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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 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.

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The parts of ISO 5222 are given as below:

— Part 1: Sensible heating recovery seasonal performance factors of HRV

— Part 2: Sensible cooling recovery seasonal performance factors of HRV

— Part 3: Annual sensible heating and cooling recovery performance factor of HRV

— Part 4: Total heating recovery seasonal performance factors of ERV

— Part 5: Total cooling recovery seasonal performance factors of ERV

— Part 6: Annual total heating and cooling recovery performance factor of ERV

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

Part 1:
Sensible heating recovery seasonal performance factors of HRV

1 Scope

1.1 ISO 5222-1 specifies the testing and calculating methods for sensible heating recovery seasonal performance factor of HRV covered by ISO 16494-1.

1.2 ISO 5222-1also 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 ISO 5222-1, the rating conditions are those specified in the standard ISO 16494 and in the Annex B. The procedures of ISO 5222-1 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 16494-1:2014, *Heat recovery ventilators and energy recovery ventilators — Method of test for performance : Part1 : Development of metrics for evaluation of energy related performance*

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
heat recovery, sensible heating
transference of sensible energy from exhaust airflow to outdoor airflow in the HRV while heating

3.2
bypass ventilation function
For reducing power input of the fans when the heat recovery profit is less than the additional energy input due to overcoming the resistance of recovery heat exchangers during its operation time, the function which makes the supply air and exhaust air go through the heat recovery exchanger by pass with energy saving control. "

3.3
coefficient of energy, sensible heating
COE_{SEN_h}
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 the COE_{SEN_h} is given in clause 6.2.1 and 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 9.5.

3.5
power value of moving air
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 ISO 16494 9.6.1.

3.6
net supply airflow
Q_{SANet}
portion of the leaving supply airflow that originated as entering supply airflow.

Note 1 to entry: The net supply airflow is expressed in m^3/s.

Note 2 to entry: The formulas for determining net supply air flow are given in ISO 16494-1 9.4.1(ducted units) and 9.4.2 (un-ducted units)

3.7
rating points
sets of supply and return airflow, 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 are performed.

3.8
sensible heating recovery rate
rate of sensible heat recovery from the exhaust air flow.

3.9
maximum rated airflow
the highest supply and return airflow, specified by the manufacturer, confirmed by the airflow performance measurement.

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

3.10
minimum rated airflow
the lowest supply and return airflows, specified by the manufacturer, confirmed by the airflow performance measurement.

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 measurement is performed.

3.11
speed control device
device integrated into the ventilator which controls the speed of the fan for changing the airflow rate and power input.

3.12
standard air
dry air with a density of 1,200 kg/m^3.

3.13
static pressure differential
absolute difference between inlet static pressure and outlet static pressure for each of the two air streams.

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

3.14
Bypass outdoor temperatureT_{bypass}
outdoor temperature in heating conditions, at which the electric power inputted to the HRV for overcoming the airflow resistances of heat recovery core is equal to the sensible heat recovered by the HRV.

3.15
Seasonal performance factor of sensible heating recovery
SPF_{SEN_h}
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 annual outdoor temperature bins selected from this standard.

3.16
Building heating balance temperature
T_{BHB}
the outdoor air temperature at which building internal heat gain and solar radiation etc , equals to heat loss to outdoor.

4 Symbols and Abbreviated terms

Symbol	Description	Unit
C_{SSEN_h}	Capacity of seasonal sensible heating recovery	Wh
COE_{SEN_h}	Energy coefficient of sensible heating recovery	W/W
c_p	Specific heat of air	kJ/kg· °C
$L_{SEN\_h}(t_j)$	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, m	Number of temperature bins	-
$P_{in}(t_j)$	Input power to ventilator at outdoor air bin temperature t_j	W
$P_{SEN\_h}(t_j)$	Sensible heat recovery power input of the HRV at outdoor air bin temperature t_j	W
$P_{VENTILATION}(t_j)$	Ventilation power input of the HRV at outdoor air bin temperature t_j	W
P_{vma}	Power value of moving air	J/s or W
PI_{SSEN_h}	Electricity power input of seasonal sensible heating recovery	Wh
SPF_{SEN_h}	Seasonal performance factor of sensible heating recovery	Wh/Wh
T_{BHB}	the outdoor air temperature at which building internal heat gain equals to heat loss to outdoor	°C
T_{bypass}	Outdoor air temperature when HRV operates under air bypass function	°C
T_{FROST}	The outdoor air bin temperature at which the frost occurs	°C
$\Delta P_{E\text{-heat exchanger}}$	The air flow resistance of heat recovery exchanger combined with the air channel of exhaust side	Pa

$\Delta P_{\text{S-heat exchanger}}$	The air flow resistance of heat recovery exchanger combined with the air channel of supply side	Pa
$\varepsilon_{\text{SEN\_h}}$	Gross sensible heating effectiveness of HRV	%
η_{fan}	The efficiency of fan, assumes as 0,6 .	-
$\phi_{\text{SEN\_h}}\ (t_j)$	Sensible heat recovery capacity of the HRV at outdoor air bin temperature t_j	W

5 Tests

5.1 General requirements

The tests conditions used, the accuracy and uncertainties of the instruments used shall conform with the ISO 16494-1 and those in this standard.

5.2 Test conditions

For the purpose of $\varepsilon_{\text{SEN-h}}$, $COE_{\text{SEN\_h}}$ and $SPF_{\text{SEN-h}}$, there are three standard test conditions T5/T6/T7 corresponding to ISO 16494-1 table 2, combined with three application temperature bin types A(average) , W(warmer) and C(colder).

Temperature and humidity conditions as well as default values for test and calculation shall be as the requirement specified in Table1.

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 tables F.2. in ISO 16494-1					

5.3 Test methods

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

5.3.1 energy saving stage limit temperature

For assessment the energy saving ability of HRV, the operation stages under the application temperature bin are showed in Annex A using a schematic diagram.

5.3.2 sensible heating recovery performance test

5.3.2.1 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 as table 1.

5.3.2.2 Determination of performance at application climate

The sensible heating recovery performance under certain climate temperature bins shall also be determined in accordance with ISO 16494-1, by substituting of outdoor temperature using the climate bins temperature see Annex B and D.1

5.3.3 The determination of bypass outdoor temperature

For the determination of bypass outdoor temperature, it should use ways as below:

a) The manufacture specifies the value of bypass outdoor temperature, but the lab shall verify whether the tested unit is with the function and what is the action temperature by test in lab.

b) If the manufacture doesn't specify it, calculating it out following annex E by referring to the definition.

c) compare the value of a)and b), define the lower as the T_{bypass}.

5.3.4 Measurement of power input of heat recovery ventilator with bypass ventilation function.

5.3.4.1 Due to the additional air resistance of heat recovery exchanger, when the heat recovery profit is less than the additional energy input due to overcoming the resistance of heat exchanger, the equipment may provide with the bypass ventilation function to reduce the additional energy consumption, when only ventilation is necessary.

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

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

5.3.4.4 The tests below shall be conducted at the required control setting which allows steady state operation of the equipment at the given test conditions.

5.3.4.4.1 Test of unit with bypass ventilation function and fan speed control

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

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 within the 5% of tested unit's nominal value, the air flow rate larger or equal to its nominal value

c) According to the ISO 16494-1, measure and record the data of air flow 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 SPF_{SEN_h} corresponding to each outdoor bin temperature in ventilation period.

5.3.4.4.2 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 manufacture instruction

b) Adjust test auxiliary device to keep the average pressure value within the 5% of tested unit's nominal value, 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 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 calculation for SPF_{SEN_h} corresponding to each outdoor bin temperature in ventilation period.

5.3.4.4.3 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 manufactures' instruction

b) According to the ISO 16494-1, don't adjust any of the test auxiliary devices during test and record the data of air flow rate, the pressure and power input.

c) Determine and record the outdoor temperature that the bypass ventilation function acts, either by 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 SPF_{SEN_h} corresponding to each outdoor bin temperature in ventilation period.

5.3.4.4.4 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 5.3.2.1 all stages, which shall be used for calculation for *SPF* corresponding to each outdoor temperature in ventilation period.

5.3.5 Determination of the frosting temperature by test

The frost occurring temperature tests shall conducted in accordance with ISO 16494-1.

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

5.3.5.1 The test condition shall be as bellow:

a) The airflow rate and static pressure shall keep the same as 5.3.2.1.

b) The return air temperature shall be kept at conditions T5/T6/T7 specified in table 1 and outdoor air temperature shall be gradually reduced from 0 °C, or, in order to reduce the duration of the test, from the pre-T_{FROST}, which is described in annex C, plus 2K.

5.3.5.2 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 efficiency of HRV by changing outdoor temperature from the pre- T_{FROST} plus 2K to more lower temperature. While adjusting the outdoor air temperature, keep the reducing rate of temperature not less than 0,5K per hour and not greater than 1,0K per hour.

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

d) Calculate the gross sensible heat efficiency in accordance with clause 9.5 in ISO16494-1.

e) If absolute value of change rate of the gross sensible heating efficiency 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 T_{FROST} tested and the one practical acts, if the T_{FROST} tested is lower than the one practical acts, select the temperature practical acts as the stage limitation temperature, otherwise, the T_{FROST} tested shall be the stage limitation temperature.

5.3.5.3 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. Continuously air temperature variation curve drawing shall be necessary.

6 Calculations

6.1 Gross sensible heating recovery efficiency (ε_{SEN_h})

The gross sensible heating recovery efficiency of HRV at rated test condition is described in ISO 16494-1 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 ($COE_{\ SEN\_h}$) for a ducted ventilator is described by the following formula:

$$COE_{SEN\_h\,ducted} = \frac{\left|q_{m2,net} * c_p * \left(T_0 - t_j\right)\right| * \mathring{a}_{SEN\_h} * 1000 + P_{vma}}{P_{in}()} \quad (1)$$

where

T_0 is the dry temperature of entering exhaust airflow temperature (RA)to 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_{SEN_h} is the gross sensible heating recovery efficiency of HRV at rated test condition is described in ISO 16494-1-2014 8.5.

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

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

6.2.2 Sensible heating coefficient of energy: unducted ventilators

The sensible heating coefficient of energy ($COE_{\ SEN\_h}$) for a unducted ventilator is described by the following formula:

$$COE_{SEN\_h\,unducted} = \frac{\left|q_{m2,net} * c_p * \left(T_0 - t_j\right)\right| * \mathring{a}_{SEN\_h} * 1000}{P_{in}\left(t_j\right)} \quad (2)$$

where

T_0 is the dry temperature of entering exhaust airflow temperature (RA)to ISO 16494 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_{SEN_h} is the gross sensible heating recovery efficiency of HRV at rated test condition is described in ISO 16494-2014 8.5.

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

6.3 Calculation of seasonal performance factor of sensible heating recovery (SPF_{SEN_h})

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 value 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)	$L_{SEN\_h,under\ T5}(t_j)$	$L_{SEN\_h,under\ T6}(t_j)$	$L_{SEN\_h,under\ T7}(t_j)$
recovery capacity(W)	$\phi_{SEN\_h,under\ T5}(t_j)$	$\phi_{SEN\_h,under\ T6}(t_j)$	$\phi_{SEN\_h,under\ T7}(t_j)$

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

Outdoor air sensible heating load $L_{SEN\_h}(t_j)$ at outdoor temperature t_j , which is necessary to calculate the seasonal sensible heating heat recovery, shall be determined by Formula (3),:

$$L_{SEN\_h}\left(t_j\right) = q_{m2,net} * c_p * \left|T_0 - t_j\right| \quad (3)$$

where

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

T_0 is the dry temperature of entering exhaust airflow temperature (RA) corresponding to ISO 16494 standard testing conditions(T5/T6/T7) (°C);

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

6.3.2 The characteristics of sensible heating recovery capacity against outdoor temperature

Sensible heating recovery capacity $\phi_{SEN\_h}(t_j)$ (W) of the HRV at outdoor temperature t_j changes depending on outdoor temperatures, as shown in Figure A.1 in Annex A, and it is determined by Formula (4) to (8) below: