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Standard

ISO 5222-2

**Heat recovery ventilators and
energy recovery ventilators —
Testing and calculating methods for
seasonal performance factor —**

**Part 2:
Sensible cooling recovery seasonal
performance factors of heat
recovery ventilators (HRV)**

*Ventilateurs récupérateurs de chaleur et ventilateurs
récupérateurs d'énergie — Méthodes d'essai et de calcul des
facteurs de performances saisonnières —*

*Partie 2: Facteurs de performances saisonnières de la
récupération de froid sensible des ventilateurs récupérateurs de
chaleur (HRV)*

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Foreword

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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 document 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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Heat recovery ventilators and energy recovery ventilators — Testing and calculating methods for seasonal performance factor —

Part 2: Sensible cooling recovery seasonal performance factors of heat recovery ventilators (HRV)

1 Scope

This document specifies the testing and calculating methods for sensible cooling recovery seasonal performance factor of heat recovery ventilators (HRV) covered by ISO 16494-1.

This document also specifies the test conditions and the corresponding test procedures for determining the sensible cooling recovery seasonal performance factor of HRVs. The rating conditions are those specified in [Annex B](#) and in ISO 16494-1. The procedures of this document can be used for other temperature conditions.

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 16494-1:2022, *Heat recovery ventilators and energy recovery ventilators — Method of test for performance — Part 1: Development of metrics for evaluation of energy related performance*

ISO 16494-1:2022/Amd 1:2023, *Heat recovery ventilators and energy recovery ventilators — Method of test for performance: Part 1: Development of metrics for evaluation of energy related performance — Amendment 1*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16494-1 and the following apply.

ISO and IEC maintain terminology 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

sensible cooling heat recovery

transfer of sensible energy from exhaust air to supply air in the HRVs while cooling

3.2

bypass ventilation function

function for reducing power input of the fans while the heat energy recovered is less than the additional energy input due to overcoming the resistance of recovery heat exchanger during its operation time

Note 1 to entry: The bypass ventilation function makes the supply air and/or exhaust air go through the heat recovery exchanger by bypass way with energy saving control.

3.3

sensible cooling gross effectiveness

ε_{sc}

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

Note 1 to entry: The sensible cooling gross effectiveness of an HRV, at equal airflow, is described in ISO 16494-1:2022 9.5.

3.4

net supply airflow

$Q_{m2,net}$

portion of the leaving supply airflow that originated as enter in supply airflow

Note 1 to entry: The net supply airflow is expressed in kg/s.

Note 2 to entry: The formulae for determining net supply air flow are given in ISO 16494-1:2022, 9.4.1 (ducted units) and 9.4.2 (unducted units).

3.5

bypass outdoor temperature

T_b

outdoor temperature in cooling conditions, at which the electricity power reduction for the HRVs by operating in bypass mode is equal to the saving of electricity power input to the cooling system due to the heat recovered by the HRVs

3.6

seasonal performance factor of sensible cooling recovery

F_{sc}

ratio of seasonal amount of sensible cooling recovered together with power value of moving air to the whole electricity input of HRVs, under the rating conditions and seasonal outdoor temperature bins selected from this document

3.7

building cooling balance temperature

T_{BCB}

outdoor air temperature at which building heat gain equals to heat loss through the building envelope

4 Symbols and abbreviated terms

Symbol	Description	Unit
c_p	Specific heat of leaving supply air (SA)	kJ/(kg·°C)
E_{sc}	Capacity of seasonal sensible cooling recovery	Wh
F_{sc}	Seasonal performance factor of sensible cooling recovery	Wh/Wh
$L_{sc,t,j}$	Reference outdoor air sensible cooling load at outdoor air bin temperature t_j	W
n_j	Bin hours which the outdoor air bin temperature occurs	h
n	Number of temperature bins	-
$P_{in,t,j}$	Power input to ventilator at outdoor air bin temperature t_j	W
$P_{in,no,t,j}$	Power input to the HRVs to operate the fans at outdoor air bin temperature t_j for all stages, for HRVs without bypass ventilation function	W
$P_{in,by,t,j}$	Power input to the HRVs at outdoor air bin temperature t_j for bin temperature in C_{stage1} or C_{stage2} , for HRVs with bypass ventilation function	W
$P_{vma,t,j}$	Power value of moving air at outdoor air bin temperature t_j	J/s or W
$P_{in,E}$	Electricity power input of seasonal sensible cooling recovery	Wh
$Q_{m2,net}$	Net supply mass flow rate	kg/s
Q_{vwr}	Ventilation air cooling load with recovery	W
Q_v	Ventilation air cooling load without recovery	W

Symbol	Description	Unit
Q_{ig}	Cooling load generated from internal gain and solar gain etc	W
Q_s	Cooling amount saved by recovery function	W
t_j	The outdoor air bin temperature at bin number j	°C
T_b	Outdoor air temperature when HRVs operates under air bypass ventilation function	°C
T_{BCB}	Outdoor air temperature at which building heat gain equals to heat loss through the building envelope	°C
T_0	The dry bulb temperature of entering exhaust air (RA) under ISO 16494-1:2022 standard testing conditions (T1/T2/T3/T4/T8)	°C
T_{oac}	Lowest outdoor temperature during cooling season	°C
ε_{sc}	Gross sensible cooling effectiveness of HRVs	%
$\phi_{sc,t,j}$	Sensible cooling recovery capacity of the HRVs at outdoor air bin temperature t_j	W

5 Tests

5.1 General requirements

The test conditions used, the accuracy and uncertainties of the instruments used shall conform to [5.2](#) and ISO 16494-1.

5.2 Test conditions

For ε_{sc} , E_{sc} and F_{sc} , there are five standard test conditions T1/T2/T3/T4/T8 corresponding to ISO 16494-1:2022, Table 1. The HRVs shall be tested at one of the five test conditions, which shall be selected to most closely represent the outdoor temperature bin distribution in the region as described in [Annex B](#) and [Annex C](#).

Outdoor temperature bin distribution and bin hours differ from region to region. If the bin hours are set to a certain value for a certain region, the integrated value of cooling load and electric energy consumption can be determined.

[Table 1](#) shows the requirements for the default values and the reference outdoor temperature bin distribution for testing and calculation. If a different outdoor temperature bin distribution is to be set, refer to the setting method as described in [Annex C](#).

Table 1 — Conditions of performance test (cooling)

	Outdoor air temperature (°C)		Indoor air temperature (°C)		Application temperature bin type for calculation
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
T1	35	23	21	15	In Annex B or C
T2	35	24	24	17	
T3	35	31	27	20	
T4	35	24	27	19	
T8	35	24	25	18	
NOTE	Allowable variation of readings is given in ISO 16494-1:2022, Table F.2.				

5.3 Test methods

5.3.1 General

For higher seasonal energy performance, HRVs can be designed with an air flow bypass ventilation function integrating fan speed control or airflow dampers adjustment, which can change the fan power input according to different outdoor temperature conditions, while maintaining necessary aerodynamic performance.

5.3.2 Energy saving stage limit temperature

To assess the energy saving ability of HRVs, the operation stages under the application temperature bin are showed in [Annex A](#) using a schematic diagram.

5.3.3 Sensible cooling recovery performance test

5.3.3.1 Standard condition performance tests

Sensible cooling recovery performance, efficiency as well as airflow and static pressure shall be measured corresponding to the selected standard cooling performance tests conditions in [Table 1](#), conducted in accordance with ISO 16494-1.

5.3.3.2 Determination of performance at application climate

The sensible cooling recovery performance under certain climate temperature bins shall also be determined by calculation using the temperature bins see [Annex B](#) and [Annex C](#).

5.3.4 The determination of bypass outdoor temperature

The manufacturer shall specify the value of bypass outdoor temperature, the laboratory shall verify whether the tested unit has this function and what is the action temperature by test. If the manufacturer does not specify it, the laboratory shall calculate the bypass outdoor temperature as per [Annex D](#) and set it as T_b .

5.3.5 Measurement of power input of heat recovery ventilator with bypass ventilation function

5.3.5.1 The manufacturer may provide information on how to set the bypass ventilation function if requested by the testing laboratories.

NOTE 1 Due to the additional air resistance of heat recovery exchanger, when the heat energy recovered is less than the additional energy input due to overcoming the resistance of recovery heat exchanger during its operation time, the equipment can provide the bypass ventilation function to reduce the additional energy consumption, when only ventilation is necessary.

NOTE 2 When the bypass ventilation function is active, there can be several means to reduce the additional energy consumption, for example, with fan speed control or valve control in the fan's inlet or outlet, etc., to keep the same airflow rate and pressure as the rating performance condition.

5.3.5.2 The tests shall be conducted at the required control set which allows steady state operation of the equipment under the given test conditions.

5.3.5.3 Test of unit with bypass ventilation function and fan speed control:

- a) Set up the bypass ventilation function according to the manufacturer's instructions.
- b) Adjust the test auxiliary device to keep the average pressure value at air outlet and inlet of unit in Figure A.1 of ISO 16494-1:2022/Amd 1:2023 within 5 % of the tested unit's nominal value and the air flow rate larger or equal to its nominal value.

- c) According to ISO 16494-1:2022, measure and record the data of the air flow rate, pressure and electricity power input.
- d) Determine and record the outdoor temperature at which the bypass ventilation function acts, either by the manufacturer's statement, or by measurement. The power input value measured when the bypass ventilation function is activated is recorded as the bypass ventilation function power input, used to calculate F_{sc} corresponding to each outdoor bin temperature in the ventilation period.

5.3.5.4 Test of unit with bypass ventilation function and with electric driving air damper automatically, but without fan speed control:

- a) Set up the bypass ventilation function according to the manufacturer's instructions.
- b) Adjust the test auxiliary device to keep the average pressure value within 5 % of the tested unit's nominal value and the air flow rate larger or equal to its nominal value.
- c) Determine and record the outdoor temperature at which the bypass ventilation function acts, either by the manufacturer's statement, or by measurement. The power input value measured when the bypass ventilation function is on shall be recorded as the bypass ventilation function power input, used to calculate F_{sc} corresponding to each outdoor bin temperature in the ventilation period.

5.3.5.5 Test of unit with bypass ventilation function and without fan speed control and without automatic adjust air damper:

- a) Set up the bypass ventilation function according to the manufacturer's instructions.
- b) According to ISO 16494-1:2022, do not adjust any of the test auxiliary devices during the test after the test of the bypass ventilation function turns on and record the data of air flow rate, the pressure and power input.
- c) Determine and record the outdoor temperature at which the bypass ventilation function acts, either by the manufacturer's statement, or by test.
- d) The power input value measured when the bypass ventilation functions is recorded as the bypass ventilation function power input, used to calculate F_{sc} corresponding to each outdoor bin temperature in the ventilation period.

5.3.6 Measurement of power input of heat recovery ventilator with no bypass ventilation function

For the equipment with no bypass ventilation function, the power input is the same at all stages as specified in [5.3.3.1](#), which shall be used to calculate F_{sc} corresponding to each outdoor temperature bin in the ventilation period.

6 Calculations

6.1 Gross sensible cooling recovery effectiveness (ϵ_{sc})

The gross sensible cooling heat recovery effectiveness of HRVs at rated test condition is described in ISO 16494-1:2022, 9.5.

6.2 Calculation of seasonal performance factor of sensible cooling recovery (F_{sc})

6.2.1 Reference outdoor air cooling load and sensible cooling recovery capacity

The reference outdoor air cooling load shall be determined by a set of values and is assumed that they change linearly depending on the change in outdoor temperature. The sensible cooling recovery capacity is also assumed to change linearly, see [Figure A.1](#). The conditions for the reference cooling load and recovery capacity are shown in [Table 2](#).

Table 2 — Reference outdoor air sensible cooling load and recovery capacity

	T1	T2	T3	T4	T8
Outdoor air temperature(°C)	Climate bins	Climate bins	Climate bins	Climate bins	Climate bins
T_0 Indoor air temperature(°C)	21	24	27	27	25
Outdoor air cooling load(W)	$L_{sc,t,j}$				
recovery capacity(W)	$\phi_{sc,t,j}$				

The outdoor air sensible cooling load $L_{sc,t,j}$ at outdoor temperature t_j , which is necessary to calculate the seasonal sensible cooling heat recovery, shall be determined by [Formula \(1\)](#):

$$L_{sc,t,j} = Q_{m2,net} \times c_p \times (t_j - T_0) \times 1\,000 \quad (1)$$

where

$L_{sc,t,j}$ is outdoor air sensible cooling load at the outdoor temperature t_j (W) ;

$Q_{m2,net}$ is the net supply mass flow rate (kg/s);

T_0 is the dry bulb temperature of entering exhaust air (RA) under ISO 16494-1:2022 standard testing conditions (T1/T2/T3/T4/T8) (°C);

t_j is the dry bulb temperature of outdoor air corresponding to application temperature bin j (°C).

6.2.2 The characteristics of sensible cooling recovery capacity against outdoor temperature

6.2.2.1 General

The sensible cooling recovery capacity $\phi_{sc,t,j}$ (W) of the HRVs at outdoor temperature bin t_j changes depending on outdoor temperatures, as shown in [Figure A.1](#), and is determined by [Formulae \(2\)](#) to [\(5\)](#).

The stages are described in [Annex A](#).

6.2.2.2 C_{stage1} ventilation with or without bypass ventilation function

For HRVs with bypass ventilation function, recovery capacity $\phi_{sc,t,j}$ at outdoor temperature t_j shall be determined by [Formula \(2\)](#)

$$\phi_{sc,t,j} = -L_{sc,t,j} \quad (2)$$

NOTE For HRVs with bypass ventilation, due to the outdoor temperature is low than the indoor air temperature, the total amount of supply air, which total cooling capacity, can be used as free cooling capacity and be seen as positive contribution to F_{sc} .

For HRVs without bypass ventilation function, recovery capacity $\phi_{sc,t,j}$ at outdoor temperature t_j shall be determined by [Formula \(3\)](#).

$$\phi_{sc,t,j} = L_{sc,t,j} \times \varepsilon_{sc} \quad (3)$$

6.2.2.3 C_{stage2} ventilation with, or without bypass ventilation function at cooling recovery mode

For HRVs with bypass ventilation function, recovery capacity $\phi_{sc,t,j}$ at outdoor temperature t_j shall be determined by [Formula \(3\)](#), where $\varepsilon_{sc} = 0$.