BS ISO 16494:2014

BSI Standards Publication

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

bsi.

...making excellence a habit.™

Document Sharing Hub

National foreword

This British Standard is the UK implementation of ISO 16494:2014.

The UK participation in its preparation was entrusted to Technical Committee RHE/17, Testing of air conditioning units.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2014. Published by BSI Standards Limited 2014

ISBN 978 0 580 77088 3

ICS 23.120; 27.080

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2014.

Amendments issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS ISO 16494:2014

INTERNATIONAL STANDARD

ISO 16494

First edition
2014-11-01

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

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

Reference number
ISO 16494:2014(E)

Documents
Document Sharing Hub

© ISO 2014

Full document details: BS ISO 16494:2014

COPYRIGHT PROTECTED DOCUMENT

© ISO 2014

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 16494:2014

Contents

Page

Foreword ..... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Symbols and abbreviated terms **5**

5 Airflow test **6**
5.1 General conditions 6
5.2 Ducted heat recovery ventilators and energy recovery ventilators 6
5.3 Unducted heat recovery ventilators and energy recovery ventilators 9

6 Tracer gas tests **9**
6.1 General conditions 9
6.2 Temperature conditions 9
6.3 Preconditions 9
6.4 Airflow conditions 9
6.5 Unit operating voltage and frequency 9
6.6 Tracer gas measurement methods 9

7 Determination of efficiency **10**
7.1 General conditions 10
7.2 Temperature and humidity conditions: inlets to ventilator 10
7.3 Preconditions 10
7.4 Airflow conditions 10
7.5 Static pressure conditions: ducted heat and energy recovery ventilators 11
7.6 Static pressure conditions: unducted heat and energy recovery ventilators 11
7.7 Unit operating voltage and frequency 11
7.8 Thermal performance measurement 11

8 Performance calculations **11**
8.1 Performance calculations: ducted ventilators 11
8.2 Performance calculations: unducted ventilators 11
8.3 Unit Exhaust Air Transfer Ratio (UEATR) 11
8.4 Net supply airflow 12
8.5 Gross effectiveness 13
8.6 Coefficient of energy (COE) 14
8.7 Effective work (EW) 15

9 Test results **16**

Annex A (normative) **Airflow measurement method for both ducted and unducted ventilators** **17**

Annex B (normative) **Decay method for measurement of net supply airflow** **19**

Annex C (normative) **Unit exhaust air transfer ratio measurement methods** **21**

Annex D (normative) **Thermal performance measurement** **25**

Annex E (informative) **Example data collection and reporting sheets** **28**

Annex F (normative) **Required instrument uncertainty** **36**

Annex G (informative) **Construction of plenums for connection to inlets or outlets not designed for connection of ductwork** **37**

Bibliography **38**

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

INTERNATIONAL STANDARD ISO 16494:2014(E)

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

1 Scope

This International Standard prescribes 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.

2 Normative references

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

ISO 3966:2008, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes*

ISO 5167-1:2003, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

ISO 5801:2007, *Industrial fans — Performance testing using standardized airways*

3 Terms and definitions

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

3.1
outdoor airflow
OA
volume of outside air entering the ventilator

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

Note 2 to entry: Also referred to as ‘entering supply air’.

3.2
supply airflow
SA
outside air after passing through the ventilator

Note 1 to entry: Indicated in Figure 1 as 2.

Note 2 to entry: Also referred to as ‘leaving supply air’.

3.3
return (extract) airflow
RA
indoor air entering the ventilator

Note 1 to entry: Indicated in Figure 1 as 3.

Note 2 to entry: Also referred to as ‘entering exhaust air’.

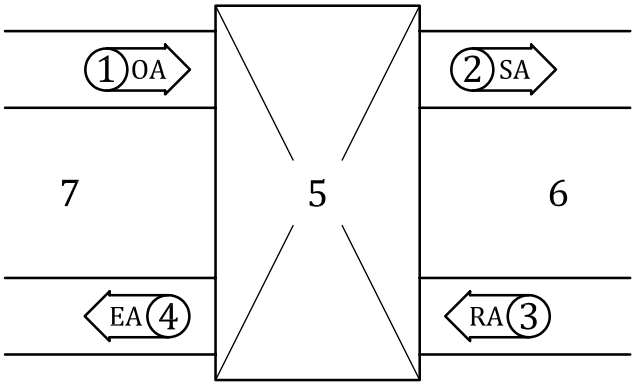
© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

3.4
exhaust airflow
EA
indoor air after passing through the ventilator

Note 1 to entry: Indicated in Figure 1 as 4.

Note 2 to entry: Also referred to as 'leaving exhaust air'.



Key

1 outdoor airflow (OA) (entering)
2 supply airflow (SA) (leaving)
3 return airflow (RA) (entering)
4 exhaust airflow (EA) (leaving)
5 ventilator
6 indoor side
7 outdoor side

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

3.5
station
location in the test apparatus at which conditions such as temperature, humidity, pressure, or airflow are measured

Note 1 to entry: These locations are identified as "station 1", "station 2", "station 3" and "station 4" for each of the airflows indicated in Figure 1.

3.6
coefficient of energy
COE
total exchanged energy between the airstreams plus the power value of moving air, divided by the power input

Note 1 to entry: The equation for determining the coefficient of energy is given in 8.6.

3.7
rating points
sets of supply and return 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

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

3.8
effective work
EW
total exchanged energy between the airstreams plus the power value of moving air minus the power input

Note 1 to entry: The equation for determining the effective work is given in 8.7.

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

3.9
power value of moving air
rate of pressure energy and kinetic energy of the air delivered by the ventilator

Note 1 to entry: The equation that determines the power value of moving air is given in 8.6.1.

Note 2 to entry: Power value of moving air is expressed in J/s for P_{vma}.

3.10
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 8.5.

3.11
maximum rated airflow
the largest supply and return 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.

3.12
minimum rated airflow
the smallest supply and return 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.

3.13
net supply airflow
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_{SANet}, measured in m^3/s.

Note 2 to entry: The equations for determining net supply airflow are given in 8.4.1 (ducted units) and 8.4.2 (unducted units).

3.14
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 8.4.1 and 8.4.2.

3.15
speed control device
device incorporated into the ventilator which controls the speed of the fan

3.16
standard air
dry air with a density of 1,2 kg/m^3

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

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

3.17
static pressure differential
absolute difference between inlet static pressure and outlet static pressure for each of the two airstreams

EXAMPLE Static pressures measured at $|X_2\text{-}X_1|$, or $|X_4\text{-}X_3|$.

3.18
thermal performance measurement
test procedure which measures the temperature and humidity of the supply air when a ventilator is operating with the outside air and return air at specific psychrometric conditions

3.19
unit exhaust air transfer ratio
UEATR
tracer gas concentration difference between the supply airflow and the outdoor airflow divided by the tracer gas concentration difference between the return airflow and the outdoor airflow, at a specified airflow

Note 1 to entry: The equation for UEATR is given in 8.3.

Note 2 to entry: UEATR is expressed as a percentage.

3.20
ventilator
self contained unit that includes fans to move air through the heat/energy exchanger

3.21
energy recovery ventilator
ERV
ventilator which is designed to transfer both heat and moisture between two isolated airstreams

3.22
fresh air mass flow rate
qm_2
leaving supply mass airflow rate at station 2

3.23
heat recovery ventilator
HRV
ventilator which is designed to transfer only heat between two isolated airstreams

3.24
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 3.27

3.25
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)

3.26
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

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

3.27
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

3.28
net supply mass flow rate
$qm_{2,net}$
portion of the leaving supply mass airflow rate at station 2 that originated as entering supply mass flow rate at station 1, accounting for *UEATR*

Note 1 to entry: Per the equation in 8.6.1and 8.6.2.

4 Symbols and abbreviated terms

Symbol	Definition	Units
C_i	Initial tracer gas concentration in the test chamber (average of all measurement points)	
C_o	Tracer gas concentration in outdoor air (OA)	
C_{OA}	Tracer gas concentration at outdoor air inlet (station 1)	
C_p	Specific heat at supply airflow	kJ/kg K
C_{RA}	Tracer gas concentration at return air inlet (station 3)	
C_{SA}	Tracer gas concentration at supply air outlet (station 2)	
C_t	Tracer gas concentration in the test chamber after *t* hours (average of all measurement points)	
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
qm_2	Fresh air mass flow rate	kg/s
$qm_{2,net}$	Net supply mass flow rate	kg/s
NSAR	Net supply airflow ratio	%
P_{aux}	Input power to any other electrical components in the ventilator	W
P_{em}	Input power to all electric motors in the ventilator	W
P_{in}	Input power to ventilator	W
P_{vma}	Power value of moving air	J/s
Q	Gross airflow	m^3/s
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	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	m^3/s
Q_i	Airflow rate calculated using the data from a test 'i' as described in B.2.1.1, B.2.1.2, B.2.2.1 and B.2.2.2	m^3/s
Q_{SA}	Supply airflow	m^3/s
Q_{SANet}	Net supply airflow	m^3/s
ps_n	External static pressures at the inlet(s) or outlet(s)	Pa
t	Length of time elapsed since the start of test unit operation	s
T_1	Temperature of the outdoor airflow at station 1	K
T_2	Temperature of the supply airflow at station 2	K

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

Symbol	Definition	Units
UEATR	Unit exhaust air transfer ratio	%
V	Air volume in the test chamber	m^3
v_s	Specific volume of the supply air	m^3/kg
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 J/kg
ε	Effectiveness	

5 Airflow test

5.1 General conditions

All tested equipment within the scope of this International Standard shall have the airflows determined in accordance with the following provisions:

5.1.1 Temperature conditions

When measuring airflow, the laboratory ambient conditions shall be 20 ± 15 °C and 30 to 95 % RH. Laboratory ambient temperature during the test shall be recorded and reported.

5.1.2 Speed control setting

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

5.1.3 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.

5.2 Ducted heat recovery ventilators and energy recovery ventilators

5.2.1 Airflows measured

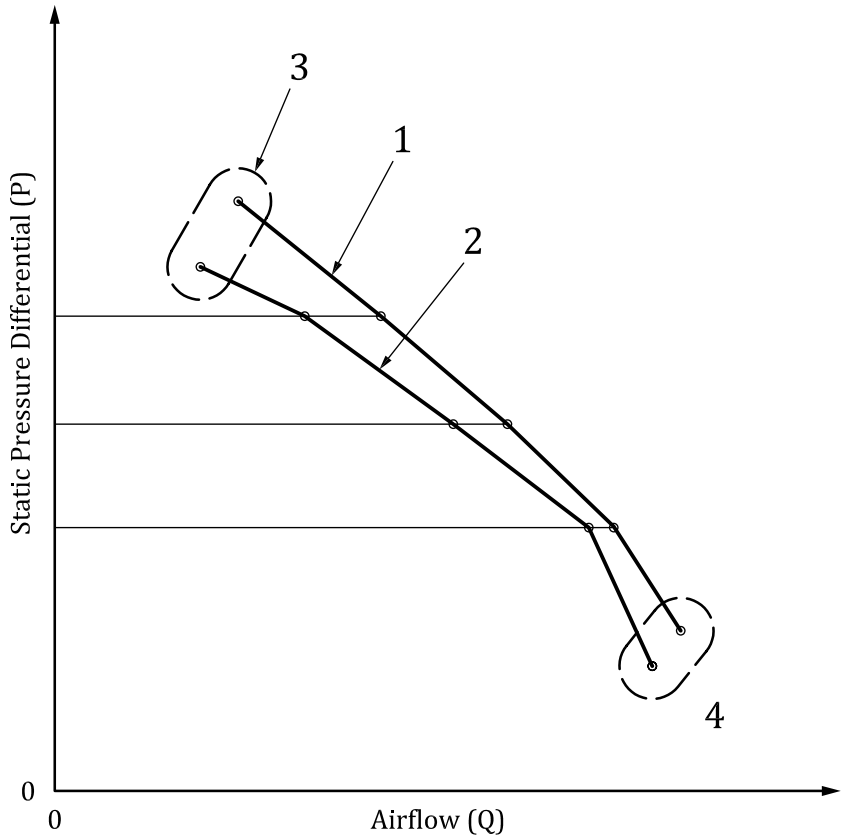
The gross airflow shall be measured and recorded at station 2 (Supply Airflow) and at station 3 (Return Airflow) as shown in Figure 1, under the static pressure conditions indicated in 5.2.2.

5.2.2 Static pressure conditions

5.2.2.1 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 must be reached by adjusting the test apparatus to change the static pressure differential. If the ventilator is equipped with a speed control device, it shall not be adjusted during this test. Input power in watts shall be measured and recorded at each test point.

5.2.2.2 Any inlet or outlet which is not designed for duct connection shall be maintained at an average value of 0 ± 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 3.27, that system shall be installed.

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014



Key

1 P-Q curve (supply airflow)
2 P-Q curve (return airflow)
3 minimum rated airflow
4 maximum rated airflow

Figure 2 — Representative chart of airflow performance

5.2.2.3 Static pressure measurement requirements

When testing for airflow, the requirements of 5.2.2.3 a) or 5.2.2.3 b) 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 (ps_1) and outlet (ps_2) shall be equal within 10 Pa or 5 %, whichever is greater, of the larger of the measured values of ps_1 or ps_2, except as noted in 5.2.2.2.

2) The absolute value of static pressure at inlet (ps_3) and outlet (ps_4) shall be equal, within 10 Pa or 5 %, whichever is greater, of the larger of the measured values of ps_3 and ps_4, except as noted in 5.2.2.2.

3) For each intermediate test point, the absolute value of static pressures at each inlet and outlet (ps_1, ps_2, ps_3 and ps_4) shall be equal within 10 Pa or 5 %, whichever is greater, of the largest of the measured value of ps_1, ps_2, ps_3 or ps_4, except as noted in 5.2.2.2.

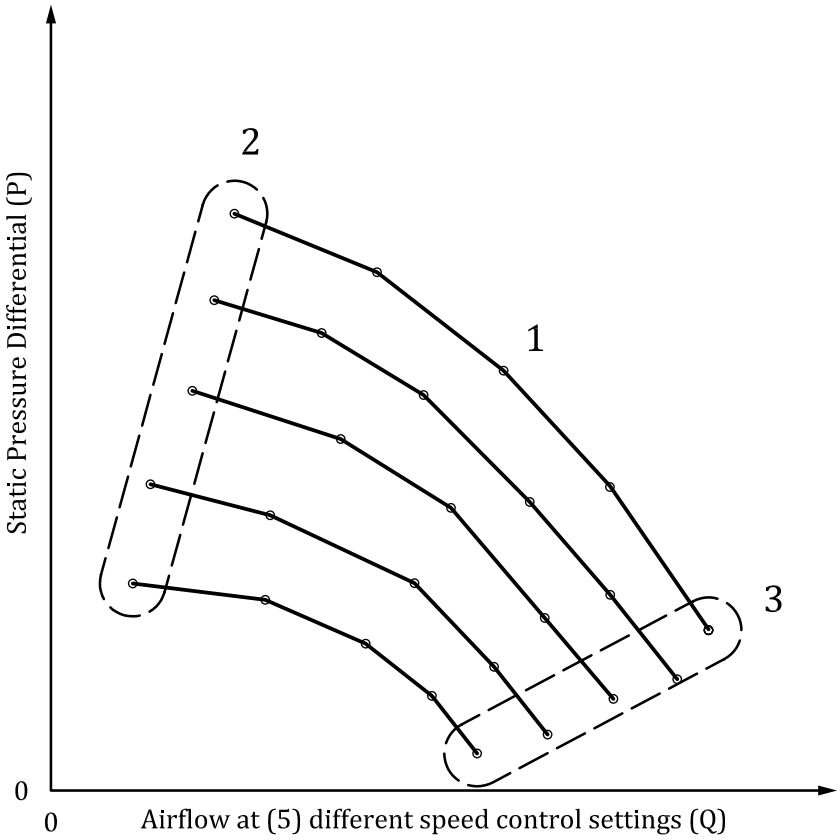
b) Only for units tested in a two room setup:

1) For all tests the value of static pressure at inlet (ps_1) and inlet (ps_3) shall be ≤ 0 Pa, and (ps_1) and (ps_3) shall be equal within 10 Pa, or 5 %, whichever is greater, of the larger of the measured values of ps_1 or ps_3.

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

2) The value of static pressure at the outlets (ps_2) and (ps_4) shall be equal, within 10 Pa, or 5 %, whichever is greater, of the larger measured value of ps_2 or ps_4, except as noted in 5.2.2.2.



Key

1 P-Q curves

2 minimum rated airflows

3 maximum rated airflows

NOTE Each of the individual P-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 5.2.2.4. For simplification, in this example only the supply air P-Q curves are shown.

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

5.2.2.4 For units with speed controls, additional airflow tests must be performed at the alternate speed settings. If the speed control device setting is infinitely variable, the test as described in 5.2.2.1 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.

5.2.2.5 If supply and return airflows cannot be measured simultaneously, static pressures at all four stations at the time of measurement of the second airflow must 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.

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

Airflow measurement methods are given in Annex A.

© ISO 2014 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014

5.3 Unducted heat recovery ventilators and energy recovery ventilators

5.3.1 Airflows measured

The net supply airflow shall be determined. Input power, in watts, shall be measured and recorded.

5.3.2 Static pressure conditions

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

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

Net supply airflow measurement methods are given in Annex B for the decay method. Alternately, the net supply airflow for unducted ventilators may be measured at points 2 and 3, by the methods given in Annex A and Annex C, and the Formula in 8.4.1 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.

6 Tracer gas tests

6.1 General conditions

All heat recovery ventilators and energy recovery ventilators within the scope of this International Standard 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 International Standard.

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

6.2 Temperature conditions

During tracer gas tests the laboratory ambient conditions shall be 20 ±15 °C and 30 to 95 % RH.

6.3 Preconditions

Airstreams shall be held at lab ambient temperature and humidity conditions and must remain stable for the duration of the tracer gas test. Test(s) shall be performed until tracer gas levels have stabilized.

6.4 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 sections 5.2.2.2, 5.2.2.3 and 5.2.2.4 in accordance with the setup type (ducted or two-room) chosen for the tracer gas testing.

6.5 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.

6.6 Tracer gas measurement methods

Tracer gas measurement methods are given in Annex B or Annex C.

© ISO 2014 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 16494:2014