Technical Assistance Study for the Ventilation Units Product Group

Explanatory note

On internal Specific Fan Power, SFP_{int} and draft transitional methods

Preliminary DRAFT prepared for the first stakeholder meeting of the Technical Assistance Study of the Ventilation Units Product Group
15 June 2015

(www.ventilationunits.eu)

Explanatory note on SFP_{int} and transitional methods (preliminary DRAFT for discussion at stakeholder meeting 15 June)

1. Introduction

This explanatory note is focussing on the internal specific fan power of ventilation components 'SFP_{int}' which is a part of COMMISSION REGULATION (EU) No 1253/2014 of 7 July 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to **ecodesign requirements for ventilation units**

The note has been prepared based on a number of proposals for determining SFP_{int} as well as questions on clarification of SFP_{int} that have been submitted to the Commission.

The note shall be considered a background document for the transitional methods of SFP_{int}.
The resulting draft transitional methods are included in the Annex 1 of this note.

See Annex 1 for the proposed draft transitional method of SFP_{int}

The explanatory note is slightly different from a normal procedure, as it starts with clarification of the definition of SFP_{int} by answering some of the questions submitted and by explaining (justifying) the answers (Chapter 2). Next section (Chapter 3) is presenting some general considerations about measuring SFP_{int} of ventilation units. Chapter 4 is reviewing proposals submitted on measurements and calculation of SFP_{int}. Measuring the internal pressure drop inside a ventilation unit can be very difficult. Chapter 5 summarizes an alternative method to determine SFP_{int} without measuring inside the unit. In Chapter 6, the alternative method is tested and compared with other methods. In case, the internal pressure drop can be measured, Chapter 7 is proposing a simple method for measuring inside the ventilation unit. Finally, Chapter 8 is summarizing some of the challenges of calculation of SFP_{int} for a whole unit according to measurements of single components.

In the regulation, in the standards and within Industry different wordings are used for the same entities. Consequently, the following should be taken into account in the document:

- **Inlet-side** is interpreted as in **the supply air side (air stream)** (SUP)
- **Extract-side** is interpreted as **the exhaust air side (air stream)** (EHA)
- Modular NRVU constructed/designed each time for a specific task is considered as a '**Tailor-made NRVU**'
- Standardised compact NVRUs not constructed/designed for at specific task but with a wide operation area are to considered as a '**mass-produced standardized compact NRVU**'

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 approximately equal to an air density of 1,2 kg/m³.

2. SFP_{int} – Definition, reference configuration, questions from stakeholders

A large number of SMEs have found the regulation difficult to understand, and want a simple and straightforward description of SFP_{int} to make sure that they follow the regulation correct. Such description is sought by answering some of the questions submitted and by explaining (justifying) the answers in the following.

SFP_{int} definition:
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:

$$SFP_{int} = \frac{p_{int}}{\eta_{stat,fan-integrated}}$$

Reference for SFP_{int} in the regulation (for information)

$\Delta p_{s,int}$ – The internal pressure drop of ventilation components (Δps,int) (expressed in Pa) means the sum of the static pressure drops in a reference configuration of a BVU or an UVU at nominal flow rate.

Reference configuration of a BVU means a product configured with a casing, at least two fans with variable speed or multi-speed drives, a HRS, a clean fine filter on the inlet-side and a clean medium filter on the exhaust-side

Reference configuration of an UVU means a product configured with a casing and at least one fan with variable speed or multi-speed drive, and — in case the product is intended to be equipped with a filter on the inlet-side — this filter must be a clean fine filter

Question 1
SFP_{int} for a BVU - is it for one or both side of the BVU?

Answer
According to the definition of the BVU reference configuration it is for both sides (p_{int} and n_{stat} is determined for both sides of the BVU). The 'fan efficiency (η_{fan})' is the static efficiency including motor and drive efficiency of the individual fan(s) in the ventilation unit. The electric power input P used to calculate the fan efficiency (η_{fan}) must be measured individually for the two fans and not the power consumption divided by two.

Justification
Sometimes the BVU is configured/designed with two non-equal pressures, and sometimes with different types of fan.

Question 2
Two possible equations with two different results for BVU's – Which to use? (*Supply and extract referees to the supply air stream and extract air stream*)

$$1: SFP_{int} = \frac{\Delta p_{int,SUP} + \Delta p_{int,EHA}}{\eta_{fan,SUP} + \eta_{fan,EHA}} \qquad 2: SFP_{int} = \frac{\Delta p_{int,SUP}}{\eta_{fan,SUP}} + \frac{\Delta p_{int,EHA}}{\eta_{fan,EHA}}$$

for subscripts see ANNEX 1

Answer
Equation No. 2 is to be used. Equation No. 2 gives approximately twice as high value and also twice as tough requirements. However, the benchmarks, and thereby the requirements in the regulation are determined based on this equation.

Justification

SFP (external) is defined as the sum of the power input divided by the mean/maximum airflow of SUP/EHA air side according to EN 13779. **This justifies that equation 2 is used.** Likewise, this solution is described in VHK's draft 'Possible transitional measurement method preliminary DRAFT'. Furthermore, the SFP_{int} limit for BVU's (depending on size) is between 900 and 1700 W/m3/S (with some corrections for E and F), where the SFP_{int} for UVU is limited to 'only' 250 W/m3/s. Therefore, the total power consumption of BVUs should be included to achieve uniform requirements between UVU and BVU.

Question 3

Use of internal or external fan efficiency for calculating the SFPint?

Definition of η_{fan} in the regulation (for information)

'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;

Answer

The fan efficiency η_{fan} is the 'overall static efficiency drive' at nominal airflow and nominal external pressure drop to be measured at the fan section, in %, according to ISO 12759 but for the fan when it is placed in intended casing i.e. considering system effects.

Placement of a fan in a casing will affect both the fan pressure rise (less pressure rise due to system losses) and the power consumption.

The fan efficiency is to be measured/calculated with in the BVU and with the external (and internal) pressure loss at nominal airflow (defined by the manufacturer) according to the definition of SFP even though the calculation of SFP_{int} only uses the internal pressure drop.

fan efficiency: $\eta_{fan} = \frac{q_{nom} \cdot \Delta p_{fan}}{P}$ where $\Delta p_{fan} = \Delta p_{s,ext} + \Delta p_{s\ int}$

For BVU calculated for both airstreams respectively, the supply air stream (SUP) and the extract air stream (EHA) for determination of SFP_{int}. For UVU calculated for one airstream.

'Fan static pressure' (p_{sf}) means the fan total pressure (p_f) minus the fan dynamic pressure at nominal airflow for one airstream.

'Internal pressure drop of ventilation components ($\Delta_{ps,int}$)' (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;

'Nominal external pressure ($\Delta p_{s\ ext}$)' (expressed in Pa) means the declared design external static pressure difference at nominal flow rate;

'Nominal flow rate (q_{nom})'(expressed in m^3/s) means the declared design flow rate of an NRVU at standard air conditions 20 °C and 101325 Pa.

'Nominal electric power input (P)' (expressed in W and not as stated in the regulation in kW as SFP_{int} is in W/m3/s) means the effective electric power input of the fan drive, including any motor control equipment, at the nominal external pressure and the nominal airflow;

Justification

The fan efficiency 'η_{fan}' is used to calculate SFP_{int}, but the regulation does not specify in detail whether it is measured inside the unit (internal) or under idealised conditions as a fan measured according to the fan regulation (external).

The difference between the internal and external fan efficiency can be relatively high due to internal system (pressure) loss, so it is essential that the correct efficiency is used in relation to the requirements set out in the regulation. However, it is difficult and not usually measured and there is no standard for this area.

The previous 'Possible transitional measurement method preliminary DRAFT' states under 'Section 2, Component-based compliance assessment of NRVU ventilation units', page 5, paragraph 4 in a small note that:

'Explanation: Fan efficiency in the unit η_{fan} may be lower than fan efficiency η_e as declared by the fan manufacturer e.g. in order to optimize for lower face velocity at nominal flow rate'.

Which states that the intention is to use the internal fan efficiency measured in the unit. The same applies to a recalculation of the normal used external SFP to SFP_{int}.

However, 'the internal efficiency' is subject to additional costs to measure and the manufactures of the tailor-made NRVU cannot calculate these values directly based on data on their individual components because of missing knowledge of built-in system loss.

Further, the mass-produced standardised compact NRVU manufactures cannot measure inside the unit because of disturbances and lack of space.

The efficiency of the fan declared in the fan regulation cannot be used either, because it is measured outside the unit and measured in BEP. (However, manufacturers of fans as a minimum often got informative measurements throughout the whole area.)

Therefore, this note also works with a number of alternatives to the direct measurement and calculation of SFP_{int} in the unit, presented in the following sections. Still based on the built in loss/system loss included in fan efficiency (the internal fan efficiency that includes this loss).

Question 4:

Which pressure must be used to calculate the fan efficiency?

Answer

'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** (and internal pressure drop).

The 'static efficiency' means the overall static efficiency. It is the ratio between the nominal airflow multiplied with the static pressure rise of the fan (equal to the sum of pressure drops of all ventilations components, clean and dry, and the nominal external pressure) divided by the electrical power of the fan drive.

Justification

The definition can be interpreted as if the fan efficiency only may be calculated from the external pressure drop. However, it may be calculated from both the internal and external pressure i.e. the total pressure rise over the fan measured in the unit. This is due to the wording 'static efficiency'; otherwise, the requirements become twice as strict.

It is the situation where the unit provides the nominal flow rate and at the external pressure performance at the same time. The fan provides a higher pressure at the same time, which partially goes to cover the pressure loss in the internal ventilation components.

Question 5:

Is the nominal airflow the maximum airflow of the NRVU?

Below input from Eurovent Certification Company (ECC) for information

'The "nominal flow rate" cannot be higher than the highest airflow at which the "thermal efficiency of a non-residential HRS (ηt_nrvu)" is fulfilled at equal s, supply and extract'.

*'A NVRU is normally designed for one specific working point but when Variable Air Volume flow system or Demand Controlled Ventilation are used there will be a range of working points from a minimum airflow up to a maximum. The "nominal flow rate" shall in such case be the design working point **winter time** when heat recovery is fully used. The design working point summer time can be at a higher airflow but will only be used a short period during the year and may not fulfil the requirements in this Regulation'.*

Answer
The nominal airflow and pressure must be seen as the maximum airflow of the NRVU in the sale of which the NRVU can fulfil the requirements according to the definitions in the regulation:

Definition of nominal flow rate in the regulation:
'Nominal flow rate (qnom)' (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.

The design point is usually the maximum conditions the VU must meet according to demands from the contractor.

Justification
Mostly the same point is used for summertime and wintertime, and this interpretation will provide a huge loophole and can therefore not be used.

In winter, ventilation demands are mostly due to the atmospheric indoor climate, and in the summer due to the thermal indoor climate. The airflow demand for atmospheric indoor climate (winter) is often lower than the thermal (summer) because of the cooling demand in summer. However, in winter there is also often the demand for heat, which increases the airflow. Likewise, in summer, there is often a demand for cooling recovery, when the air outside has a higher temperature than the air inside the building, which increases the airflow over the HRS and does not make it lower than in the winter.

Question (claim) 6
What is the nominal airflow when using a mixing section?

Below input from* Eurovent Certification Company (ECC) *for information

'When a mixing section is installed, HRS and filter are selected for outdoor air demand only and in some cases they are not able to handle the full design flow rate of the unit – calculate the internal pressure losses of the ventilation components (HRS+filter) for the design airflow. If they are designed only for the outdoor air and not for the total airflow, calculate only the outdoor air part.

Fan characteristics, system losses, fan efficiency etc. shall be calculated with the total airflow through the fan'.

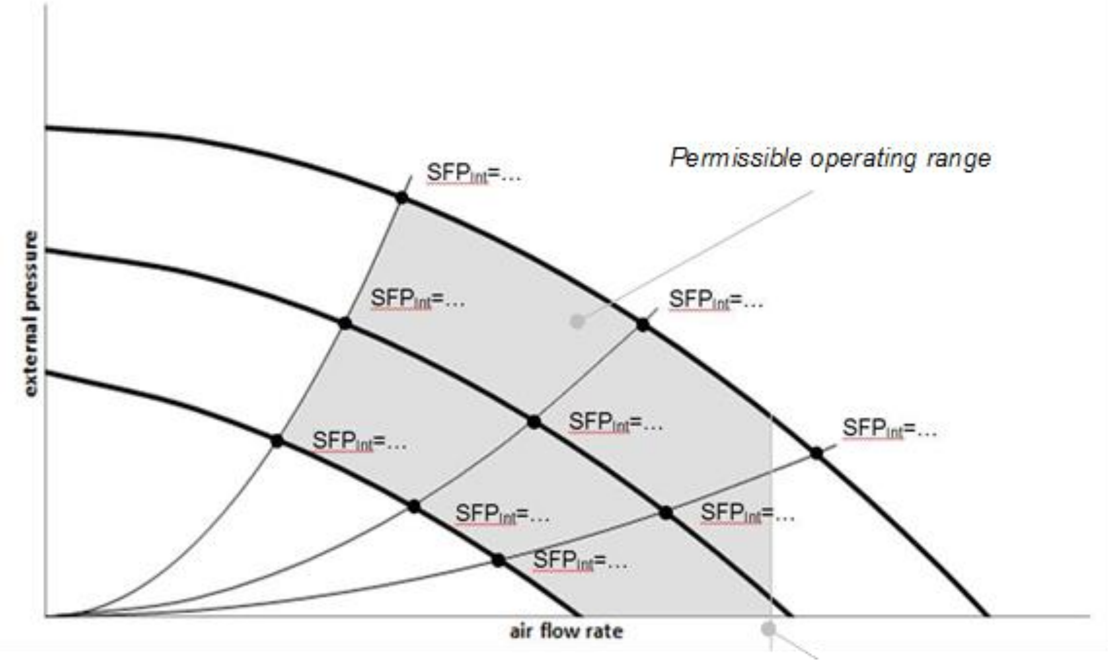
Answer
Measurements and declaration must be performed as a 'normal' unit with a heat recovery system, not recirculating.

Question 7
Can an area be used instead of only one point?

Answer
Final formulation to be still confirmed. Preliminary input:

NVRU consists of two main groups, i.e. **tailor-made** NVRUs and **mass-produced** standardised compact NVRUs. They deviate in the matter of working point. A tailor-made NVRU is designed for specific working points but a compact NVRU is used for a wide range of working points.

If the working point is not specified by the customer, which can be the case for a small **mass-produced** compact NVRU, one could declare a field (graph) of nominal airflows with associated 'nominal external pressure (Δps, ext)', see below (The NRVU is considered to have balanced airflows).



The customer could then be allowed to use the NRVU if the design working point is within the declared field. The NRVU is considered to have balanced airflows.

Question 8

*Is the 'internal pressure drop of **additional non-ventilation components** (Δps,add)' (expressed in Pa) with or without the NRVU inlet and outlet losses if applicable?*

Answer

The inlet and outlet is a part of the casing and therefore not part of the '**non-**ventilation components.

The NRVU inlet and outlet losses must be included in the **'**The internal pressure drop of ventilation components (Δps,int)'

If a ducted air-handling unit has full size openings (the internal cross section of the duct systems is equal to the cross section of the NRVU), it mostly experiences no additional pressure losses at the inlet and outlet opening.

3. Consideration regarding measurements of SFP_{int}

The regulation is faced with two issues that must be taken into consideration:

1: Mass-produced standardised compact NRVUs.
Documentation is easy because they are mass-produced and the manufacturer often measures on one unit that is applicable to all. However, on these units the internal pressure drop is difficult to measure because they are compact and with large disturbances. In this instance, it is important that there is an alternative or a secure way to measure the internal pressure

2: Tailor-made NRVUs
In these units, it is easier to measure the internal pressure because the face velocity is often lower. However, they are customised and manufactured in thousands of different configurations. Here the manufactures mostly rely on measurements of single components and assemble them in an overall performance based on customer requirements in their product selection programme. Units will not be measured separately and only occasionally randomly (if they are members of a certification scheme). In this instance, it is important that the method take into consideration that manufacturers within some uncertainty is able to calculate the internal pressure drop and efficiency by measuring on the individual components.

Approach
The internal pressure used to calculate SFP_{int} cannot be measured with the current standards. This also applies to the fan efficiency (η_{fan}). It is important that SFP_{int} and associated values can be measured and verified, but it is also equally important that:

1. The values can be measured in the laboratory.
2. The values can be calculated in the manufacturers' product selection programmes from measurements/knowledge of the individual incoming components.
3. SFP_{int} has to be calculated with a minimum of extra measurements.
4. Should be useful for both compact and tailor-made units.

What is essential is to find SFP_{int} that is equal to the energy consumption (loss) in W/m3/h caused by the 'not ideal' fan installation in the unit and the pressure loss-making components (filter, heat exchanger and the casing).

The big question is how to measure/calculate the fan installation system loss and the additional pressure loss caused by the casing (mainly in and outlet, and secondly not idealized built in components). DTI has previously measured on units in many different ways to find a solution on how to measure correctly inside a unit:

- with a large number of measuring points inside the unit after each component;
- measurement with fans switch off and air pulled/pushed through the system from the outside, where it turned out that the lack of rotation had a strong influence and improved the performance unintended in relation to the true values;
- with pitot tube measurements in a grid with a large number of measuring points; and
- with anemometer measurements (to analyse the face velocity grid and thereby the difference in dynamic and static pressure) in a grid with a large number of measuring points.

All measurements provided unequal results, and it could not be determined whether one was more correct than the other one. This resulted for the specific verification scheme at that time in an agreement that pressure was to be measured on pressure taps mounted by the manufacturer. This is not an ideal method, but a way for laboratories and manufacturers to measure identical at low cost. Therefore, DTI's focus is to find:

1. an alternative to the measurements inside unit (using external values); and
2. a simple method for measuring pressure inside the unit.

The focus is a method that can rank the product in accordance with regulations and can be measured and calculated within an appropriate uncertainty.

Roadmap:

The determination of the internal pressure drop and fan efficiency is the key element for the calculation of SFP int.

1. Methods for determination of SFP_{int}
    a. Indirect determination by comparison of fan data and unit data
        i. A simple method for measuring pressure inside the unit correctly
    b. Measurement - A simple method for measuring pressure inside the unit correctly
        i. Direct measurement over all components
        ii. Indirect measurement by removing components
    c. Reliable components data
        i. Calculation from components data

2. Declaration which method is used
    a. Which method for which units
    b. Tolerances

3. Experience with methods 1a and 1.b.

1.c is not part of the transitional methods but will be taken into consideration. Manufacturers can rely on their individual component data calculated to overall performance of the unit, but test activity will be conducted according to 1.a and 1.b

A number of manufacturers have supplied proposals on these topics, which DTI has evaluated and tested in the laboratory and summarised in one proposal (see Chapter 5 and 6). Manufacturers are invited to share their preliminary testing results based on the presented methodology, in order to further assess its easiness of use.

In the next chapter follows a brief description of the various proposals. For further clarification, reference is made to the proposal in question.

4. Review of submitted proposal for measurement and calculation of SFP_{int}

It is our intention to publish the different proposals in the 'Documents' section of the webpage www.ventilationunits.eu before the first stakeholder meeting. We will use the numbering (I to VII) to refer to the different proposals.

I: Helios

The proposal focuses primarily on compact units

Alternative measurements for SFP_{int}. Internal pressure losses and efficiency are calculated from idealised measurements of the fan outside the unit (acc. to the fan regulation) in relation to measurements with the fan inside the unit.

$$SFP_{int} = \frac{p_{int}}{\eta_{stat,fan-integrated}} \approx \frac{p_{int,compl}}{\eta_{stat,fan-outside}} \cdot \frac{P_{el,AHU}}{P_{el,fan-outside}}$$

$p_{int,\,compl} =$ a) $p_{fan\text{-}outside} - p_{ext}$ (add. components removed)

b) $p_{fan\text{-}outside} - p_{ext}$ (add. comp. not removed)

Δp_{int} is calculated from the units pressure rise with fan inside / outside.

Evaluation:
Measurement has to be made at the exact same point inside/outside (m3/h, pressure, rpm, power consumption) where the difference is measured in the external pressure (supplied to the duct system).

A problem could be that both flow and pressure in some few cases can change when 'installing the fan' in the unit (Pre-rotation or very poor fitting can change the velocity profile into the fan and thereby reducing the fan 'real efficiency' and thereby the power consumption). The effect can also decrease if the fan performance drops (pressure * flow), which is take into consideration with the correction by Pel,AHU /Pel,fan-outside. It is a good starting point, which, however, must be tested to make sure that it is both possible to calculate and measure approximately the same (theoretical correct corrected empirically). It has to be evaluated by measurements whether or not the last part of the formula is to be included.

II: Aldes - CALCULATION OF SFP_{int} (CEN/EVIA)

Primarily a clarification of what SFP is and the link to SFP_{int} and whether to use internal or external fan efficiency.

Finally, there is a rewriting of SFP_{int}, which does not lead to an easier measurement.

It points out that there is a difference in measured total value and calculated summarised values based on measurements of individual components for which there are not readily data available, and which should be taken into consideration.

Evaluation:
The document contains good considerations that have been taken in to consideration. However, it does not contain a new solution, mainly a statement that S SFP_{int} must be based on internal values (fan efficiency), which it points out is difficult to measure and has been taken in to consideration.

III: Uniclima (Cetiat)

Proposal No. 1
Mainly compact units with the same basic ideas as Helios with use of the external pressure measured at the units terminals in relation to fan measurement and the use of the external fan efficiency.

$$SFP_{int,} = \frac{\Delta p_{fan} - (\mathbf{\Delta ps, ext})}{\boldsymbol{\eta_{fan}}}$$

Where $\eta_{fan} = C_c * (q_{v,\,in} * \Delta p_{fan}) / P_{fan}$

The calculation is made for both sides of BVU and for one side for VU.

It does not contain the same additional correction (P_{elAHU} / $P_{el\ fan\ outside}$) as Helios where the 'fan efficiency (η_{fan})' is corrected by the measured power consumption inside and outside.

Evaluation:
It is a good starting point, which, however, must be tested to make sure that it is both possible to calculate and measure approximately the same (theoretical correct corrected empirically). Cc control factor from Fan regulation must not be in the equation otherwise measured inside the unit will give the same results.

Proposal No. 2 (Aldes)
Mainly tailor-made units and how to calculate exclusively from values measured on individual components. Values for casing effects are not known and there is no existing test method so they propose to disregard them.

SFP_{int} is measured according to EN 13053 based on single components

$$SFP_{int,sup} = \frac{\Delta ps,int,_{supply}}{\eta_{fan\ in\ unit,supply}} \ \textit{with}\ \eta_{fan\ in\ unit,supply} = \frac{qnom * (\mathbf{\Delta ps,ext},_{supply} + \Delta ps,int,_{supply})}{P_{unit}/2}$$

The unit is at reference configuration without non-ventilation components.

Evaluation
The main problem is that system losses are not included and may be significant, but at the same time they can also be difficult to measure. Market surveillance will not be able to measure the same value in a unit as measurement of individual components. They state that the choice must be supported by tests and calculation simulations of manufacturers on their units, which is an a very good point.

'P_{unit} /2' must be changed to the power consumption of the indvidual fans.

IV: Eurovent Product Group 'Air Handling Units'
A lot of god input on all aspects. Regarding SFP_{int} mainly focus on tailor-made units and how to calculate exclusively from values measured on individual components, which will be taken into consideration.

Evaluation:
The document contains many good considerations but does not contain any alternative solutions regarding SFP_{int}, but a lot of good descriptions and statements which have been used.

V: Claus Händel (EVIA)
Looking at the different considerations and problems concerning the SFP_{int} and a proposal for a Road Map for the further actions:

$$\mathrm{SFPint} = \mathrm{SFPall} \cdot \frac{\Delta p\_int}{\Delta p\_all}$$

- Evaluation:

The road map is a god suggestion and has been adopted. For the equation the internal pressure drop has to be known, and therefore the original formula in the regulation can be used as well.

VI: Doctor Christoph Kaup

A suggestions on how to measure the pressure loss when the unit contains additional non-ventilation components ($\Delta p_{s,add}$) by measuring with and without the additional non-ventilation components, corrected by an increased external pressure (e.g. damper) to give the same flow with and without the additional non-ventilation components.

Evaluation

The proposal describes an alternative method for measurement on units with and without additional non-ventilation components and at the same time how to measure the internal pressure performance direct with loops/ring line, which will be taken into consideration. However, the applied flow measurement and related correction to normal conditions will not be used in this transition method, and SFP_{int} must be measured for both air streams.

VII: Rosenberg/ Fachverband (Claus Haendel/Manfred Mueller)

Mainly compact units with the same basic ideas as Uniclima with use of the external pressure measured at the unit's terminals in relation to fan measurement and the use of the external fan efficiency. It does not contain the same additional correction (P_{elAHU} / $P_{el\ fan\ outside}$) as Helios where the 'fan efficiency (η_{fan})' is corrected by the measured power consumption inside and outside.

Furthermore, that make a proposal that indicates an area instead of a single point where SFP_{int} is fulfilled, defined as the allowed operation area. The proposal suggests that the area may be calculated from one measurement only.

Evaluation

Like Helios and Uniclima's suggestions it is a god good suggestion, which has to be evaluated by measurements to make sure it will work in practice. The proposal is well-described and contains - in an addition to Helios and Uniclima's proposals, a proposal for the measurement of units with and without additional non-ventilation components.

However, the proposal, which suggests that an area may be calculated from only one measurement, is unclear and needs documentation.

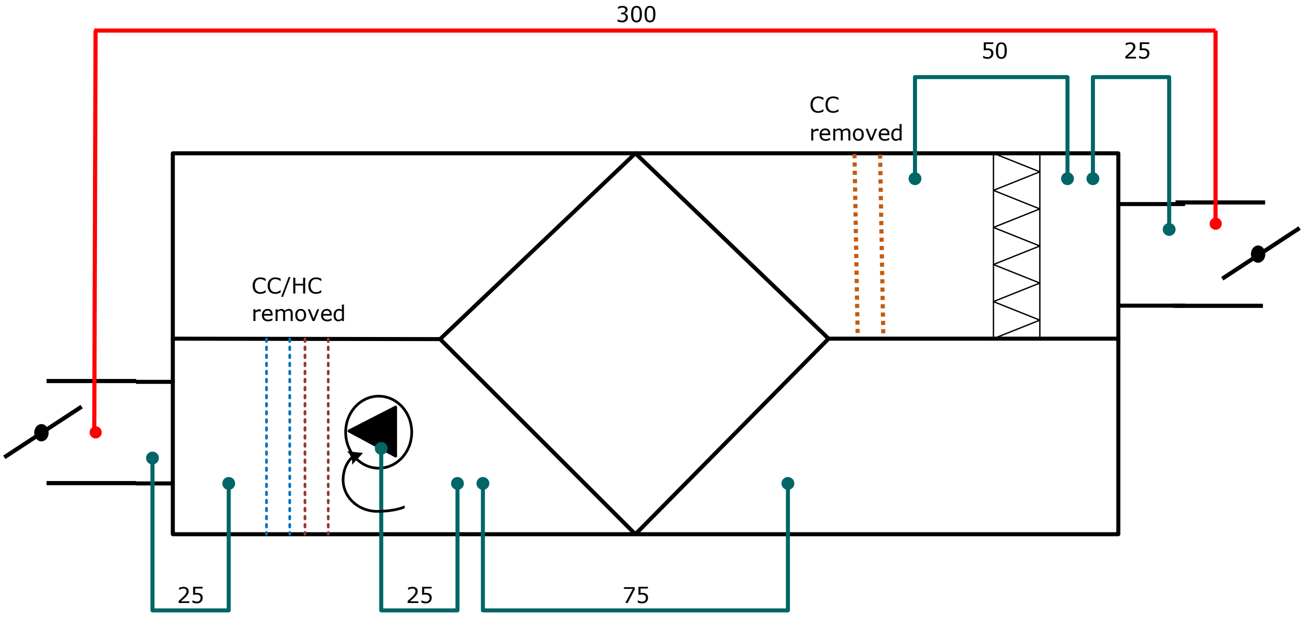
5. Summarized alternative to determinate SFP_{int} (DTI)

Based on the basic SFP_{int}-formula, an example is given:

$$SFP_{int} = \frac{\Delta p_{int\ inlet}}{\eta_{inlet\ fan}} + \frac{\Delta p_{int\ outlet}}{\eta_{outlet\ fan}}$$

The example is only shown for **one side** of the unit, but for BVU's SFP_{int} for both sides has to be measured and calculated.

For the ventilation unit below, the pressure loss distribution is show (the pressure losses are fictive).



Internal pressure drop (green) = 200Pa, External pressure drop (red) = 300Pa

If the unit was a '**mass-produced standardised compact NRVU**' with significant internal disturbance, the internal pressure drop and thus the fan efficiency would not be measurable. The unknown would be:

I. Pressure drop caused by integration of the fan, which is expressed in the 'internal efficiency of the fan'.
II. Pressure drop caused by integration of the individual components, which can be considered as the 'casing system pressure loss'.

From measuring on the unit, the measured data are:

q_{nom} = 3600 m3/h
$\Delta p_{s\_external}$ = 300 Pa
P = 625 W
rpm = 1800

If the fan were measured outside the unit (under ideal conditions, according to the fan regulation, but not in BEP, corresponding to nominal flow) in the same fixed point with same rpm, flow rate, electric power input, it would have the following data:

η_{fan} = 80%
q_{nom} = 3600 m3/h
Δp_s = 500 Pa
P = 625 W
rpm = 1800

The fan stays at the same working point (inside/outside the unit) on the fan curve, but we can only observe an external pressure drop. Right before the fan, the fan sees the same working situation as the test outside, but we only observe the external pressure, or if we measure inside only the pressure without the system loss around the fan.

The difference in the external pressure drop (300Pa) and the ideal measuring of the fan (500Pa), which is 200Pa in this situation, is an expression of both the total internal pressure loss AND the internal efficiency of the fan.

This way it may be reasonable to use the external efficiency of the fan instead of the internal efficiency to calculate SFP_{int} as the loss is covered by the measured pressure difference between the two measurements.

$$SFP_{int} = \frac{\Delta p_{fan\ ext -}\ \Delta p_{unit\ ext}}{\eta_{ext\ fan}}$$

A problem is that the electric power input can change when installing the fan in the unit (pre-rotation or poor installation can change the velocity profile into the fan and thereby reduce the fan's 'real efficiency' and thereby the power consumption in 'the same point'). The effect can also decrease if the fan performance drops (pressure * flow).

There may be system losses not related to an asymmetric inlet to the fan, but due to other flow conditions in the casing between the pressure measuring point and fan. These will be reflected in the difference in pressure between the two measurements (inside/outside) and will not lead to different power consumption.

This problem can be solved by using a correction between the power consumption in the two measurements. This leads to the final formula for calculation of SFP_{int}:

$$SFP_{int} = \frac{\Delta p_{fan\ outside} - \Delta p_{s\_ext}}{\eta_{fan\ outside}} \cdot \frac{P_{unit}}{P_{Fan\ outside}}$$

Rewritten to standard terms it becomes:

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

Values is inserted with numerical values for Δp. All values is calculated for SUP or EHA for UVU's depending on whether it is a SUP or EHA fan unit and calculated values for SUP and EHA for BVU's.

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

Where

Δp_{Fan} means the static pressure difference of the fan measured outside the unit according to the fan regulation, not in best efficiency point (BEP), but corresponding to the nominal flow and rpm regarding the unit regulation (according to the measurements conducted on the unit).

$\Delta p_{s,ext}$ means the static nominal external pressure drop as described under Annex A1.2.3 measured at the terminals at the unit.

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 air flow and nominal external and internal pressure drop (and corresponding revolutions of the fan installed inside the unit) measured outside the unit according to the fan regulation.

The static efficiency is the ratio between the nominal air flow multiplied with 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 corresponding Δp_{Fan} measured outside the unit according to the fan regulation

If the unit is equipped with control equipment (inverter, etc.) η_{fan} shall 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.

For the measurement and calculation of SFPint 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 approximately equal to an air density of 1,2 kg/m³.

For further information regarding symbols and subscripts, see Annex 1.

6. Test of alternative determination of SFP_{int}

Based on the previous proposal, the different calculation methods have been tested and measured using two types of ventilation units in DTI's accredited laboratories: A compact and a tailor-made unit.

The following table displays the most difficult unit to measure on (lack of space inside and poor velocity distribution) **for one side** of a BVU.

The measurements show that 'SFPint 2' (which is adjusted for the difference in input power) gives the best results in relation to the reference value determined and measured according to the direct text of the regulation and measured directly in the unit. This is because the inlet losses in the fan are not included if the power consumption is kept constant and the rpm corrected. If no inlet loss occurs, there will be no/only a small change in power consumption in the measurement inside/outside of the unit.

There may be system losses not related to an asymmetric inlet to the fan, but due to other flow conditions in the casing between the pressure measuring point and fan. These will be reflected in the difference in pressure between the two measurements (inside / outside) and will not cause a different power consumption.

Measurement	**Unit**	**Laboratory (ref)** Measured in unit	**Fan data** Data from fan manufacture P=Constant	 RPM=Constant	**Manufacture** Production selection programe
Flow	[m3/h]	5000	5000	5000	5000
Eletric power input	W	2006	2006	1811	1830
Revolution	RPM	1811	1867	1811	1811
Total Pressure	Pa	773	867	778	796
Ekstern pressure	Pa	392	392	392	415
Intern pressure = dptotal-dpekstern	Pa	381	475	386	381
Eff. of fan	[%]	53,5%	59,7%	59,7%	57,0%
Calculated	[%]	53,5%	60,0%	59,7%	60,4%
SFPall	[%]	1444	1444	1304	1318

SFPint_regulation $\text{SFPint} = \frac{\Delta p_{int}}{\eta_{intern}}$	[W/m3/s]	$\frac{381\,Pa}{0{,}535}$ 713			$\frac{381\,Pa}{0{,}57}$ 669 631
SFPint_1 $\text{SFPint} = \frac{\Delta p_{fan} - \Delta p_{s\_ext}}{\eta_{fan}}$	[W/m3/s]		$\frac{475\,Pa}{0{,}597}$ 796	$\frac{386\,Pa}{0{,}597}$ 647	
SFPint_2 $\text{SFPint} = \frac{\Delta p_{fan} - \Delta p_{s\_ext}}{\eta_{fan}} \cdot \frac{P_{el\_AHU}}{P_{el_{fan-outside}}}$	[W/m3/s]			$\frac{386\,Pa}{0{,}597} \cdot \frac{2006\,W}{1811\,W}$ 717	$\frac{381 Pa}{0{,}57} \cdot \frac{2006\,W}{1830\,W}$ 734
SFPint_3 $\text{SFPint} = \text{SFPall} \cdot \frac{\Delta p\_int}{\Delta p\_all}$	[W/m3/s]	$1444 \cdot \frac{381\,Pa}{773\,Pa}$ 713			$1318 \cdot \frac{381\,Pa}{796\,Pa}$ 631

P=constant means that data from Fan manufacture has be chosen so they are constant between two measurements (inside/outside) regarding the flow and power consumption (total pressure and rpm is noted).

RPM = constant means that data from Fan manufacture has be chosen so they are constant between two measurements (inside/outside) regarding the flow and rpm (total pressure and power consumption is noted).

DTI recommend SFPint_2 be used, and it would be preferable that manufacturers perform similar measurements and calculations to validate the methods, so possible adjustments can be obtained and it can be assured that it is a good-validity method which is simple to use.

'SFPint 3' also provides an accurate result, but for this equation the internal pressure drop has to be known, and therefore the original formula in the regulation can be used as well.

7. A simple method for measuring pressure inside the unit

In the current standards there are several good description of how to measure in a long, straight duct with non-rotating air and disturbances. There are also standards describing traversing measurements and alternative measurement plans in situ. However, there is no existing standard that describes where, how, and in how many points to measure the pressure inside a unit.

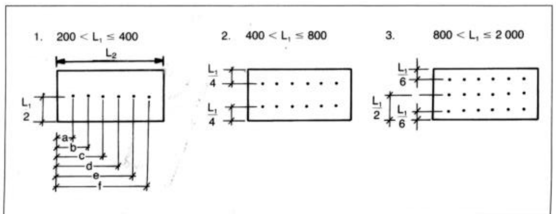
It is important that traversing measurement with pitot tube for example is not used, as it will increase the test period and cost significantly and make data logging impossible. Furthermore, it is important that the measuring equipment does not cause a disturbance in the airflow or result in a pressure drop.

To analyse which method is applicable, DTI has conducted a series of measurements in the unit and in idealized airflow respective. For the analysis the, we have tested the following methods:

- parallel/cross tubes (NVG);
- pitot;
- static pressure instrument (alternatively pitot exclusively with static pressure);
- pressure relief box (simple electric membrane box); and
- pressure taps mounted by the manufacture in the casing (has to be in level with the inside of the unit casing and not as the picture below)

				
Parallel / cross section tubes	*Pitot*	*Static pressure instrument*	*Pressure relief box*	*Pressure taps*

The cross tubes/parallel tubes are made with a distribution of pressuring holes according to experience from *'NVG - metoder för mätning av luftflöden I ventilationsinstallationer T9:2007'*. Tubes in both 4 and 10 mm with 1 mm pressure holes pointing 180 degrees opposite to the direction of airflow have been tested.

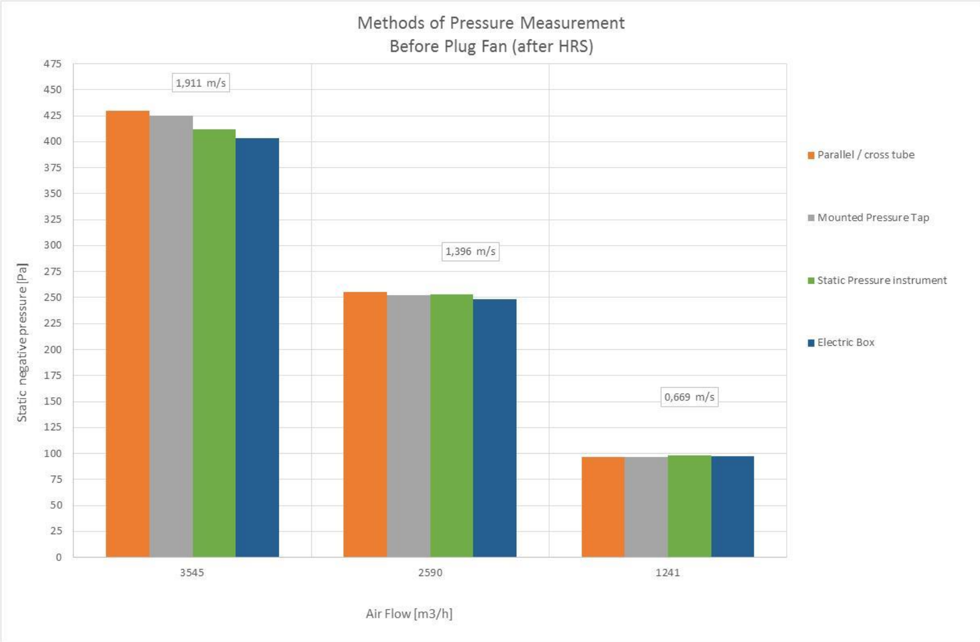


L_2 [mm]	200	250	300	400	500	600	800	1000	1200	1400	1600	1800	2000
a	16	20	25	25	30	35	50	60	70	85	95	110	120
b	85	110	130	95	120	140	190	235	280	330	375	420	470
c	115	140	170	170	215	260	345	430	515	600	690	775	860
d	184	230	275	230	285	340	455	570	685	800	910	1025	1140
e	–	–	–	305	380	460	610	765	920	1070	1225	1380	1530
f	–	–	–	380	470	565	750	940	1130	1315	1505	1690	1880

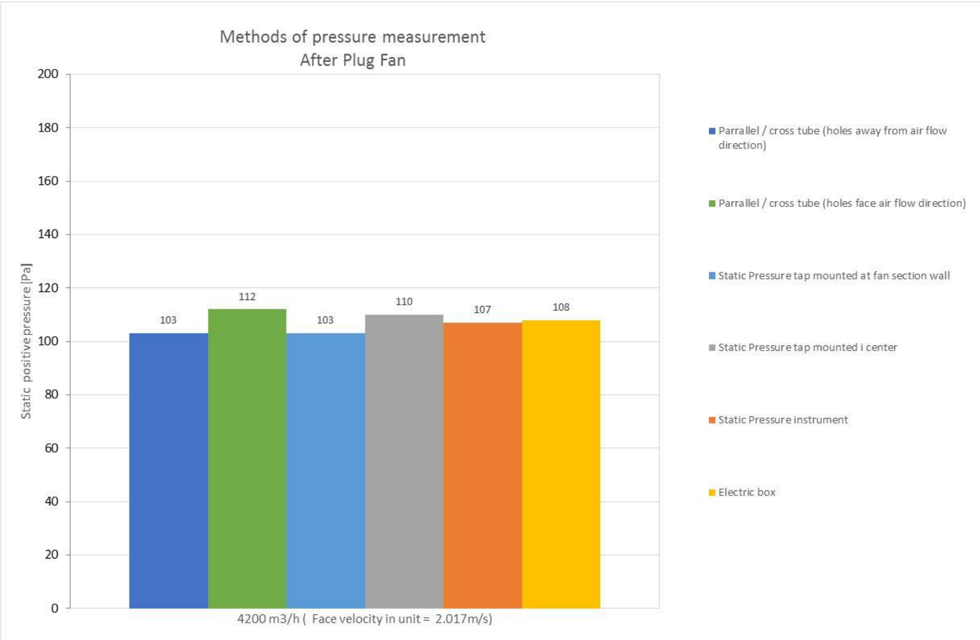
Distribution of pressuring holes

Ring Line (loops) has not been included because it is often not possible to fit properly due oblique heat exchangers, etc.

All measurements have been conducted in the same level (plan) and have been conducted on a number of units, of which the most critical measurement plane of the test is set out below.



The measurement has also been conducted on the fan section pressure side, where the results are not as divergent due to the larger chamber and low velocity.

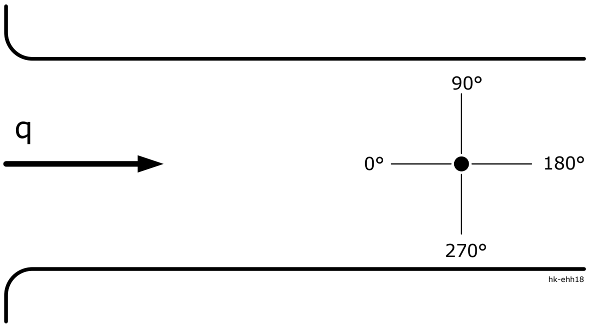


The experience is that one thinks that one knows the air direction and movement in the unit and therefore can perform a reference measurement with traversing pitot tube measurement. However, this is not the case, even at low face velocities, as local internal disturbances accelerate and rotate the airflow, which can result in an incorrect reference.

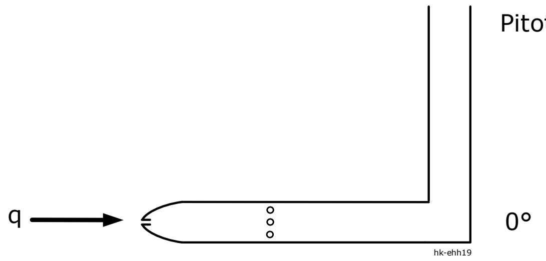
The difference in the results depends on the location and direction of the different measuring equipment, resulting in a variation of the results from positive to negative local maximum dynamic pressure. This phenomenon has been studied by additional measurements at a steady velocity field where the measuring equipment, is rotated in relation to a known air direction.

Study of the angle of attacks influence on the pressure measurement

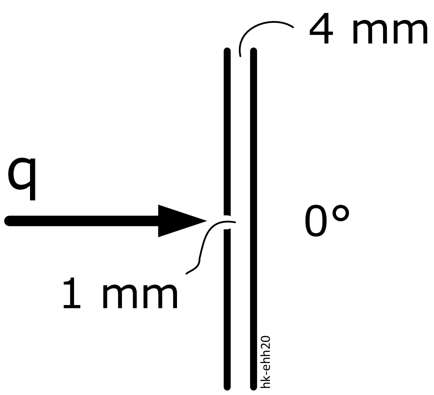
Three different measurement methods for static pressure were tested. One method with a pitot, one method with a 4 mm tube (pipe) and one method with a 10 mm tube (pipe). The measurements were carried out with air velocity of 2.5 m/s and 4.7 m/s.



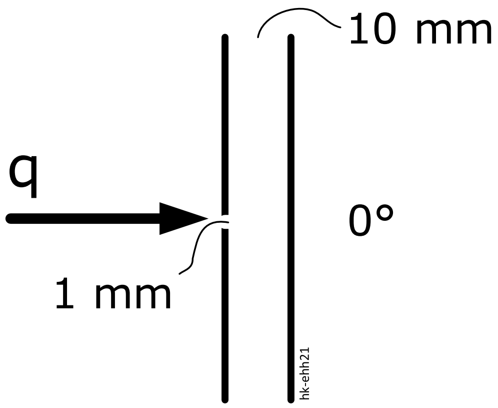
Direction of measuring equipment



Pitot tube



4 mm tube (pipe)

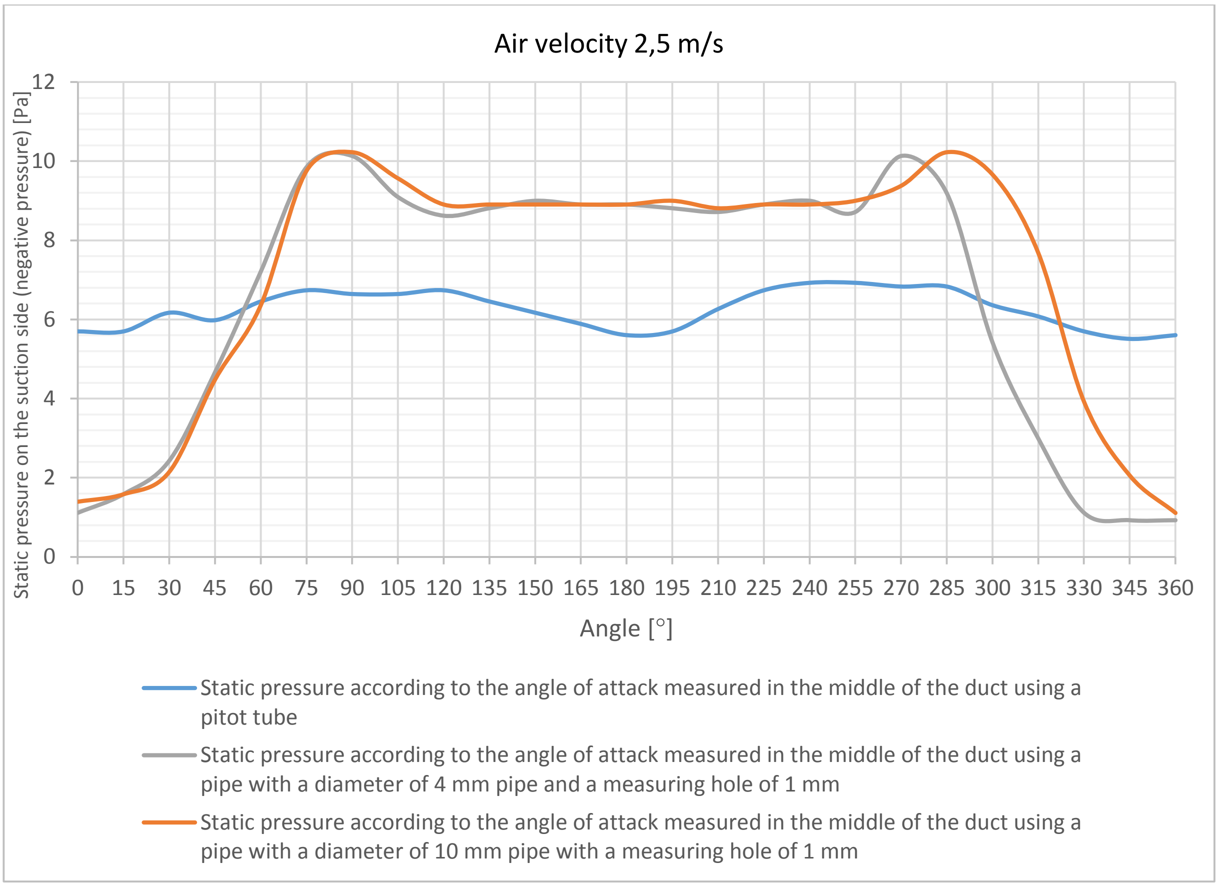


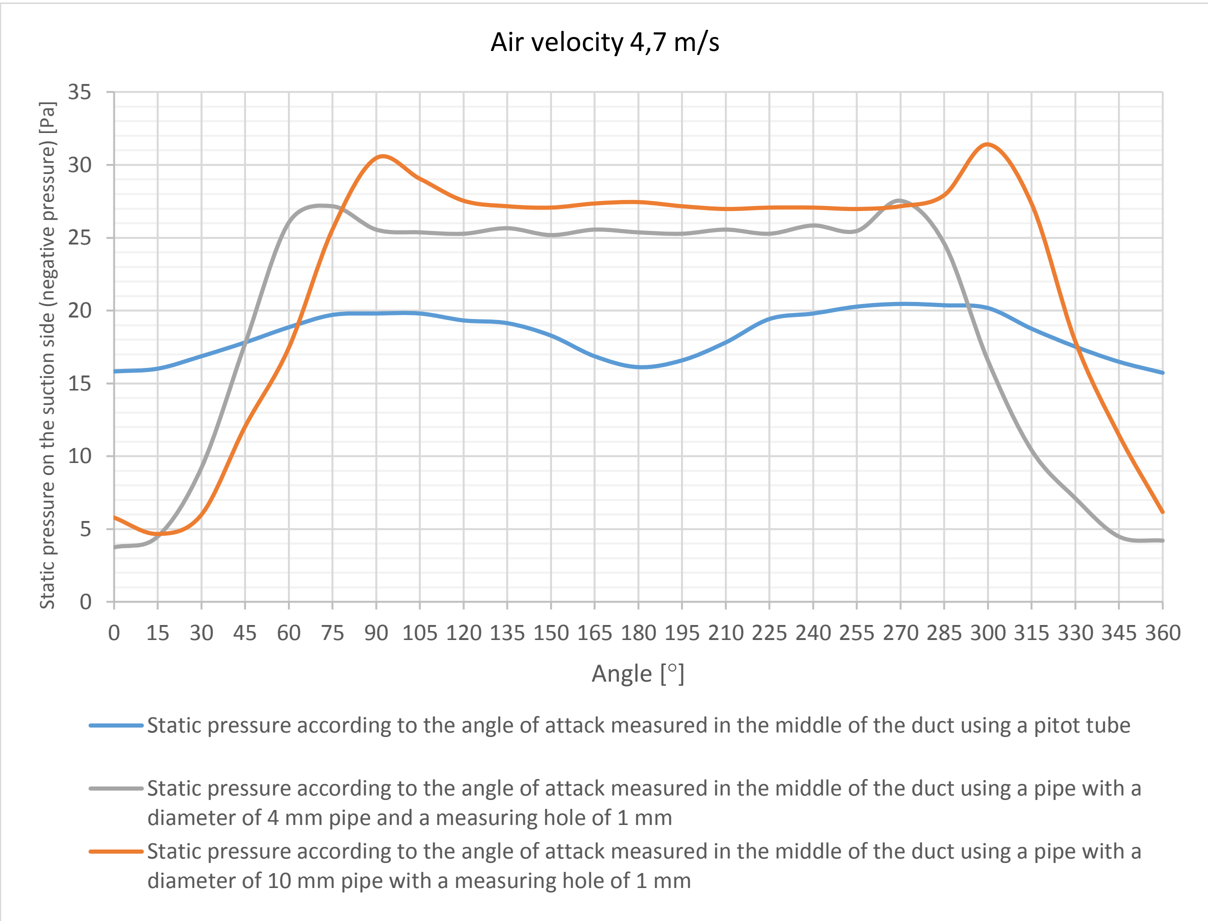
10 mm tube (pipe)

From the measurements, it can be seen that the angle of attack has a significant influence on the static pressure. Assuming that the pitot tube measures the correct static pressure at 0° angle of attack, it can be concluded that the pipes are not suitable for measurements of static pressure.

The measurements indicate that pipes are not suitable for measurements of static pressure even with a ring line, cross or parallel tubes with multiple holes. This is because the measured pressure with the pipe is not representable for the exact static pressure.

This is probably because a negative pressure (suction) occurs across the hole when the air is directed from the opposite side of the hole (in these experiments 180°). Fluctuations downstream the hole affect the measured static pressure and a higher pressure than the actual pressure is therefore detected. In a negative pressure duct/chamber, the absolute measured negative pressure will be higher and in a positive duct/chamber it will be lower.


Air velocity 2,5 m/s
Static pressure on the suction side (negative pressure) [Pa]
12
10
8
6
4
2
0
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360
Angle [°]
Static pressure according to the angle of attack measured in the middle of the duct using a pitot tube
Static pressure according to the angle of attack measured in the middle of the duct using a pipe with a diameter of 4 mm pipe and a measuring hole of 1 mm
Static pressure according to the angle of attack measured in the middle of the duct using a pipe with a diameter of 10 mm pipe with a measuring hole of 1 mm


Air velocity 4,7 m/s
Static pressure on the suction side (negative pressure) [Pa]
35
30
25
20
15
10
5
0
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360
Angle [°]
Static pressure according to the angle of attack measured in the middle of the duct using a pitot tube
Static pressure according to the angle of attack measured in the middle of the duct using a pipe with a diameter of 4 mm pipe and a measuring hole of 1 mm
Static pressure according to the angle of attack measured in the middle of the duct using a pipe with a diameter of 10 mm pipe with a measuring hole of 1 mm

Recommendation:
The best result was obtained with a very simple solution by using one or more pressure relief box (electrical membrane box) with holes on the back.

When measuring inside the unit, we recommend using a pressure relief box (electrical membrane box) under the following conditions:

- placed on a fluidically quiet location;
- at a distance from stagnation regions;
- located on a plane surface;
- prepare with only one hole in the bottom of the box (centre);
- the back of the box of must be equipped with spacers (distance buds) that ensure a distance between the box and the casing of approximately 1-2 mm; and
- the fan must not blow directly on the box, and if the fan blows along a surface, for example, at the bottom of the unit, the box cannot be placed at this surface.

Pressure measurements inside the unit should not be conducted at face velocities above 3m/s according to the experiences of ECC and DTI. However, there must be great awareness of local reduction of the cross sectional area that can increase the local velocity significantly and lead to incorrect measurement, although the face velocity based on the free area in the unit is respected.

8. Ventilation components data

It is not a part of the standard/transitional methods to deal with the calculation of a whole unit according to measurements of single components, but this can be a challenging task.

Here the manufacturer does not know:

I. Pressure drop caused by integration of the fan, which is expressed in the 'internal efficiency of the fan'.

Manufacturer may know by experience (when they are a part of a scheme, have a product selection programme, etc.):

II. Pressure drop caused by integration of the individual components, which can be considered as the 'casing system pressure loss'

The value 'I' can be calculated approximately by the loss of dynamic pressure regarding to radial fans. This is, however, not the same for plug/box free blowing fans and axial fans. Nevertheless, a correction can be made in some way. However, in many cases the influence of asymmetric inlet to the fan cannot be calculated.

It is the DTI's laboratory experience that there are often up to 20% difference between the manufacturer's specified pressure drop over components (single component data from production selection/designing program) and the values measured at the laboratory inside the unit (reference), which is why it is very important that manufacturers take this seriously.

Annex 1 Draft calculation and measurement of SFP_{int}

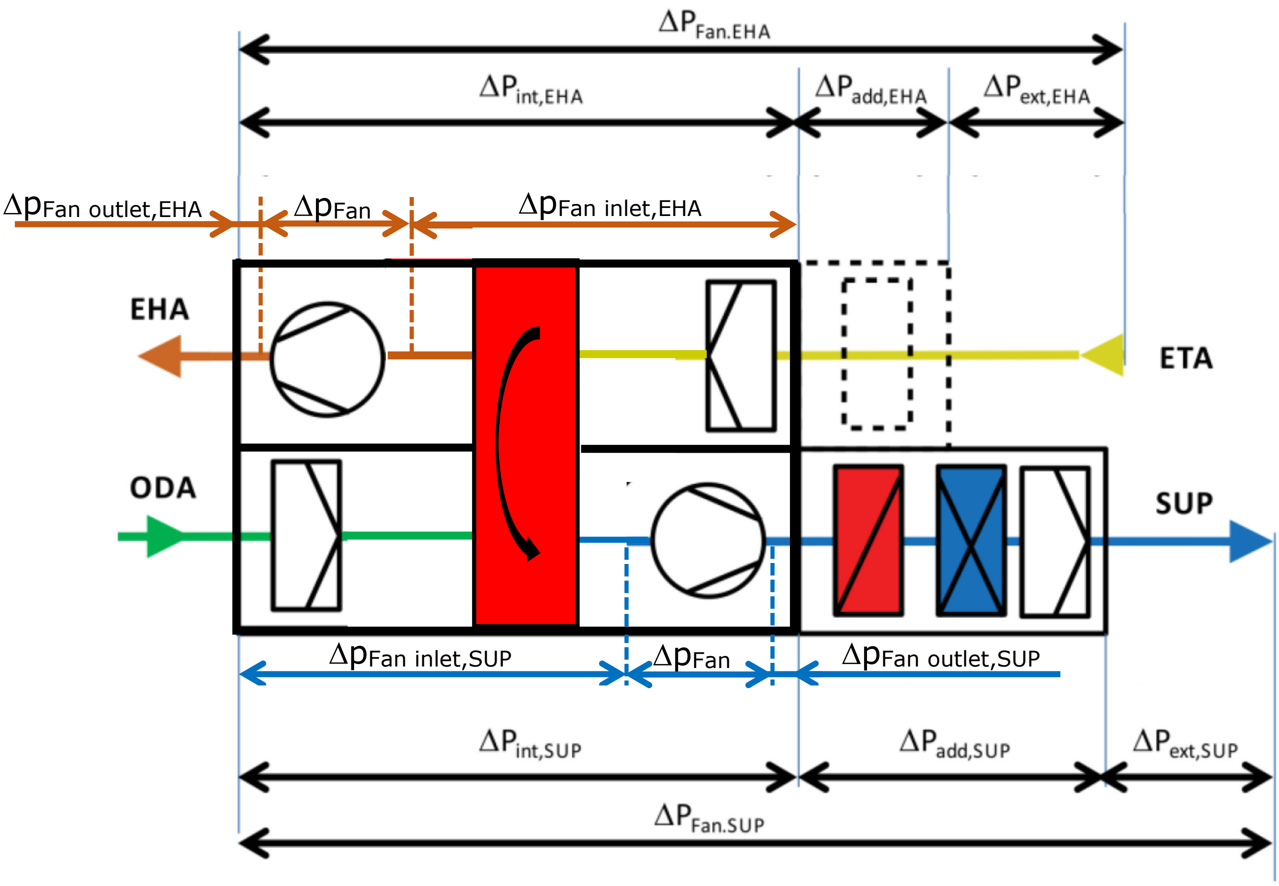
To be adopted in draft transitional methods document

Based on the background analysis as described in the "Explanatory note on internal Specific Fan Power, SFP_{int} and draft transitional methods" this Annex proposes that the following methods are used to determine SFP_{int}.

A1.1 Terminology related SFP_{int} values

For consensus between standards and regulations, symbols and subscripts from prEN 16798-3 has been adopted for the cases where no such are described in Regulations 1253/2014 and 1254/2014. Where there is inconsistency between symbols used in the standard and the regulations, the regulations symbols are used. Reference is to prEN 16798-3 as the revision of this standard is advanced and that RVU and NRVU relevant standards under revision might therefore adopt the prEN 16798-3 symbols and subscripts.

The figure below is a sketch of a bidirectional ventilation unit (BVU) from prEN 16798-3, with minor modifications for illustrative reasons (Heat recovery system (HRS) is changed from cross to rotating heat exchanger). Components are placed randomly and can be placed in different order. The figure applies to both BVU and unidirectional ventilation units (UVU). For UVU is only one of the sides considered, either the exhaust air side (EHA) or the supply air side (SUP).



Symbols and subscripts are described in in the following

Symbols

Acc. to prEN 16798-3		Acc. to regulation	
$\Delta p_{int\ tot}$	*is total internal pressure rise from the ventilation components (fan casing, heat recovery, and filters) in Pa*	*None*	*None*
$\Delta p_{add\ tot}$	*is total additional pressure rise from the additional components (cooler, heat exchanger, humidifier, silencer, etc.) in Pa*	*None*	*None*
$\Delta p_{ext\ tot}$	*is total external pressure rise from the ductwork and external components in Pa*	*None*	*None*
$\Delta p_{int\ stat}$	*is 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.*
$\Delta p_{add\ stat}$	*is 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 (Δps,int);*
$\Delta p_{ext\ stat}$	*is static external pressure rise from the ductwork and external components in Pa*	$\Delta p_{s,\ ext}$	*nominal external pressure ($\Delta p_{s,\ ext}$)' in (expressed in Pa) means the declared design external static pressure difference at nominal flow rate.*
η_{tot}	*is $\eta_{fan\ tot}$ x η_{tr} x ηm x ηc based on total pressure*	*None*	*None*
η_{stat}	*is ηfan stat x ηtr x ηm x ηc based on static pressure*	*None*	*None*
$P_{sfp,int}$	*is the 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}	*'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 air flow and nominal external pressure drop;*
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 air flow 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

Acc. to prEN 16798-3		*Acc. to regulation*	
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*

Other specifications		*Acc. to regulation*	
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****	*Supply air side. 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****	*Exhaust air side. 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*

Acc. to ISO 5801		*Acc. to regulation*	
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*

**Outdoor is in the regulation used as both outdoor-side and outdoor air.*

***Indoor is in the regulation used as both indoor-side and indoor air.*

******* *It should be considered to use the specification "SUP-SIDE" 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) and not only the terminal as it can be misunderstood.*

A1.2. 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. For further information se "Explanatory note on internal Specific Fan Power, SFP_{int} and draft transitional methods"

A1.2.1 Definition of SFP_{int}

Unidirectional ventilation unit (UVU):

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

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:

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

A1.2.2 Applicable test methods

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

1. VU where internal pressure measurements can be performed (recommended with local face velocity's in the measuring section for internal pressure drop below 3 m/s)
2. VU where internal pressure measurements cannot be performed (can be used with both low and high local face velocity's)

A1.2.3 SFP_{int} determination for VU where internal pressure measurements can be performed

Unidirectional ventilation unit (UVU):

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

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:

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

Pressure drop of ventilation components is inserted with numerical values for Δp. All values is calculated for SUP or EHA for UVU's depending on whether it is a SUP or EHA fan unit and calculated values for SUP and EHA for BVU's.

$$\Delta p_{s,int} = \Delta p_{fan\ inlet} + \Delta p_{fan\ outlet}$$

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

$$\Delta p_{s,int} = \Delta p_{fan\ inlet} + \Delta p_{fan\ outlet} - \Delta p_{s,add}$$

Where the fan efficiency is determined as:

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

Further description

To measure pressure inside the unit it is recommended to use pressure relief box (electrical membrane box – for further information see "Explanatory note on internal Specific Fan Power, SFP_{int} and draft transitional methods") under the following conditions:

- Placed on a fluidically quiet location.
- At a distance from stagnation regions
- Located on a plane surface
- Prepare with only one hole in the bottom of the box (center)
- The backside of the box of must be equipped with spacers (distance buds) that secure a distance between the box and the casing of approximately 1-2 mm.
- The fan must not blown directly on the box and if the fan blows along a surface, for example, in the bottom of the unit, the box cannot be placed at this surface.

Pressure measured external acc. to ISO 5801

$\Delta p_{s,int}$	***$\Delta p_{s,int}$*** *is the internal pressure drop of ventilation components (Δps,int) (expressed in Pa)* means the sum of the static pressure drops in a reference configuration of a BVU or an UVU at nominal flow rate. **Reference configuration of a BVU** means a product configured with a casing, at least two fans with variable speed or multi-speed drives, a HRS, a clean fine filter on the inlet-side and a clean medium filter on the exhaust-side **Reference configuration of an UVU** means a product configured with a casing and at least one fan with variable speed or multi-speed drive, and — in case the product is intended to be equipped with a filter on the inlet-side — this filter must be a clean fine filter The NRVU inlet and outlet losses must be included in the 'the internal pressure drop of ventilation components ($\Delta p_{s,int}$). If a ducted air-handling unit has full size openings (the internal cross section of the duct systems is equal to the cross section of the NRVU), it mostly experiences no additional pressure losses at the inlet and outlet opening.
$\Delta p_{s,add}$	*'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 (Δps,int);
Δpf_{an}	*The static pressure difference between the fan outlet and inlet section.*
η_{fan}	*The fan efficiency η_{fan}* is the 'overall static efficiency drive' at nominal airflow and nominal external pressure drop to be measured at the fan section, in %, according to ISO 12759 but for the fan when it is placed in intended casing i.e. considering system effects. It is 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** (and internal pressure drop). It is the ratio between the nominal airflow multiplied with the static pressure rise of the fan (equal to the sum of pressure drops of all ventilations components, clean and dry, and the nominal external pressure) divided by the electrical power of the fan drive. Placement of a fan in a casing will affect both the fan pressure rise (less pressure rise due to system losses) and the power consumption. The fan efficiency is to be measured/calculated with in the BVU and with the external (and internal) pressure loss at nominal airflow (defined by the manufacturer) according to the definition of SFP even though the calculation of SFP_{int} only uses the internal pressure drop. For BVU calculated for both airstreams respectively, the supply air stream (SUP) and the extract air stream (ETA) for determination of SFP_{int}. For UVU calculated for one airstream. For measurement see the containing parameters of the formula

p_{sf}	*Fan static pressure* means the fan total pressure (p f) minus the fan dynamic pressure at nominal airflow for one airstream in respect to the face area.
$\Delta_{ps, ext}$	*Nominal external pressure* (expressed in Pa) means the declared design external static pressure difference at nominal flow rate; To be measured in connected ducts so the consumers receive consistent values of pressure and flow. The nominal external pressure is the static pressure difference between inlet and outlet, for BVU both airflows. The test is overall described in EN 13141-7 (6.2.2) which describes that the test shall be conducted in all 4 ducts. EN 13141-7 refers to EN 13141-4 (5.2.2), where the installation of the ducts is defined. But how the pressure is measured in the duct (measurement ducts) and the permissible deviation is not described. This shall be designed and tested according ISO 5801. To which connection the pressure is delivered is only described in EN 13053. For ducted VU to be distributed with 50 Pa on the outside (12 21). For no-ducted with 100% on the building side.
q_{nom}	*Nominal flow rate* (expressed in m³/s) means the declared design flow rate of an NRVU at standard air conditions 20 °C and 101325 Pa. The nominal airflow and pressure must be seen as the maximum airflow of the NRVU in the sale of which the NRVU can fulfil the requirements according to the definitions in the regulation. For BVU test the airflow shall be balanced mass airflow within 3% (acc. to experience with EN 13141-7 cap. 6.3 thermal testing). The value for q_{nom} used to calculate the n_{fan} for BVU's is the current in respect to the air flow side (SUP/ETA) and not value is the sum of both supply and extract airflow divided by 2. The declared information value for q_{nom} is the sum of both supply and extract airflow divided by 2. Can measured according to EN 13141-4,5,6,7,8,11 regarding type of unit and ISO 5801. Also EN 13053 and ISO 5801.
P	*'Nominal electric power input (P)*' (expressed in W and not as stated in the regulation in kW as SFP_{int} is W/m3/s) means the effective electric power input of the fan drive, including any motor control equipment, at the nominal external pressure and the nominal airflow; Can be measured according to EN 13141-4,5,6,7,8,11 regarding type of unit and ISO 5801. EN 13053 insufficiently described in this area.

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 approximately equal to an air density of 1,2 kg/m³.

A1.2.4 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:

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

Numerical values of Δp are inserted.

All values is calculated for SUP or EHA for UVU's depending on whether it is a SUP or EHA fan unit and calculated values for SUP and EHA for BVU's.

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

Where

Δp_{fan}	means the static pressure difference of the fan measured outside the unit according to the fan regulation, not in best efficiency point (BEP), but corresponding to the nominal flow and rpm regarding the unit regulation (according to the measurements conducted on the unit).
$\Delta p_{s,ext}$	means the static nominal external pressure drop as described under A1.2.3 measured at the terminals at the unit.
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 air flow and nominal external and internal pressure drop (and corresponding revolutions of the fan installed inside the unit) measured outside the unit according to the fan regulation. The static efficiency is the ratio between the nominal air flow multiplied with 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 corresponding Δp_{Fan} measured outside the unit according to the fan regulation

If the unit is equipped with control equipment (inverter, etc.) η_{fan} shall 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.

For the measurement and calculation of SFPint 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 approximately equal to an air density of 1,2 kg/m³.

For further information, see "Explanatory note on internal Specific Fan Power, SFP_{int} and draft transitional methods"