows:

- a) The unit shall be equipped with ductwork, airflow measurement devices, and pressure balancing means as shown in [Figure A.1](#).
- b) Static pressure controllers shall be provided as necessary to balance the static pressures at the inlets and outlets as prescribed. Static pressure controllers may include dampers and or speed-controllable blowers. The static pressure controllers shall be airtight if they are located between the ventilator and the airflow measuring apparatus.
- c) Static pressure measurement devices shall be located so as to accurately characterize the static pressures at the inlets and outlets of the ventilator. Appropriate measurement devices are further defined in ISO 3966, ISO 5167 (all parts), and ISO 5801.
- d) The airflow shall be measured according to ISO 3966, ISO 5167 (all parts), and ISO 5801 shall be expressed in standard m³/s.

[Figure A.1](#) shows the basic measurement principle.



Key

- | | |
|---------------------------------------|------------------------------|
| 1 ventilator | a Entering supply air (OA). |
| 2 static pressure control apparatus | b Leaving supply air (SA). |
| 3 static pressure measuring apparatus | c Entering exhaust air (RA). |
| 4 airflow measuring apparatus | d Leaving exhaust air (EA). |

Simultaneous measurement of supply and exhaust airflow is preferred. However, at least one airflow measuring apparatus shall be in use as per [6.2.2.5](#).

Figure A.1 — Arrangement for airflow measurement

Annex B
(normative)

Decay method for measurement of net supply airflow

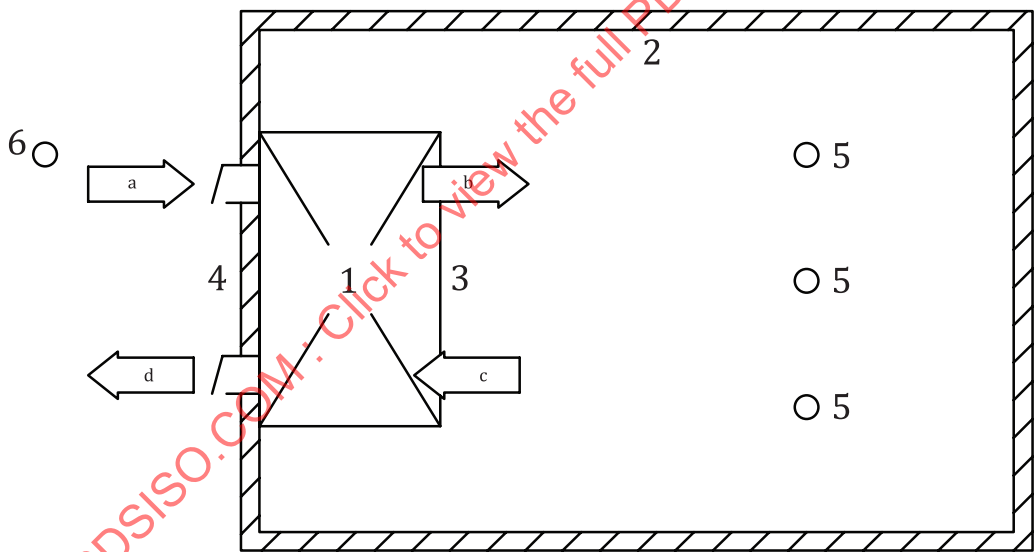
B.1 Measurement equipment

B.1.1 Tracer gas, sampling equipment, room volume and gas concentration levels shall be selected so as to be capable of accurately measuring the unit performance.

B.1.2 Three sampling pipes shall be installed inside the test chamber, in three vertical positions around the centre of the chamber.

B.1.3 The inner wall material of the test chamber shall not be gas permeable or gas absorbent.

B.1.4 The air tightness of the test chamber shall be 0,3 or less natural air change per hour.



Key

- | | | | |
|---|-----------------------|---|----------------------------|
| 1 | ventilator | 6 | outdoor sampling pipes |
| 2 | test chamber | a | Entering supply air (OA). |
| 3 | indoor side | b | Leaving supply air (SA). |
| 4 | outdoor side | c | Entering exhaust air (RA). |
| 5 | indoor sampling pipes | d | Leaving exhaust air (EA). |

Figure B.1 — Basic measurement principle for sample measurement equipment setup (decay method) for net supply airflow measurement of unducted units

B.2 Measurement procedures

B.2.1 The tracer gas concentration measurement shall be as follows:

B.2.1 Determination of overall room air change rate with ventilator in operation: Install the ventilator, complete with all model-specific exterior termination systems and/or grilles, as shown in [Figure B.1](#).

B.2.1.1 Measurement of initial concentration of tracer gas: Fill the test chamber with the tracer gas and verify that the concentration level is uniform throughout the chamber by measuring the concentration in at least three locations with approximately equal spacing between the floor and the ceiling. Stop the supply of tracer gas to the chamber. The ventilator shall not be operating. The tracer gas concentration shall be such that tracer gas will be measurable after 30 min of operation of the unit under test. The measurement shall be started after the tracer gas supply is stopped and confirming that the tracer gas concentration of station 3 (RA) in [Figure B.1](#) is stably decreased

B.2.1.2 Measurement of concentrations of tracer gas during the test: Start the ventilator. After making several measurements and confirm that the tracer gas concentration of station 3 (RA) in [Figure B.1](#) is stably decreasing. Start to measure the concentration of tracer gas at time zero. Record the concentration of the tracer gas at time zero, 600 s, 1 200 s and 1 800 s after the start of the test.

B.2.1.3 The test as described in [B.2.1.1](#) and [B.2.1.2](#) shall be performed three times.

B.2.2 Determination of natural air change rate with ventilator not in operation: Remove the test unit and seal the unit installation opening.

B.2.2.1 Measurement of initial concentration of tracer gas: Fill the test chamber with the tracer gas and verify that the concentration level is uniform throughout the chamber by measuring the concentration in at least three locations with approximately equal spacing between the floor and the ceiling. Stop the supply of tracer gas to the chamber. The tracer gas concentration shall be such that tracer gas will be measurable after 30 min of natural ventilation of the chamber. The measurement shall be started after the tracer gas supply is stopped and confirming that the tracer gas concentration of station 3 (RA) in [Figure B.1](#) is stably decreased

B.2.2.2 Measurement of concentrations of tracer gas during the test: Measure and record the concentration of tracer gas at time zero, 600 s, 1 200 s and 1 800 s after the start of the test, where time zero is the time of the first measurement.

B.2.2.3 The test as described in [B.2.2.1](#) and [B.2.2.2](#) shall be performed three times.

Annex C (informative)

Unit exhaust air transfer ratio measurement methods

C.1 Test equipment

C.1.1 The unit shall be equipped with ductwork, and external static pressure controllers. Tracer gas, sampling equipment, room volume and gas concentration levels shall be selected so as to be capable of accurately measuring the unit internal and external leakages.

All test equipment arrangements can be divided into two categories: ducted test facilities and two-room test facilities.

C.1.2 The tracer gas generation equipment shall be designed to provide a stable concentration of tracer gas that is uniform in the chamber or duct to which the tracer gas is introduced.

C.1.3 Measurement equipment shall be provided at each location where tracer gas concentration shall be measured such that

- tracer gas concentration readings are taken at a minimum of three representative locations (1, 2 and 3 in [Figure 1](#)), or
- by a means of collecting and transporting air samples from these multiple locations to the analyser (i.e., a sampling grid).

This equipment shall meet the following requirements (mixing devices may be necessary to meet these requirements):

- a) a gas chromatograph analyser or an alternative instrument that satisfies the uncertainties of measurements required by [Annex F](#); if the analyser will be sequentially measuring the tracer gas concentration in samples from more than one of the stations, then either the data or the sample from the beginning of each sample measurement period should be purged until the concentration readings have stabilized;
- b) a means of injecting a tracer gas that is nontoxic, identifiable, measurable, and inert. Common tracer gases include, but are not limited to SF₆ and CO₂; and
- c) the tracer gas concentrations at each sample point shall be within ± 5 % of the mean when taken simultaneously or within ± 2 % of the mean if taken at different times.

C.1.4 Ducts and other components of the test equipment shall not be permeable to or absorbent of the tracer gas.

C.1.5 Ducts and other components of the test equipment shall not allow air leakage.

C.1.6 Static pressures shall be measured according to ISO 3966, ISO 5167 (all parts), and ISO 5801.

C.2 General procedures

C.2.1 Extreme care shall be taken to ensure that dilution does not occur in the sampling system.

C.2.2 The injection concentration of the tracer gas shall be sufficient that a unit exhaust air transfer ratio of 0,25 % can be measured by the device being used.

C.3 Procedure for ventilators intended for installation in a conditioned space

C.3.1 General

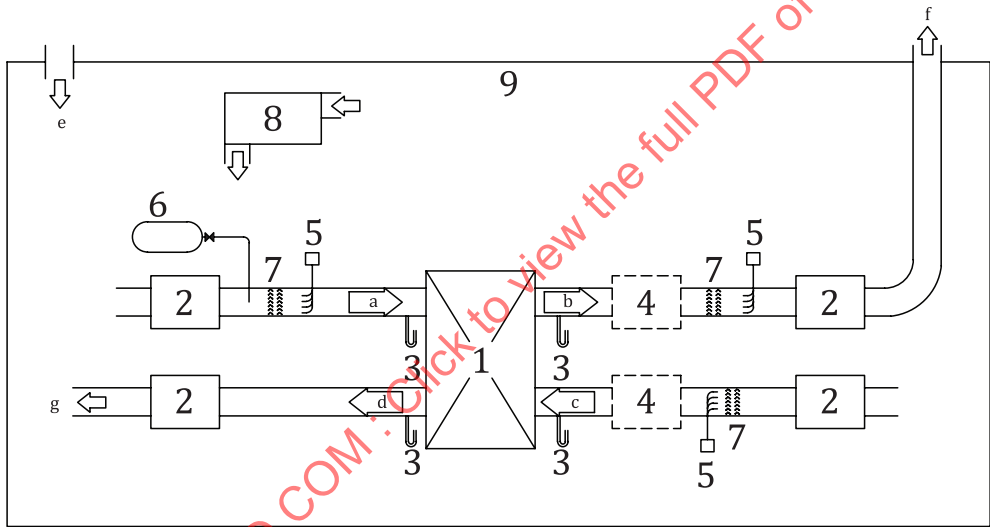
These tests determine the total amount of leakage inside the unit from the exhaust air, x_3 , to the fresh air, x_2 , and from the surrounding room to the fresh air, x_2 .

C.3.2 Testing by injection of tracer gas into outside air

C.3.2.1 A tracer gas shall be injected into a turbulent region upstream of station 1 (See [Figure C.1](#)).

C.3.2.2 Air samples shall be drawn from stations 1, 2 and 3 to determine the concentration of the tracer gas.

C.3.2.3 Unit exhaust air transfer ratio, R_{UEATR} , shall be determined.



Key

- | | | | |
|---|-------------------------------------|---|----------------------------|
| 1 | ventilator | 9 | test facility |
| 2 | static pressure control apparatus | a | Entering supply air (OA). |
| 3 | static pressure measuring apparatus | b | Leaving supply air (SA). |
| 4 | airflow measuring apparatus | c | Entering exhaust air (RA). |
| 5 | tracer gas sampler | d | Leaving exhaust air (EA). |
| 6 | tracer gas source | e | Make up air inlet. |
| 7 | air mixer | f | Supply air outlet. |
| 8 | air conditioning apparatus | g | Exhaust air outlet. |

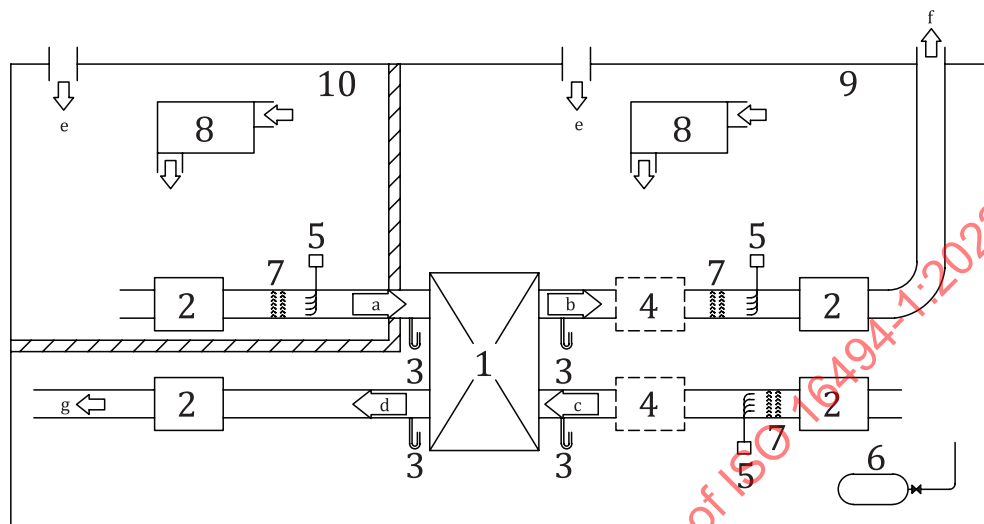
Figure C.1 — Basic measurement principle schematic for ducted R_{UEATR} measurement system for ventilators intended for installation in a conditioned space

C.3.3 Testing by tracer gas injected into indoor chamber

C.3.3.1 A tracer gas shall be injected into the inside room (See [Figure C.2](#)).

C.3.3.2 Air samples shall be drawn from stations 1, 2 and 3 to determine the concentration of the tracer gas.

C.3.3.3 Unit exhaust air transfer ratio, R_{UEATR} , shall be determined.



Key

- | | |
|---------------------------------------|------------------------------|
| 1 ventilator | 10 “outdoor” test facility |
| 2 static pressure control apparatus | a Entering supply air (OA). |
| 3 static pressure measuring apparatus | b Leaving supply air (SA). |
| 4 airflow measuring apparatus | c Entering exhaust air (RA). |
| 5 tracer gas sampler | d Leaving exhaust air (EA). |
| 6 tracer gas source | e Make up air inlet. |
| 7 air mixer | f Supply air outlet. |
| 8 air conditioning apparatus | g Exhaust air outlet. |
| 9 “indoor” test facility | |

Figure C.2 — Basic measurement principle schematic for two-room R_{UEATR} measurement system for ventilators intended for installation in a conditioned space, with tracer gas introduced into “Indoor” chamber

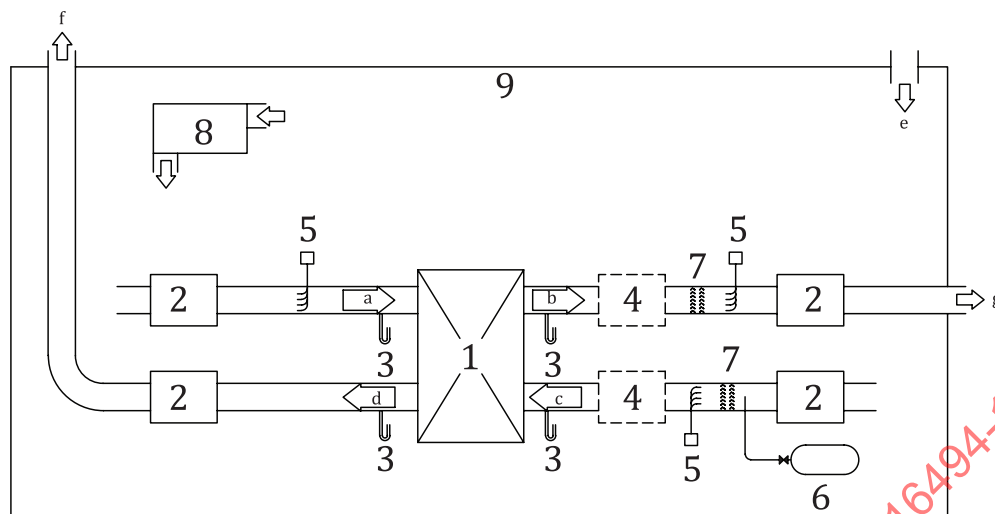
C.4 Procedure for ventilators intended for installation in outdoors space

C.4.1 This test determines the amount of leakage inside the unit from the exhaust air to the fresh air.

C.4.2 A tracer gas shall be injected a turbulent region upstream of station 3 or into the inside room.

C.4.3 Air samples shall be drawn from stations 1, 2, and 3 to determine the concentration of the tracer gas (See [Figure C.3](#)).

C.4.4 Unit exhaust air transfer ratio, R_{UEATR} , shall be determined.



Key

- | | |
|---------------------------------------|------------------------------|
| 1 ventilator | 9 test facility |
| 2 static pressure control apparatus | a Entering supply air (OA). |
| 3 static pressure measuring apparatus | b Leaving supply air (SA). |
| 4 airflow measuring apparatus | c Entering exhaust air (RA). |
| 5 tracer gas sampler | d Leaving exhaust air (EA). |
| 6 tracer gas source | e Make up air inlet. |
| 7 air mixer | f Exhaust air outlet. |
| 8 air conditioning apparatus | g Supply air outlet. |

Figure C.3 — Basic measurement principle schematic for ducted R_{UEATR} measurement system for ventilators intended for installation outdoors

Annex D (informative)

Thermal performance measurement

D.1 Test equipment

D.1.1 When measuring thermal performance as per [Figure D.1](#), the laboratory ambient conditions shall be $(20 \pm 10) ^\circ\text{C}$ and 30 % RH to 95 % RH. Laboratory ambient temperature during the test shall be recorded and reported.

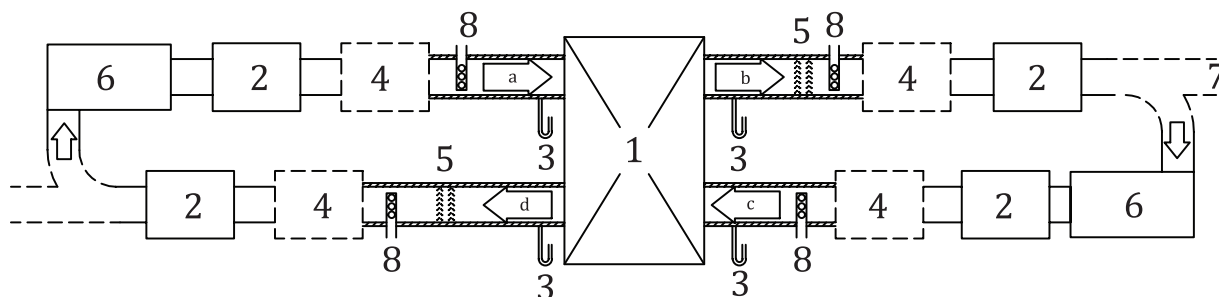
D.1.2 Unit shall be equipped with ductwork, static pressure measurement devices, and pressure balancing means as shown in schematic [Figures D.1, D.2 and D.3](#). Temperature and humidity at all the measurement stations shall be recorded during the testing period at a rate of not less than once per minute. Once the unit is at steady-state, operation, including preconditioning as per [8.3](#), shall continue until at least 30 measurements have been recorded over a period of at least 15 min. Construction of plenums required to connect these devices to unducted inlets or outlets is described in [D.2](#). [Annex G](#) shows an example of plenum construction.

D.1.3 Static pressures shall be measured according to ISO 3966, ISO 5167 (all parts), and ISO 5801 and shall be expressed in Pa.

D.1.4 Airflow shall be measured according to ISO 3966, ISO 5167 (all parts), and ISO 5801 and shall be expressed in standard m^3/s .

D.1.5 Ducts connected to ventilator inlets and outlets shall be of the dimensions specified by the manufacturer.

D.1.6 The ducts shall be thermally insulated to minimize heat leakage between the equipment inlet or outlet and the temperature measuring instruments, so that the test results are not changed by the effects of surrounding temperatures.

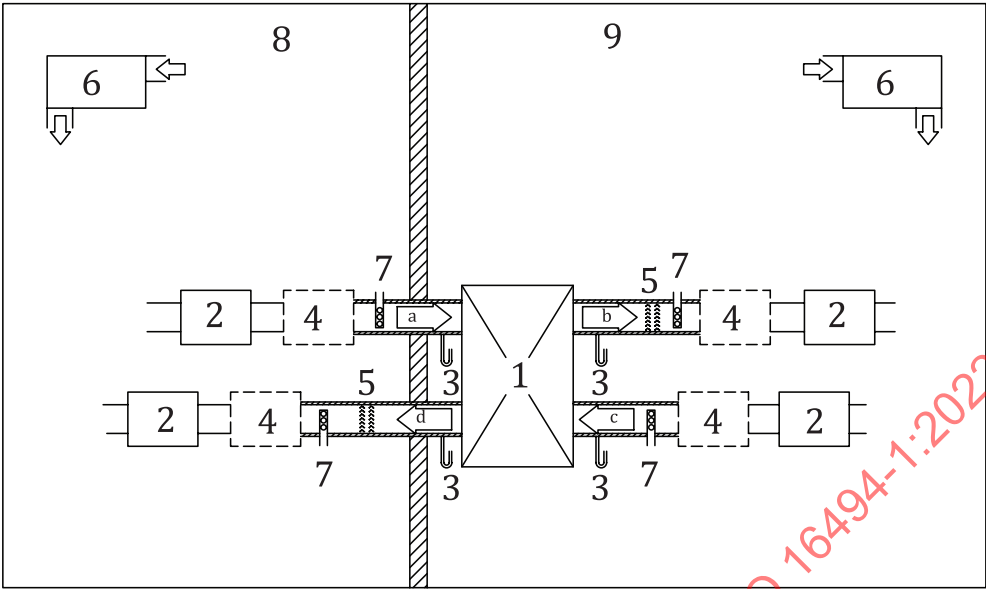


Key

- | | |
|---------------------------------------|---|
| 1 ventilator | 7 relief inlet/outlet |
| 2 static pressure control apparatus | 8 temperature and humidity measuring instrument |
| 3 static pressure measuring apparatus | a Entering supply air (OA). |
| 4 airflow measuring apparatus | b Leaving supply air (SA). |
| 5 air mixer | c Entering exhaust air (RA). |
| 6 air conditioning apparatus | d Leaving exhaust air (EA). |

NOTE Airflow measurement devices are optional. Temperature and humidity measurement and mixing station at station 4 (EA) are optional.

Figure D.1 — Basic measurement principle schematic for ducted thermal performance measurement setup

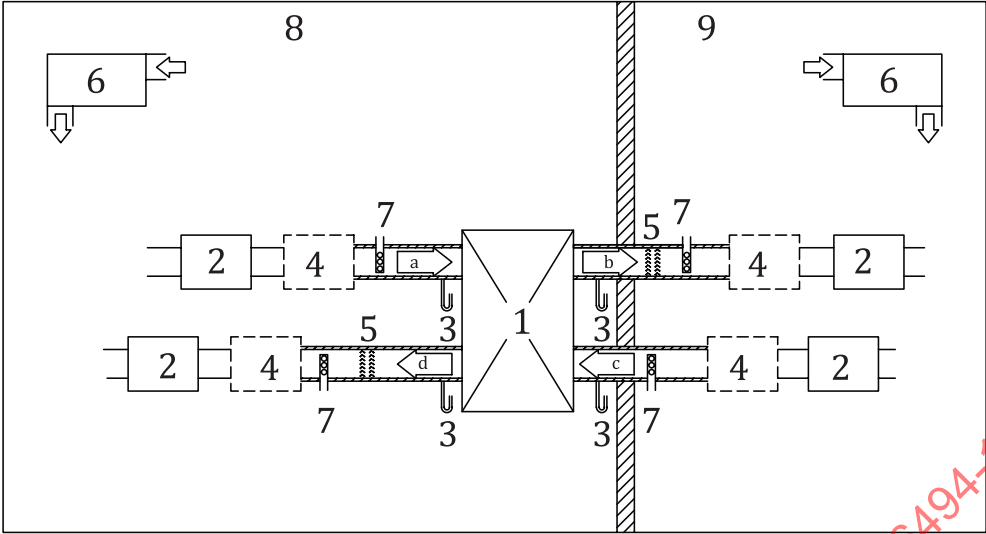


Key

- | | |
|---|------------------------------|
| 1 ventilator | 8 “outdoor” test facility |
| 2 static pressure control apparatus | 9 “indoor” test facility |
| 3 static pressure measuring apparatus | a Entering supply air (OA). |
| 4 airflow measuring apparatus | b Leaving supply air (SA). |
| 5 air mixer | c Entering exhaust air (RA). |
| 6 air conditioning apparatus | d Leaving exhaust air (EA). |
| 7 temperature and humidity measuring instrument | |

NOTE Airflow measurement devices are optional. Mixing station and temperature and humidity measurement at station 4 (EA) are optional.

Figure D.2 — Basic measurement principle schematic for two-rooms thermal performance measurement for ventilators intended for installation in a conditioned space



Key

- | | | | |
|---|---|---|----------------------------|
| 1 | ventilator | 8 | “outdoor” test facility |
| 2 | static pressure control apparatus | 9 | “indoor” test facility |
| 3 | static pressure measuring apparatus | a | Entering supply air (OA). |
| 4 | airflow measuring apparatus | b | Leaving supply air (SA). |
| 5 | air mixer | c | Entering exhaust air (RA). |
| 6 | air conditioning apparatus | d | Leaving exhaust air (EA). |
| 7 | temperature and humidity measuring instrument | | |

NOTE Airflow measurement devices are optional. Mixing station and temperature and humidity measurement at station 4 (EA) are optional.

Figure D.3 — Basic measurement principle schematic for two-room thermal performance measurement for ventilators intended for installation outside

D.2 Test performance

Verify that the difference between the highest and the lowest temperatures inside the duct at the temperature measurement location will not be more than 0,3 K. Provide a mixing device upstream of the temperature measurement location if necessary to meet this requirement.

Annex E (informative)

Example data collection and reporting sheets

The example data collection and reporting sheets are provided in [Tables E.1](#) to [E.14](#).

Table E.1 — Airflow measurement per [Annex A](#)

		Airflow measurement: Collected data ^a					
		Point 1 (Max)	Point 2	Point 3	Point 4	Point 5 (Min)	Unit
Temperature (dry bulb) ^b	T_2^c						°C
	T_3						°C
Temperature (wet bulb)	$T_{WB,1}$						°C
	$T_{WB,2}$						°C
Barometric pressure, lab ambient	p_{BAR}						kPa
Temperature, lab ambient	T_{LAB}						°C
Static pressures ^d	p_{s1}						Pa
	p_{s2}						Pa
	p_{s3}						Pa
	p_{s4}						Pa
Δp at nozzles, or velocity pressures ^e	Δp_2						Pa
	Δp_3						Pa
Static pressures before nozzles ^e	$p_{s,N2}$						Pa
	$p_{s,N3}$						Pa
Voltage ^f	V						V
Power input	P_{in}						W
Current	A						A
Frequency ^f	f						Hz
Speed control settings ^g	—						High, medium, and low

^a Point 1 is the maximum rated airflow. Point 5 is the minimum rated airflow. If the unit has multiple speed control settings, the airflow performance test is repeated to characterize unit airflow at the different speed control settings.

^b Psychrometric conditions are measured to determine mass flow rates and equivalent volumetric flow rates at standard density.

^c Subscripts indicate station(s) at which measurements are taken.

^d Measured relative to lab atmospheric pressure. Static pressures are to be controlled within specific tolerances.

^e Depending on the method of airflow measurement, other data might need to be collected.

^f To be controlled within tolerances.

^g Speed is not measured. Control setting (if any) is recorded.

Table E.2 — Airflow performance per [Annex A](#): Calculated results

		Airflow performance: Calculated results ^a					
		Point 1 (Max)	Point 2	Point 3	Point 4	Point 5 (Min)	Unit
Leaving supply airflow	Q_2						m ³ /s

^a Point 1 is the maximum rated airflow. Point 5 is the minimum rated airflow.

Table E.2 (continued)

		Airflow performance: Calculated results ^a					
		Point 1 (Max)	Point 2	Point 3	Point 4	Point 5 (Min)	Unit
Entering exhaust airflow	Q_3						m ³ /s
External static pressure difference	$\Delta p_{s,ext}[2-1]$						Pa
	$\Delta p_{s,ext}[3-4]$						Pa

^a Point 1 is the maximum rated airflow. Point 5 is the minimum rated airflow.

Table E.3 — Airflow measurement per Annex B

		Data collected with Ventilator running ^a			
		Test 1 ^b	Test 2	Test 3	Unit
Ambient temperature (dry bulb) ^c	T_a				°C
Ambient temperature (wet bulb)	T_{WBa}				°C
Barometric pressure, lab ambient	P_{BARa}				kPa
Temperature, lab ambient	T_{LAB}				°C
Tracer gas concentration in chamber, $C_{l,ti}$ ^d	$C_{l,t0}$				μmol/mol
	$C_{l,t10}$				μmol/mol
	$C_{l,t20}$				μmol/mol
	$C_{l,t30}$				μmol/mol
Tracer gas concentration in outdoor air, $C_{o,ti}$	$C_{o,t0}$				μmol/mol
	$C_{o,t10}$				μmol/mol
	$C_{o,t20}$				μmol/mol
	$C_{o,t30}$				μmol/mol
Voltage ^e	V				V
Power Input	P_{in}				W
Current	A				A
Frequency ^e	f				Hz
Speed control setting ^f					High, medium, and low

^a If the unit has multiple speed control settings, the airflow performance test is repeated to characterize unit airflow at the different speed control settings.

^b For any one speed control setting, the test procedure is repeated three times.

^c Psychrometric conditions are measured to determine mass flow rates and equivalent volumetric flow rates at standard density.

^d Subscript n indicates the time in minutes after beginning the test at which the measurement is taken.

^e To be controlled within tolerances.

^f Speed is not measured. Control setting (if any) is recorded.

Table E.4 — Airflow measurement per Annex B: Calculated Results with ventilator removed

		Data collected with Ventilator removed			
		Test 1 ^a	Test 2	Test 3	Unit
Ambient temperature (dry bulb) ^b	T_a				°C
Ambient temperature (wet bulb)	T_{WBa}				°C

^a With the ventilator removed, the test procedure is repeated three times.

^b Psychrometric conditions are measured to determine mass flow rates and equivalent volumetric flow rates at standard density.

^c Subscript i indicates the time in minutes after beginning the test at which the measurement is taken.