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

Part 1: Sensible heating 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 1: Facteurs de performances saisonnières de la récupération de chaleur sensible des ventilateurs récupérateurs de chaleur (HRV)

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Foreword

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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*.

A list of all parts in the ISO 5222 series can be found on the ISO website.

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

Part 1: Sensible heating recovery seasonal performance factors of heat recovery ventilators (HRV)

1 Scope

This document specifies the testing and calculating methods for sensible heating 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 heating recovery seasonal performance factor of HRV and is intended for use only in marking, comparison, and certification purposes. For the purposes of this document, the rating conditions are those specified in ISO 16494-1 and in Annex B. The procedures of this document may 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*

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
heat recovery
<sensible heating> transfer of sensible energy from exhaust air to supply air in the HRV while heating

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 function makes the supply air and exhaust air go through the heat recovery exchanger bypass with energy saving control.

3.3
coefficient of energy
<sensible heating> total sensible heating energy exchanged between the air streams plus the power value of moving air, divided by the power input

Note 1 to entry: The formula for determining $C_{sh,d,t,j}$ is given in 6.2.1 and $C_{sh,u,d,t,j}$ in 6.2.2.

3.4
gross effectiveness
<sensible heating> measured effectiveness, not adjusted for leakage, motor heat gain, or heat transfer through the unit casing

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

3.5
bypass outdoor temperature
T_b
outdoor temperature in heating conditions, at which the electric power reduction to the HRV by operating in bypass mode is equal to the saving of electric power input to the heating system due to the heat recovered by the HRV

3.6
seasonal performance factor of sensible heating recovery
F_{sh}
ratio of seasonal amount of sensible heat recovered together with power value of moving air to the whole electricity input of HRV, under the rating conditions and seasonal outdoor temperature bins selected from this standard

3.7
building heating balance temperature
T_{BHB}
outdoor air temperature at which building internal heat gain, solar radiation, and so on, equals to heat loss through the building envelope

4 Symbols and abbreviated terms

Symbol	Description	Unit
E_{sh}	Capacity of seasonal sensible heating recovery	Wh
$C_{sh,d,t,j}$	Sensible heating coefficient of energy for ducted ventilator at outdoor air bin temperature t_j	W/W
$C_{sh,u,d,t,j}$	Sensible heating coefficient of energy for unducted ventilator at outdoor air bin temperature t_j	W/W
c_p	Specific heat of leaving supply air (SA)	kJ/kg· °C
$L_{sh,t,j}$	Reference outdoor air sensible heating 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 HRV to operate the fans at outdoor air bin temperature t_j for all stages, for HRVs without bypass	W
$P_{in,by,t,j}$	Power input to the HRV at outdoor air bin temperature t_j for bin temperature in stage 1 or 2, for HRVs with bypass	W
$P_{in,h,t,j}$	Power input to a supplementary preheater at full capacity	W
$P_{in,v,t,j}$	Ventilation power input of the HRV at outdoor air bin temperature	W
$P_{vma,t,j}$	Power value of moving air at outdoor air bin temperature t_j	J/s or W

Symbol	Description	Unit
$P_{in,E}$	Electricity power input of seasonal sensible heating recovery	Wh
$Q_{m2,net}$	Net supply mass flow rate	kg/s
F_{sh}	Seasonal performance factor of sensible heating recovery	Wh/Wh
T_b	Outdoor air temperature when HRV operates under air bypass function	°C
T_F	The outdoor air bin temperature at which the frost occurs	°C
$T_{set,h}$	Temperature defined in ISO 16494-1:2022, Table 2 as T5/T6/T7	°C
ε_{sh}	Gross sensible heating effectiveness of HRV	%
$\phi_{sh,t,j}$	Sensible heat recovery capacity of the HRV 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 with ISO 16494-1 and those in this document.

5.2 Test conditions

For the purpose of ε_{sh}, E_{sh} and F_{sh}, there are three standard test conditions T5/T6/T7 corresponding to ISO 16494-1:2022, Table 2. The HRV shall be tested at one of the three 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 D.

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

Table 1 shows the requirement of default values and the reference outdoor temperature bin distribution for test and calculation. In case of setting other outdoor temperature bin distribution, refer to the setting method as described in Annex D.

Table 1 — Conditions of performance test (heating)

	Outdoor air temperature (°C)		Indoor air temperature (°C)		Application temperature bin type for calculation
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
T5	2	1	21	14	In Annex B or D
T6	5	3	20	15	
T7	7	6	20	12	
NOTE Allowable variation of readings is given in Table F.2 in ISO 16494-1:2022.					

5.3 Test methods

5.3.1 General

For higher seasonal energy performance, HRV can be designed with airflow bypass function integrating fan speed control or airflow dampers adjust, which can change the fan power input according to different outdoor temperature condition, while keeping necessary aerodynamic performance.

5.3.2 Energy saving stage limit temperature

To assess the energy saving ability of HRV, the operation stages under the application temperature bin are shown in Annex A using a schematic diagram.

5.3.3 Sensible heating recovery performance test

5.3.3.1 Standard condition performance tests

The sensible heating recovery performance tests shall be conducted in accordance with ISO 16494-1. The sensible heating recovery performance, efficiency, as well as airflow and static pressure shall be measured corresponding to the selected standard heating performance tests conditions in Table 1.

5.3.3.2 Determination of performance at application climate

The sensible heating recovery performance under certain climate temperature bins shall also be determined by calculation using the temperature bins see Annex B and Annex D.

5.3.4 Determination of bypass outdoor temperature

The manufacturer shall specify the value of bypass outdoor temperature. The laboratory shall verify that the unit under test is functioning and what the test action temperature is. If it is not specified by the manufacturer, the laboratory shall calculate the outdoor bypass temperature and set it as the T_b in accordance with Annex E.

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 function if requested by the testing laboratories.

NOTE 1 Due to the additional air resistance of the 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 acts, there can be several means to reduce the additional energy consumption (e.g. with fan speed control or valve control in the fan's inlet or outlet, etc., to keep the same airflow rate and pressure as 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 at 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 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, within the 5 % of tested unit's nominal value, the airflow rate larger or equal to its nominal value.

c) According to ISO 16494-1, measure and record the data of airflow rate, the pressure and electricity power input.

d) Determine and record the outdoor temperature at which the bypass ventilation function acts, either by manufacturer's statement, or by measure. The power input value measured when bypass ventilation functions is activated is recorded as the bypass ventilation function power input, used for calculation for F_{sh} corresponding to each outdoor bin temperature in 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 the 5 % of the tested unit's nominal value, the airflow 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 bypass ventilation function is on shall be recorded as the bypass ventilation function power input, used for the calculation of F_{sh} corresponding to each outdoor bin temperature in the ventilation period.

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

a) Set up the bypass ventilation function according to manufacturer's instruction.

b) According to ISO 16494-1, do not adjust any of the test auxiliary devices during test and record the data of airflow rate, the pressure and power input.

c) Determine and record the outdoor temperature that the bypass ventilation function acts, either by the manufacturer's statement, or by test.

d) The power input value measured when bypass ventilation functions on is recorded as the bypass ventilation function power input, used for calculation for F_{sh} corresponding to each outdoor bin temperature in ventilation period.

5.3.5.6 Test of equipment with no bypass ventilation function:

For the equipment with no bypass ventilation function, the power input is the value as same as in 5.3.3.1 all stages, which shall be used for calculation for F_{sh} corresponding to each outdoor temperature in ventilation period.

5.3.6 Determination of the frosting temperature by test

5.3.6.1 The frost temperature test shall be conducted in accordance with ISO 16494-1.

The manufacturer may provide information on how to operate the equipment if requested by the testing laboratories.

5.3.6.2 The test condition shall be as follows:

a) The airflow rate and static pressure shall keep the same as 5.3.3.1.

b) The entering exhaust air (RA) temperature shall be kept at conditions T5/T6/T7 specified in Table 1 and entering supply air (OA) temperature shall be gradually reduced from 0 °C, or, in order to reduce the duration time of the test, from the $T_{F,0}$, which is described in Annex C, plus 2 K.

NOTE The calculation of $T_{F,0}$ refers to Annex C.

5.3.6.3 Confirmation of frost outdoor air temperature:

a) Turn off the supplement heat function for anti-frost.

b) Conduct the tests of gross sensible heating recovery effectiveness of HRV by changing outdoor temperature from the $T_{F,0}$ plus 2 K to lower temperature. While adjusting the outdoor air temperature, keep the reducing rate of temperature not less than 0,5 K per hour and not greater than 1,0 K per hour.

c) Record the inlet and outlet air parameters so that gross sensible heating effectiveness can be calculated every 0,5 h.

d) Calculate the gross sensible heat effectiveness in accordance with ISO 16494-1:2022, 9.5.

e) If the absolute value of the change of the gross sensible heating effectiveness between the outdoor temperature t_j and temperature t_{j-1} is greater than 5 %, the higher temperature of the outdoor temperatures is confirmed as a frost outdoor temperature.

f) Compare the tested T_F with the one in practice, if the tested T_F is lower than the one in practice, select the temperature in practice as the stage limitation temperature, otherwise, the tested T_F shall be the stage limitation temperature.

5.3.6.4 Data collection:

During the frost temperature tests, airflow rate, static pressure, barometer pressure and power input as well as air temperature shall be collected and recorded. A continuous air temperature variation curve drawing shall be necessary.

6 Calculations

6.1 Gross sensible heating recovery effectiveness (ε_{sh})

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

6.2 Sensible heating coefficient of energy

6.2.1 Sensible heating coefficient of energy: ducted ventilators

The sensible heating coefficient of energy for a ducted ventilator ($C_{sh,d,t,j}$) shall be calculated by Formula (1):

$$C_{sh,d,t,j} = \frac{\left|Q_{m2,net} \times c_p \times \left(T_0 - t_j\right)\right| \times \varepsilon_{sh} \times 1\,000 + P_{vma,t,j}}{P_{in,t,j}} \quad (1)$$

where

$C_{sh,d,t,j}$ is the sensible heating coefficient of energy for a ducted ventilator at outdoor air bin temperature t_j (W/W);

T_0 is the dry temperature of entering exhaust air (RA) under ISO 16494-1 standard testing conditions (T5/T6/T7), (°C);

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

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

c_p is the specific heat of air (kJ/kg· °C);

ε_{sh} is the gross sensible heating recovery effectiveness of HRV at rated test condition is described in ISO 16494-1:2022, 9.5 (%);

$P_{vma,t,j}$ is the power value of moving air at outdoor air bin temperature t_j (J/s);

$P_{in,t,j}$ is the input power to ventilator at outdoor air bin temperature t_j (W).

6.2.2 Sensible heating coefficient of energy: unducted ventilators

The sensible heating coefficient of energy for an unducted ventilator ($C_{sh,u,d,t,j}$) is described by Formula (2)

$$C_{sh,u,d,t,j} = \frac{\left|Q_{m2,net} \times c_p \times \left(T_0 - t_j\right)\right| \times \varepsilon_{sh} \times 1\,000}{P_{in,t,j}} \tag{2}$$

where

$C_{sh,u,d,t,j}$ is the sensible heating coefficient of energy for an unducted ventilator at outdoor air bin temperature t_j (W/W);

T_0 is the dry temperature of entering exhaust air (RA) under ISO 16494-1 standard testing conditions (T5/T6/T7) (°C);

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

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

c_p is the specific heat of leaving supply air (kJ/kg· °C);

ε_{sh} is the gross sensible heating recovery effectiveness of HRV at rated test condition is described in ISO 16494-1:2022, 9.5;

$P_{in,t,j}$ is the input power to ventilator (W).

6.3 Calculation of seasonal performance factor of sensible heating recovery (F_{sh})

6.3.1 Reference outdoor air heating load and sensible heating recovery capacity

The reference outdoor air heating load shall be by a set of values and be assumed that they are linearly changing depending on the change of outdoor temperature, the sensible heat recovery capacity is assumed also linearly changing, see figure in Annex A. Conditions of reference heating load and recovery capacity is shown in Table 2.

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

	T5	T6	T7
Outdoor air Temperature (°C)	Climate bins	Climate bins	Climate bins
T_0 indoor air Temperature (°C)	21	20	20
Outdoor air heating load (W)	$L_{sh,T5,t,j}$	$L_{sh,T6,t,j}$	$L_{sh,T7,t,j}$
Recovery capacity (W)	$\phi_{sh,T5,t,j}$	$\phi_{sh,T6,t,j}$	$\phi_{sh,T7,t,j}$

where T_0 is the temperature at which outdoor air heating load assumed zero.

The outdoor air sensible heating load $L_{sh,t,j}$ at outdoor temperature t_j, which is necessary to calculate the seasonal sensible heating heat recovery, shall be determined by Formula (3)

$$L_{sh,t,j} = Q_{m2,net} \times c_p \times \left|T_0 - t_j\right| \times 1\,000 \tag{3}$$