DANISH TECHNOLOGICAL INSTITUTE

Transitional method for determination of internal specific fan power of ventilation units, SFP_{int}

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Title:
Transitional method for determination of internal specific fan power of ventilation units, SFP_{int}

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Preface

The present document was developed under the Technical Assistance Study for the Ecodesign of the Ventilation Units Product Group. This study provided the European Commission with technical assistance on draft transitional methods, frequently asked questions and other technical issues related to the implementation of Commission Regulation (EU) No 1253/2014 and Commission Delegated Regulation (EU) No 1254/2014.

Abbreviations

In line with Commission Regulation (EU) No 1253/2014, the following abbreviations are used for ventilation units:

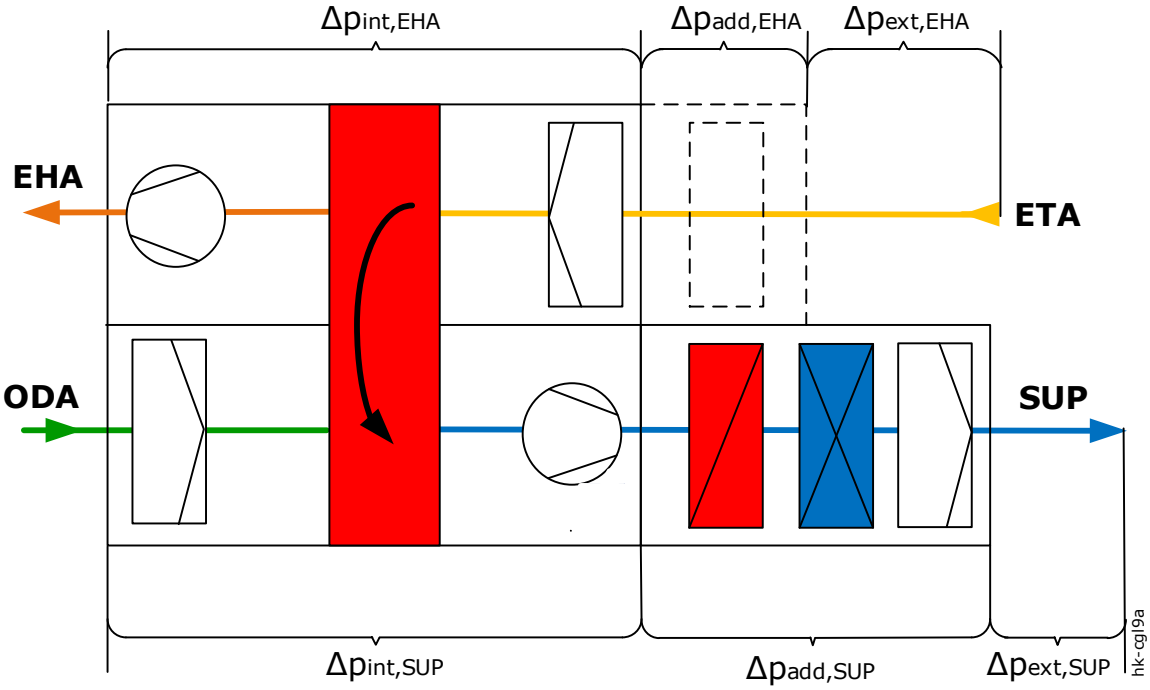
VU:	Ventilation unit
UVU:	Unidirectional ventilation unit
BVU:	Bidirectional ventilation unit
NRVU:	Non-residential ventilation unit

1. Calculation and measurement of SFP_{int}, internal pressure and internal fan efficiency

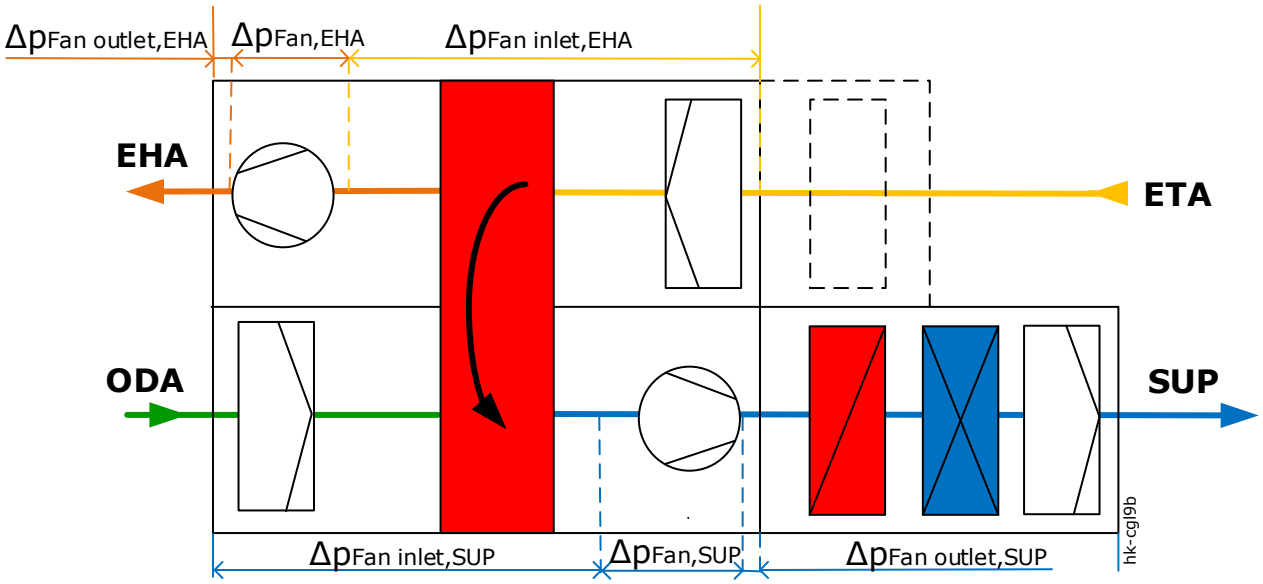
1.1. Terminology related SFP_{int} values

To achieve consensus between standards and Regulation 1253/2014, symbols and subscripts from prEN 16798-3 have been adopted for the cases where no such symbols are described in Regulation 1253/2014. Where there is inconsistency between symbols used in the standards and in Regulation 1253/2014, the Regulation symbols are used.

The figure below is a sketch of a BVU illustrating the different physical sections of a ventilation unit related to the terms and subscripts: 'internal' ('int'), 'additional' ('add') and external ('ext'). The components are placed randomly and can be placed in different orders. The figure applies to both BVU and UVU. For UVU, only one of the sides is considered, i.e. either the exhaust airside (EHA) or the supply airside (SUP).



The same BVU is sketched below to illustrate the pressure losses which are contributing to the internal pressure loss Δp_{int} ($\Delta p_{int} = \Delta p_{Fan\ inlet} + \Delta p_{Fan\ outlet}$).



Symbols and subscripts are described in detail in the following. All values can refer to both total and static pressure rise (only the static pressure is used for SFP_{int} calculation).

Symbols

According to prEN 16798-3		***According to Regulation 1253/2014***	
$\Delta p_{int\ tot}$	Total internal pressure rise from the ventilation components (fan casing, heat recovery, and filters) in Pa	*None*	*None*
$\Delta p_{add\ tot}$	Total additional pressure rise from the additional components (cooler, heat exchanger, humidifier, silencer, etc.) in Pa		*None*
$\Delta p_{ext\ tot}$	Total external pressure rise from the ductwork and external components in Pa	*None*	*None*
$\Delta p_{int\ stat}$	Static internal pressure rise from the ventilation components (fan casing, heat recovery and filters) in Pa	$\Delta p_{s,int}$	*'internal pressure drop of ventilation components ($\Delta p_{s,int}$)' (expressed in Pa) means the sum of the static pressure drops of a reference configuration of a BVU or an UVU at nominal flow rate.*
$\Delta p_{add\ stat}$	Static additional pressure rise from the additional components (cooler, heat exchanger, humidifier, silencer, etc.) in Pa	$\Delta p_{s,add}$	*'internal pressure drop of additional non-ventilation components ($\Delta p_{s,add}$)' (expressed in Pa) means the remainder of the sum of all internal static pressure drops at nominal flow rate and nominal external pressure after subtraction of the internal pressure drop of ventilation components ($\Delta p_{s,int}$);*
$\Delta p_{ext\ stat}$	Static external pressure rise from the ductwork and external components in Pa	$\Delta p_{s,ext}$	*'nominal external pressure ($\Delta p_{s,\ ext}$)' (expressed in Pa) means the declared design external static pressure difference at nominal flow rate.*

According to prEN 16798-3		***According to Regulation 1253/2014***	
Δp_{fan}	Static pressure difference between the fan outlet and inlet section.	*None*	*None. The following is used* $\Delta p_{s,Fan}$
η_{tot}	$\eta_{fan\ tot}$ x η_{tr} x ηm x ηc based on total pressure	*None*	*None*
η_{stat}	ηfan stat x ηtr x ηm x ηc based on static pressure	*None*	*None*
$P_{sfp,int}$	Internal SFP value of the bidirectional air-handling unit.	*SFP_{int} [W/(m³/s)]*	*'internal specific fan power of ventilation components (SFP_{int})' (expressed in W/(m³/s)) is the ratio between the internal pressure drop of ventilation components and the fan efficiency, determined for the reference configuration;*
η_{fan}	The overall efficiency ηfan is based on the efficiencies of the single components (impeller, motor, belt drive, speed control, etc.)	*η_{fan} ($\eta_{s,Fan}$)*	*'fan efficiency (η_{fan})' means the static efficiency including motor and drive efficiency of the individual fan(s) in the ventilation unit (reference configuration) determined at nominal airflow and nominal external pressure drop;* *In the following written as $\eta_{s,Fan}$*
P	Fan power	*P [kW]*	*'nominal electric power input (P)' (expressed in kW) means the effective electric power input of the fan drives, including any motor control equipment, at the nominal external pressure and the nominal airflow;*
$q_{V;SUP;ahu;nom.}$	Nominal airflow rate	*q_{nom} [m³/s]*	*'nominal flow rate (q_{nom})' (expressed in m³/s) means the declared design flow rate of an NRVU at standard air conditions 20°C and 101 325 Pa, whereby the unit is installed complete (for example, including filters) and according to the manufacturer instructions;*

Subscripts

According to prEN 16798-3		***According to Regulation 1253/2014***	
ODA	Outdoor air	*Outdoor**	*Annex I-6* *Annex I NRVU-6,11*
SUP	Supply air	*Air supply outlet* *Supply*	*Annex I-15* *Annex I-5,6,7,8,11* *Annex I NRVU-11,15* *Article 2-5,6*
ETA	Extract air	*Extract* *Indoor***	*Annex I-7,11* *Annex I NRVU-15* *Annex II & IV* *Annex I-6* *Annex I NRVU-6,11*
EHA	Exhaust air	*Exhaust*	*Annex 1-5,6,8* *Annex I NRVU-11,14* *Annex IV-4 (RVU)* *Annex IX* *Article 1-2a,5,6*
s	static	*s*	*static*

Other specifications		***According to Regulation 1253/2014***	
Indoor-side	Indoor side of AHU (SUP and ETA)	*Indoor***	*Annex I-10,33* *Annex I NRVU-11* *Article 2-5,6* *Annex IV & V VIII*
Outdoor-side	Outdoor side of AHU (ODA and EHA)	*Outdoor**	*Annex I-10,33* *Article 2-5,6* *Annex IV & V VIII*
SUP-SIDE*** (ODA-to-SUP)	Supply airside. The airflow going from Outdoor(ODA) through the unit to Supply (SUP).	*Inlet-side* *Supply-side*	*Annex I NRVU -3,4* *Annex I NRVU -14*
EHA-SIDE*** (ETA-to EHA)	Exhaust airside. The airflow going from Extract (ETA) through the unit to Exhaust (EHA).	*Exhaust-side* *Extract-side*	*Annex I-3,14* *ANNEX II & IV (RVU)* *Annex 1 NRVU-15*
INS	Test conducted inside the unit	*None*	*None*
OUT	Test conducted outside the unit	*None*	*None*

According to ISO 5801		***According to Regulation 1253/2014***	
Fan outlet	The positive pressure side of the fan	*Fan outlet*	*Annex I-27&29*
Fan inlet	The negative pressure side of the fan	*Fan inlet*	*Annex I-27* *Annex I NRVU-3,4*

**In Regulation 1253/2014 'outdoor' is used as both outdoor-side and outdoor air.*

***In Regulation 1253/2014 'indoor' is used as both indoor-side and indoor air.*

**** The specification 'SUP-SIDE' is used instead of 'SUP' and 'EHA-SIDE' instead of 'EHA' when using the specification for the whole side of the unit (from outdoor to supply and from extract to exhaust).*

1.2. Measurements and calculations related to SFP_{int}

Additional elements for measurements and calculations related to the internal specific fan power of ventilation components (SFP_{int}) of NRVUs.

1.2.1. Definition of SFP_{int}

Unidirectional ventilation unit (UVU):

$$SFP_{int} = \frac{\Delta p_{s,int}}{\eta_{s,Fan}}$$

For bidirectional ventilation units (BVUs), the SFP_{int} is calculated as the sum of the internal specific fan power of the air supply side and the air extract side of the unit:

$$SFP_{int} = \frac{\Delta p_{s,int\ SUP}}{\eta_{s,Fan\ SUP}} + \frac{\Delta p_{s,int\ EHA}}{\eta_{s,Fan\ EHA}}$$

1.2.2. Applicable test methods

Two test methods are applicable for determining the SFP_{int} according to Regulation 1253/2014:

1. VUs where internal pressure measurements <u>can</u> be performed (recommended with local face velocity's in the measuring section for internal pressure drop below 3 m/s);

2. VUs where internal pressure measurements <u>cannot</u> be performed (can be used with both low and high local face velocity's).

1.2.3. SFP_{int} determination for VU where internal pressure measurements <u>can</u> be performed

Unidirectional ventilation unit (UVU):

$$SFP_{int} = \frac{\Delta p_{s,int}}{\eta_{s,Fan}}$$

For bidirectional ventilation units (BVUs), the SFP_{int} is calculated as the sum of the internal specific fan power of the air supply side and of the air extract side of the unit:

$$SFP_{int} = \frac{\Delta p_{s,int\ SUP}}{\eta_{s,Fan\ SUP}} + \frac{\Delta p_{s,int\ EHA}}{\eta_{s,Fan\ EHA}}$$

The pressure drop of ventilation components is inserted with numerical values for Δp. All values are calculated for SUP-side <u>or</u> EHA-side for UVUs depending on whether it is a SUP or EHA fan unit and calculated values for SUP-side <u>and</u> EHA-side for BVUs.

$$\Delta p_{s,int} = \Delta p_{s,Fan} - \Delta p_{s,ext.TOTAL}$$

If measured with additional ventilation components as a part of $\Delta p_{s,int}$:

$$\Delta p_{s,int} = \Delta p_{s,Fan} - \Delta p_{s,ext.TOTAL} - \Delta p_{s,add}$$

Where the fan efficiency is determined as:

$$\eta_{s,Fan} = \frac{q_{nom} \cdot \Delta p_{s,Fan}}{P} \quad \text{where} \quad \Delta p_{s,Fan} = \Delta p_{s,ext} + \Delta p_{s,int} + \Delta p_{s,add}$$

Where:

$\Delta p_{s,int}$	***Δp*$_{s,int}$** *is the internal pressure drop of ventilation components (expressed in Pa)*
$\Delta p_{s,add}$	*'internal pressure drop of additional non-ventilation components (Δp$_{s,add}$)'*
$\Delta p_{s,Fan}$	*The static pressure difference between the fan outlet and inlet section*
$\eta_{s,Fan}$	*The fan efficiency η_{Fan}* is the is the internal static fan efficiency
$\Delta p_{s,ext.TOTAL}$	*Nominal external pressure* (expressed in Pa)
q_{nom}	*Nominal flow rate* (expressed in m³/s)
P	*'Nominal electric power input (P)*' (expressed in W) Is the sum of three parameters, i.e. Supply air fan + drive, exhaust air fan + drive and control (equally divided on SUP-side and EHA-side). The three parameters are measured separately.

Fan static pressure means the fan total pressure (p_f) minus the fan dynamic pressure at nominal airflow for one airstream in relation to the face area.

The stagnation pressure is only a mathematical/thermodynamic calculated value that requires expert knowledge to calculate. The use of stagnation pressure is only relevant at air velocities above 40 m/s, which is why this should not be used below 40 m/s. The measured pressure difference is the value used to calculate SFP_{int}, the external static pressure, etc.

1.2.3.1. Measuring on unit with/without additional components

If the unit has additional components the test has to be carried out with the additional components mounted inside the unit to ensure that the fan runs at its design operating point and not at a lower efficiency, which otherwise will lead to a higher SFP_{int} value.

1.2.4. SFP_{int} determination for VU where internal pressure measurements <u>cannot</u> be performed

Determining the SFP_{int} by measuring parameters measured outside the unit where the expression of SFP_{int} is given as:

$$\mathrm{SFP}_{int\ UVU} = \frac{\Delta p_{s,Fan} - \Delta p_{s,ext}}{\eta_{s,Fan}} \cdot \frac{P_{Fan}}{P_{Fan,ext}}$$

All values are calculated for SUP <u>or</u> EHA for UVUs depending on whether it is a SUP or EHA fan unit and calculated values for SUP <u>and</u> EHA for BVUs.

$$\mathrm{SFP}_{int\ BVU} = \frac{\Delta p_{s,Fan,SUP} - \Delta p_{s,ext,SUP}}{\eta_{s,Fan,SUP}} \cdot \frac{P_{Fan,SUP}}{P_{Fan,ext,SUP}} + \frac{\Delta p_{s,Fan,EHA} - \Delta p_{s,ext,EHA}}{\eta_{s,Fan,EHA}} \cdot \frac{P_{Fan,EHA}}{P_{Fan,ext,EHA}}$$

Where:

$\Delta p_{s,Fan}$	Means the static pressure difference of the fan measured outside the unit according to the ISO 5801, not necessarily at best efficiency point (BEP), but corresponding to the nominal flow and rpm regarding Regulation 1253/2014 (according to the measurements conducted on the unit).
$\Delta p_{s,ext}$	Means the static nominal external pressure drop as described under section 1.1 measured at the terminals of the unit.
$\eta_{s,Fan}$	Means the static efficiency including the motor and drive efficiency of the individual fan(s) in the ventilation unit (reference configuration) determined at nominal airflow and nominal external and internal pressure drop (and corresponding revolutions of the fan installed inside the unit) measured outside the unit according to the ISO 5801. The static efficiency is the ratio between the nominal airflow multiplied by the static pressure rise of the fan (equal to the sum of pressure drops for all ventilations components, clean and dry, and the nominal external pressure) divided by the electrical power to the fan drive.
P_{Fan}	Is the 'nominal electric power input (P)' (expressed in W) and means the effective electric power input of the fan drives, including any motor control equipment, at the nominal external pressure and the nominal airflow, measured on the unit.
$P_{Fan,ext}$	Is 'nominal electric power input (P)' (expressed in W) and means the effective electric power input of the fan drives, including any motor control equipment, at the nominal airflow and revolutions of the fan installed inside the unit and the corresponding Δp_{Fan} measured outside the unit according to the ISO 5801

If the unit is equipped with control equipment (inverter, etc.) η_{fan} must be reduced and $P_{el,Fan,ext}$ must be increased with the loss of the control unit. Alternatively, the data from the fan manufacturer must have been measured with the same equipment.

1.2.4.1. Measuring on unit with/without additional components

If the unit has additional components the test has to be carried out with and without the additional components to make sure that the fan runs at its design point and not at lower efficiency, which will otherwise lead to a higher SFP_{int} value.

I. Measure the external static pressure with additional components according to the design conditions (nominal)
II. Measure the external static pressure without additional components (take the additional components out) and:
    1. Hold RPM = constant according to situation 'I'
    2. Hold Airflow = constant according to situation 'I'
    3. Increase the external static pressure by damper until the flow is equal to situation 'I'.

The SFP_{int} is calculated as:

$$\mathrm{SFP}_{int\ UVU} = \frac{\Delta p_{s,Fan} - \Delta p_{s,ext}}{\eta_{s,Fan}} \cdot \frac{P_{FAN}}{P_{Fan,ext}}$$

$$\mathrm{SFP}_{int\ BVU} = \frac{\Delta p_{s,Fan,SUP} - \Delta p_{s,ext,SUP}}{\eta_{s,Fan,SUP}} \cdot \frac{P_{Fan,SUP}}{P_{Fan,ext,SUP}} + \frac{\Delta p_{s,Fan,EHA} - \Delta p_{s,ext,EHA}}{\eta_{s,Fan,EHA}} \cdot \frac{P_{Fan,EHA}}{P_{Fan,ext,EHA}}$$

Where $\Delta p_{s,ext} = \Delta p_{s,ext}$ in situation II and $P_{Fan} = P_{Fan}$ in situation I

If it is physically impossible to dismount the additional components measurements must be carried out according to section 1.2.3.

1.3. Pressure measurement inside a unit

To measure pressure inside the unit it is recommended either using a pressure relief box (electrical membrane box) or ring lines under the following conditions:

For both methods:

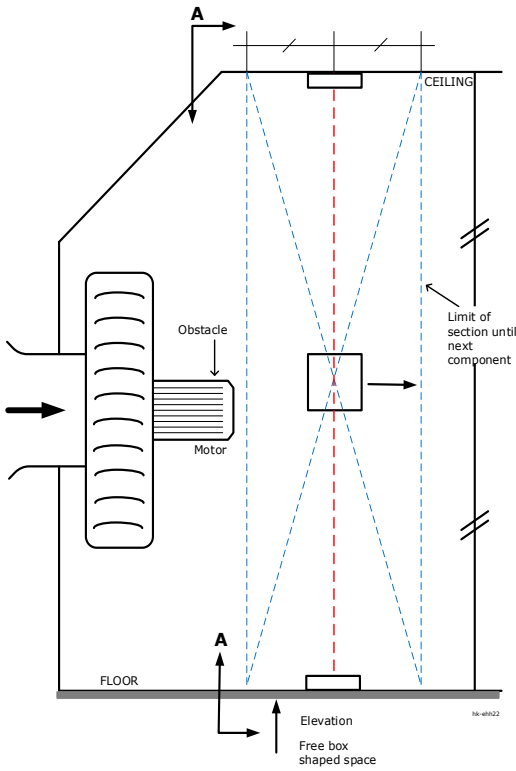
- placed at a fluidically quiet location;
- at a distance from stagnation regions; and
- the fan must not blow directly at the box/line, and if the fan blows along a surface, for example, at the bottom of the unit, the box/line cannot be placed at this surface.

For pressure relief box only:

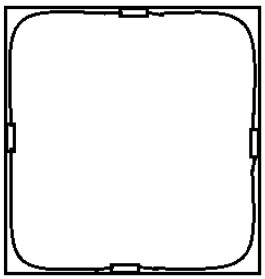
- maximum size: L=80 mm, W=80 mm, H=80 mm;
- prepare with only one hole (0,5 to 3 mm) at the bottom (backside) of the box (centre);
- the backside of the box of must be equipped with spacers (distance buds) that secure a distance between the box and the casing of approx. 1-2 mm; and
- located on a plane surface.

For ring line only:

- must be placed along all four inside surfaces of the unit at each measuring plane;
- tubes in maximum ø10 mm+/-1 mm; and
- must contain a minimum of four holes per of side (surface) of maximum 1,5mm+/-0,2 mm pr. side.



Pressure relief boxes (electric boxes)/ring-line placement in a unit



Four connected boxes or ring-line placed on internal side (wall) in unit

Pressure relief boxes (electric boxes) placed in unit

Measurements of the static pressure, before and after non-ventilation components, that cannot be dismounted and removed and for which it is impossible to use the four connected pressure relief boxes (electric box) or the ring-line method (see test setup) then measuring with four connected pressure taps in flush with the internal casing is acceptable.

Pressure tap, not in flush with internal casing

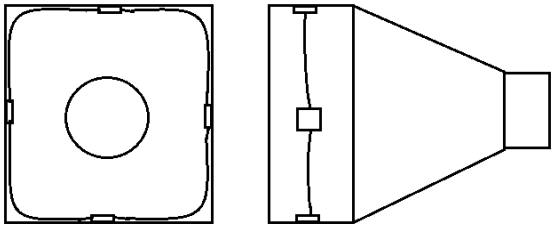
If the non-ventilation components are placed close to each other serial or in a group, the pressure drop can be measured for the entire group as follows:Static pressure after group - static pressure before group.

If the non-ventilation components are placed separately, the pressure drop must be measured for each component and summarised.

1.4. Pressure measurements in duct-connections outside the unit

Pressure measured external according to ISO 5801. If the duct connections are rectangular, and the velocity is below 10 m/s in the ducts connections at the out/inlet of the VU, and the duct connections have a length and width above 500 mm, the external pressure can be measured in the transitions mounted on the unit inlets and outlets.

Four connected (with tubes) pressure relief boxes or a ring-line must be placed as showed in the figure below in the transitions mounted at the in-and outlets on the unit. The transition has to be made with a straight duct before the start angle for placing the pressure relief boxes (electric box)/ring line.



Transition with straight duct before it angle.

The angle of the transitions may not exceed 15°. The length of the straight duct must be at least half times the maximum transverse dimension before and after the pressure measuring point.

1.5. Specifications for the measuring of SFP_{int}

In addition to the specifications of Regulation 1253/2014, the relevant Commission communication on standards and draft transitional methods, and the standards thereby referred, the following applies to testing SFP_{int}:

- For the measurement and calculation of SFP_{int} all characteristics/values are converted from the ambient temperature and pressure measured at the time of the test, to standard air conditions 20°C and 101325 Pa approx. equal to an air density of 1,2 kg/m³.
- The fan speed must be measured when carrying out the test with all panel hatches/doors closed.
- The external temperature is measured in inlet and outlet measurement ducts dimensioned in accordance with ISO 5801.

- The temperature difference between the outdoor air and extract air has to be within ± 2°C and close to isotherm.
- Condensation of moisture is not allowed.
- $T_{extract}$ = 20 ± 3°C
- Ambient temperature T_{amb} = $T_{exhaust}$ ± 2°C.
- Measurement of relative humidity in the airflow must be measured on the coldest side of the unit and in the supply airside and exhaust airside respectively.
- Barometric pressure must be measured and recorded when the test is carried out.
- Duration of test is at least 30 minutes.