RLT-Guideline Certification

Audition guideline and certification program for the evaluation of the energy efficiency of air handling units
by the
Herstellerverband Raumlufttechnische Geräte e. V.
in cooperation with the TÜV SÜD Industrie Service GmbH.

Issue November 2017

For the latest version, please refer to the internet.

Adjusted to the current ErP-criteria from 01.01.2018

Including specifications from new DIN EN 13053 and 16798-3

With sample calculation for determining of P_m

Herstellerverband Raumlufttechnische Geräte e. V.
AHU Manufacturer Association

Preface

The **RLT-Guideline Certification** is an audition guideline and certification program for the evaluation of the energy efficiency of air handling units by the Herstellerverband Raumlufttechnische Geräte e. V. (RLT-Herstellerverband) in cooperation with the TÜV SÜD Industrie Service GmbH (TÜV SÜD).

The criteria for the certification programme were previously described in the **RLT Guideline 01**. The instructions for carrying out the audition by TÜV SÜD were laid down in **RLT-TÜV-01**. With the entry into force of **EU-Regulation 1253/2014** of the European Commission on 01.01.2016 additional criteria for AHUs has been imposed, that were included in the certification programme. Besides the previous criteria for energy efficiency further design criteria were included in the certification procedure for the first time which directly or indirectly affect the energy efficiency of the AHUs. All points that were relevant for the certification were collected in this new RLT Guideline in order to get more clarity. In this context, the **RLT-TÜV-01** lost its validity and the **RLT Guideline 01** was updated.

As a result of this, AHUs whose design software was tested as specified in the **RLT Guideline Certification**, comply with the raised requirements. The energy efficiency table of the RLT-Herstellerverband and TÜV SÜD stands for clear and comprehensible statements on the energy efficiency of the AHUs marked with it.

In the present, updated version of the guideline, amongst editorial changes, also important adjustments to the set of standards were considered. For example, some standards were withdrawn in the context of the introduction of **DIN EN 16798**. Also the P- and H-Classes, specified in **DIN EN 13053**, were removed as a criteria for the different energy efficiency classes according to the RLT-Herstellerverband.

The guideline will be supplemented and brought up to date to reflect advances in technology.

Other guidelines of the RLT-Herstellerverband have been published to date on the following topics relating to central air handling units:

RLT-Guideline 01: General requirements for air handling units
RLT-Guideline 02: Explosion protection requirements for air handling units
RLT-Guideline 03: EC conformity assessment of air handling units
RLT-Guideline 04: Ventilation systems with smoke extraction function. Air handling units with maintenance of function during smoke extraction mode

Bietigheim-Bissingen, November 2017

Herstellerverband Raumlufttechnische Geräte e. V.

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1. Field of application and object

This Guideline applies to non-residential ventilation units as specified in **EU-Regulation 1253/2014**, where the volume flow is more than 1,000 m^3/h at the design point.

The object of the guideline is to enable a neutral third party to confirm to the planner, plant engineer and operator of ventilation and air conditioning units that an equipment manufacturer has considered the defined energy requirements for AHUs in the design, manufacture and construction stages. The certification ensures, that both the calculation of the technical data and the basic values for the calculation correspond to the recognized rules of engineering.

Certifications according to **RLT Guideline Certification**, issue November 2017 apply from the issue date from TÜV SÜD, but not earlier than 01.01.2018. The relevant date is shown on the certificate. Existing certificates based on **RLT Guideline Certification**, issue August 2015/a from 18.12.2015 forfeit their validity at the 31.03.2018 at the latest. In order to that, the right to mark the air handling units with the energy efficiency label according to the RLT-Herstellerverband, ends at that point. If a label should be marked after that, a new certification according to the present guideline is mandatory.

2. Regulations, standards and guidelines

During the preparation of this RLT Guideline the following regulations, standards and guidelines were taken into account:

- **Richtlinie 2009/125/EG** of the European Parliament and the Council (10/2009)
- **EU-Regulation 327/2011** of the Commission (03/2011)
- **EU-Regulation 1253/2014** of the Commission (07/2014)

- **DIN 24166** Fans - technical delivery conditions (01/1989)
- **DIN EN 308** Heat exchangers - Test procedures for establishing performance of heat recovery devices (05/1997)
- **DIN EN 1886** Mechanical properties and test methods (07/2009)
- **DIN EN 13053** Rating and performance data (Design, 03/2017)
- **DIN EN 16798-3** Ventilation of non-residential buildings - Performance requirements (11/2017)
- **DIN EN 60034-1** Rotating electrical machines - Rating and performance (Design, 02/2015)
- **DIN EN ISO 5801** Fans - Performance testing using standardized airways (12/2014)
- **VDI 6014** Energy conservation by application of variable speed drives (VSD) in building services (12/2016)
- **VDI 3803 Blatt 1** Structural and technical principles (02/2010)
- **VDI 3803 Blatt 5** Heat recovery systems in AHUs (04/2013)
- **RLT-Guideline 01** General requirements for air handling units (09/2016)

3. Energy efficiency

The air speed within an AHU, the electric power requirement of the fan (depending on the pressure increase and airflow), and performance of the heat recovery (compared with the pressure loss and heat recovery figure), have a considerable effect on the energy efficiency of an AHU.

The efficiency classes for AHUs connect the speed, power consumption and heat recovery classes to a simple, comprehensible and verifiable characteristic. This gives the planner, plant builder and operator the certainty, to plan, construct and operate energetically designed devices.

In addition, further criteria are integrated into the certification process which have an effect on the energy efficiency of the AHUs. The most important of these are the design details which can already be seen in the technical data and drawings. In general it is these criteria which are difficult to change in fitted AHUs.

Criteria not concerning energy efficiency but other, further aspects like relevant to hygiene or security issues, are not part of this guideline. They are dealt with in the **RLT-Guidelines 01 to 04**.

4. Certification

The AHU design software is tested by a neutral organisation (TÜV SÜD) for the certification. The basis of the certification for the classification of the energy efficiency class is an audit by the TÜV SÜD to see that all requirements from the RLT Guideline Certification are met. The presentation of a certificate for the audit of the AHU design software from another certifying organisation is not sufficient to be able to issue a certificate (RLT Herstellerverband - TÜV SÜD) regarding the energy efficiency without further testing.

If the manufacturer's design programme fulfils all conditions, TÜV SÜD issues a certificate. The certification is done as specified in the certification procedure of TÜV SÜD. The manufacturer must guarantee, as part of his quality assurance system, that the requirements for marking the device according to its energy efficiency class are observed.

TÜV SÜD does the testing of the AHU design software every two years as part of the production facilities inspection carried out. If there are special reasons TÜV SÜD can also issue the certification with a shorter validity period, e.g. if a significant change in the **RLT Guideline Certification** is planned during the period of validity. The members can complain to the board about the shortening, which will then decide on the final maturity.

Modifications, which may affect the energy efficiency classes shall be communicated to TÜV SÜD by the manufacturer, which shall decide whether an additional test is necessary.

In the context of certification also the facility is inspected. Here the TÜV Süd examine, regarding to the criteria of this regulation, if the production of the air handling unit is done by the company independently. Only may be marked with the energy efficiency label, which been made in the facility inspected and mentioned in the certificate.

5. Marking and requirements

The manufacturer is entitled the mark the compliance with the energy efficiency classes A+, A or B, under the following circumstances:

- AHU meets all relevant criteria of this guideline
- Energy efficiency class A+, A or B is achieved
- AHU design software is tested by TÜV SÜD
- Valid certification contract with TÜV SÜD

In this case, the AHU, and the associated technical documentation can be marked with the energy efficiency class determined with the AHU design software. The labels used for this are shown below.

Combined units are only provided with one energy efficiency label (the least favourable). A separate marking for the intake and exhaust air side is not possible. The marking of a unit without fans is not possible. The marking of a unit with an empty part for the subsequent installation of a heat recovery system not designed with the AHU design software is not possible.

To achieve the energy label A+, A or B, all criterias oft he respective energy efficiency class must be fulfilled. A compensation between the criteria is not possible.

According to **EU-Regulation 1253/2014** the requirements of class A+ are mandatory **from 01.01.2018**, requirements of class A **from 01.01.2016**. Air handling units reaching class B or worse, are only allowed to be installed outside the European Union.

6. Criteria

No.	Basic assumptions	A+	A	B
1-1	Entitlement to participate in the TÜV SÜD certification programme	The company is a member of the RLT-Herstellerverband		
1-2	Volume flow at the design point of the supply air or the extract air, if no intake air is available	≥ 1,000 m^3/h		
1-3	Information of the energy efficiency class of the RLT-Herstellerverband in accordance with this guideline	Each individual criterion of a class is observed		
1-4	Insepction of the facility	The production of the AHU is done in the inspected facility by the member company independently		

No.	Energy requirements	A+	A	B
2-1	Speed classes for units - without thermodynamic air handling - with air heating - with additional functions (*)	 V5 V4 V2	 V6 V5 V3	 V7 V6 V5

No.	Requirements from European regulations	A+	A	B
3-1	Temperature transmission degree η_t of the HRU - Circuit compound system - Rotor/plate heat exchanger/other	 0.68 0.73	 0.63 0.67	No requirement
3-2	Minimum system efficiency with UVU - $P_m \leq 30$ kW - $P_m \leq 30$ kW	 6.2% × $\ln(P_m)$ + 42.0% 63.1%	 6.2% × $\ln(P_m)$ + 35.0% 56.1%	No requirement
3-3	Maximum permissible **SFP_{int}** in $W/(m^3/s)$ for BVU **$q_{nom} < 2\ m^3/s$** - Circuit compound system - Rotor/plate heat exchanger/other for BVU **$q_{nom} \geq 2\ m^3/s$** - Circuit compound system - Rotor/plate heat exchanger/other for UVU - All units **Efficiency bonus E** in $[W/(m^3/s)]$ with - Circuit compound system - Rotor/plate heat exchanger/other (With negative results from the formula E = 0) **Correction factor F** in $[W/(m^3/s)]$ - if M5- and F7-filters are installed - with missing filter or filter < M5 - with missing filter or filter < F7 - with missing 2 filter stages or filter < M5 and < F7	 $1{,}600+E-(300\times q_{nom}/2)-F$ $1{,}100+E-(300\times q_{nom}/2)-F$ 1,300 + E - F 800 + E - F 230 $E = (\eta_t - 0.68) \times 3{,}000$ $E = (\eta_t - 0.73) \times 3{,}000$ F = 0 F = 150 F = 190 F = 340	 $1{,}700+E-(300\times q_{nom}/2)-F$ $1{,}200+E-(300\times q_{nom}/2)-F$ 1,400 + E - F 900 + E - F 250 $E = (\eta_t - 0.63) \times 3{,}000$ $E = (\eta_t - 0.67) \times 3{,}000$ F = 0 F = 160 F = 200 F = 360	No requirement
3-4	Filter with optical differential pressure indicator or acoustic warning device in the control system.	Obligation, if a filter belongs to configuration	No requirement	No requirement
3-5	Regulation device	Controlled drive		No requirement
3-6	Heat recovery system (HRS)	All BVU have a HRS with thermal by pass		BVU has a HRS

(*) Units with additional functions are units, which have thermodynamic functions like air humidification, air dehumidification, air cooling etc., which are not exclusively air heating. In addition, the use of a heat recovery system leads to such a classification.

No.	Requirements for unit design	A+	A	B
4-1	Type of fan used	Fan software (manufacturer, type, size) authorised by TÜV SÜD.		
4-2	Heat recovery unit used	HRU software, (manufacturer, type, size) authorised by TÜV SÜD.		
4-3	Values given in the technical data sheet	a) Energy efficiency class A+, A or B b) V-class complied with c) Name of the manufacturer, internet address, model recognition d) Type in accordance with EU regulation (NRVU, UVU or BVU) e) Type of drive installed or to be installed f) Type of the heat recovery system (CCS, other or none) g) Temperature efficiency of the HRU η_t (in %) at validation conditions as specified in **EN 308** as well as with design conditions h) Nominal air volume flow (in m³/s) and ext. pressure increase (in Pa) i) Heating and cooling performance with temperatures j) Effective rating P_m (electrical load taken) and $P_{m,ref}$ (in kW) k) SFP_{int} (in W/(m³/s)),SFP_V and SFP_V-class l) Flow speed (in m/s) in the clear internal housing cross section m) Differential pressures of the individual components (internal and additional) n) Differential pressure of the components of the reference configuration $dp_{s,int}$ o) Static efficiency of the fans in the efficiency optimum and in the installed condition at the design point p) Maximum allowed fan speed q) Maximum external air leakage rate of the housing r) Maximum internal air leakage rate of the BVU or transfer rate of a regenerative heat exchanger (e.g. rotary heat exchanger) s) Energy properties of the filter t) Description of the optical filter warning display u) Details of the recommended filter pressure v) Sound power radiated from housing w) Channel sound power for suction- and exhaust -L_{WA} (A-weighted as sum level over complete octave band; weighted in the octave band from 63 Hz to 8 kHz)		

7. Testing

Using the following test procedure specified by the RLT-Herstellerverband, the TÜV SÜD audit that the requirements of the energy efficient classes for AHU are complied with. In this way the manufacturer's design software is audited, which covers the complete series to be marked.

In the inspection of the production facilities, the TÜV SÜD carries out a plausibility check of whether the manufacturer is able to manufacture AHUs as specified in **RLT Guideline 01**. This includes the compliance with the model box classes, hygienic aspects of the sealing materials, minimum distances for components, accessibility of the components, etc.).

The test essentially consists of the plausibility testing of the calculation algorithms in the design software, as well as the compliance of the design criteria in the technical data sheets. The test is done using several unit designs. Alternatively individual points can be audited by the publication of the source codes of the design programme.

The audit of the AHU design software contains the following tests. The design is preferably based on an air density of 1.2 kg/$m^{3.}$ In a design with different air density this must be pointed out clearly.

7.1 Checking the validity range

No.	Basic assumptions	A+	A	B
1-1	Entitlement to participate in the TÜV SÜD certification program	The company is a member of the RLT-Herstellerverband.		

Before each test the TÜV SÜD consult the secretariat of the RLT-Herstellerverband to confirm that the company to be audited is currently a member of the above mentioned association.

No.	Basic assumptions	A+	A	B
1-2	Volume flow at the design point of the supply air or the extract air, if no supply air is available	≥ 1,000 m^3/h		

TÜV SÜD audits based on the technical data the validity range for a volume flow ≥ 1,000 m^3/h. Units under this limit may not receive a label.

No.	Basic assumptions	A+	A	B
1-3	Information of the energy efficiency class of the RLT-Herstellerverband in accordance with this guideline	Each individual criteria of a class is complied with.		

Plausibility testing, whether all the necessary criteria for specifying the energy efficiency classes are complied with and the correct energy efficiency class of the AHU design software is given. A marking of partial criteria with energy efficiency classes is not permissible.

The basis for the certification and classification of the energy efficiency class by TÜV SÜD is the audit of the compliance of all the assumptions contained in the regulations 'RLT Guideline Certification'.

Nr.	Grundlegende Voraussetzungen	A+	A	B
1-4	Insepction of the facility	The production of the AHU is done in the inspected facility by the member company independently		

The inspection by TÜV SÜD on the site is done on each estate. TÜV SÜD carries out the assessment of multiple halls or facilities as one or more estates. A estate is a facility according to this guideline, of all following points are fulfilled:

- The member company is clearly evident by its name or company logo outside the estate or at the entrance
- A PC-workplace is present, where the certified AHU-design software is installed and used
- A workplace is present, where parts lists/single-item lists for the AHU are created
- The components (fan, heat exchanger and filter) are available unmounted for the final assembly
- Parts of the housing (panels, doors, cooler tub, fan partition) are available unmounted for the final assembly
- Small parts (door handles, hinges, seals etc.) are available unmounted for the final assembly
- A production workplace is present, where the assembly of housing parts and components to modules is carried out
- The signage of the module is equal to the name of the member company

7.2 Checking the energy requirements

No.	Energy requirements	A+	A	B
2-1	Speed classes for units - Without thermodynamic air handling - With air heating - With additional functions	 V5 V4 V2	 V6 V5 V3	 V7 V6 V5

TÜV SÜD audit based on the technical data, the flow velocity in the clear internal housing cross section in the filter unit, or in the fan unit, if no filter is available.

$$w = \frac{\dot{V}}{A}$$

With

- w Flow velocity in [m/s]
- $\dot{V}$ Volume flow in [m³/s]
- A Clear internal housing cross section in [m²]

With compact units the flow velocity is determined from the sum of the supply- and extract volume flows, divided by the total clear internal housing cross section. Walls in this context are the exterior panels as well as the partition wall.

$$w_{compact} = \frac{\dot{V}_{supply} + \dot{V}_{extract}}{\left(h_a - \sum d_{wall,h}\right) \times \left(b_a - \sum d_{wall,v}\right)}$$

With

- $W_{compact}$ Flow velocity for compact devices in [m/s]
- $\dot{V}$ Volume flow for supply- and extract air in [m³/s]
- h_a External height in [m]
- b_a External width in [m]
- $\sum d_{wall,h}$ Sum of all wall thicknesses of horizontal running walls and partition walls in [m]
- $\sum d_{wall,v}$ Sum of all wall thicknesses of vertically running walls and partition walls in [m]

An airspeed class results from the flow velocity determined which is obtained from the classification from **EN 13053**.

Speed classes (**EN 13053**)

Class	Speed of the air inside the device [m/s]
V1	≤ 1.6
V2	> 1.6 to 1.8
V3	> 1.8 to 2.0
V4	> 2.0 to 2.2
V5	> 2.2 to 2.5
V6	> 2.5 to 2.8
V7	> 2.8

7.3 Checking the requirements of European regulations

It should be noted, that for the requirements of **EU-Regulation 1253/2014** the text of the English original version should be used since there are some inaccuracies in the German translation.

All required minimum values shall be observed as specified in the mathematical rounding rules.

No.	Requirements from European regulations	A+	A	B
3-1	Temperature transmission degree ηt of the HRU - Circuit compound system - Rotor/plate heat exchanger/other	 0.68 0.73	 0.63 0.67	No requirement

TÜV SÜD audits the observance of the minimum temperature transmission degree of the HRU. A plausibility check is carried out with the values from the AHU design software.

This values apply for equalised mass flows (1:1).

For non-equalised mass flows, the following formula must be used instead:

$$\eta_{t\ 1:1} = \eta_t \cdot \left(1 + \frac{\dot{m}_{Abluft}}{\dot{m}_{Zuluft}}\right) \cdot \frac{1}{2}$$

With

η_t	temperature transmission grade in dry conditions and non-equalised mass flows in [%]
$\eta_{t\ 1:1}$	temperature transmission grade in dry conditions and equalised mass flows in [%]
$\dot{m}_{Ablauft}$	mass flow of extract air in [m³/h]
$\dot{m}_{Zuluft}$	mass flow of supply air in [m³/h]

Informative:

Classes for heat recovery (**EN 13053**)

Class	Energy efficiency $\eta_{e\ 1:1}$ min [%]
H1	≥ 74
H2	≥ 70
H3	≥ 65
H4	≥ 60
H6	No requirements

$$\eta_e = \eta_t \times \left(1 - \frac{1}{\varepsilon}\right)$$

With

η_e	Energy efficiency = efficiency of the HRS in [%]
η_t	Temperature efficiency with dry conditions in [%]
ε	Coefficient of performance

In the calculation of the coefficient of performance the electrical auxiliary energy is also included in the system efficiency of the drive. In this connection a fixed value of 0.6 as specified in **EN 13053** should be used as the system efficiency or that of the fresh air fan at the design point.

No.	Requirements from European regulations	A+	A	B
3-2	Minimum system efficiency with UVU - Pm ≤ 30 kW - Pm > 30 kW	 6.2% × ln(Pm) + 42.0% 63.1 %	 6.2% × ln(Pm) + 35.0% 56.1 %	No requirement

TÜV SÜD audits the observance of the minimum system efficiency with a "unidirectional ventilation unit" (UVU).

Minimum system efficiency (corresponding to ‘fan efficiency’ as specified in **EU-Regulation 1253/2014**) designates the static efficiency including the efficiency of the motors and drive of individual fans in the ventilation equipment, determined at nominal air volume flow and nominal external pressure drop.

UVU as specified in the **EU-Regulation 1253/2014** is a ventilation unit which only produces an air stream in one direction, either from inside to outside (exhaust air) or from outside to inside (supply air) in which the mechanically produced air stream is equalised by natural supply- or extraction of air. UVU corresponds to the German ELA (Ein-Richtung-Lüftungsgeräte).

Reference configuration of an UVU designates as specified in the **EU-Regulation 1253/2014** a product with a housing, at least one fan with speed control or with multi-stage drive and a clean fine filter (at least F7), in case the product is fitted with a filter on the inlet side (outdoor or extract air).

The P_m-value is determined including all following surcharges.

Installation losses fans

A plausibility check of the calculation algorithms for the recording of installation losses of the fan in the design software (AHU design software) or a check whether the parameters given by the RLT-Herstellerverband for the installation losses in the AHU design program are included.

Below the parameters are given, which must be included in the design program, if the manufacturer can put no other verifiable correction values of the installation losses forward from test and measuring reports.

Definition of nominal diameter of fan blade

The influence of the exact diameter of the fan is negligible within many calculations and specifications. Here a simplification of the nominal diameter is permitted, which arise from the fan type in the datasheet.

Example:
Fan type 710 => d_{mittel} = 710 mm

If nominal diameter and mean blade diameter differ more than 5% from each other, the mean blade diameter must be used in all calculations.

Definition of average blade diameter

The average blade diameter on the support and cover disc (see **figure 1**) has to be used for more accurate calculation on the fan.

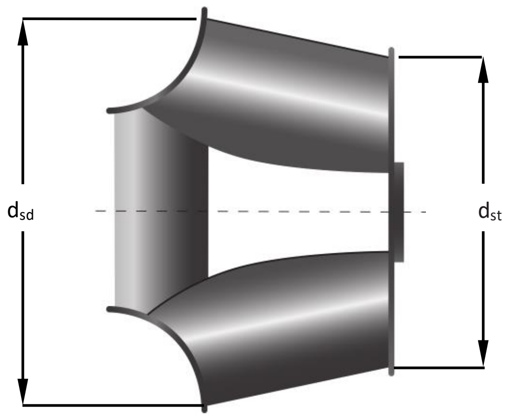

Figure 1 Display of the values for the calculation of average blade diameter

$$d_{mittel} = \frac{(d_{sd} + d_{st})}{2}$$

Where

d_{mittel} Average diameter of the blade in [mm]
d_{st} Diameter of the blade at the support disc in [mm]
d_{sd} Diameter of the blade at the cover disc in [mm]

Definition of the average distance

The average distance (a) is used for approaches on the edge distance for different types of ventilation systems. This is referencing on the nominal diameter of the fan blade and results from the average value from all edge distances to this diameter (see **figure 2**).

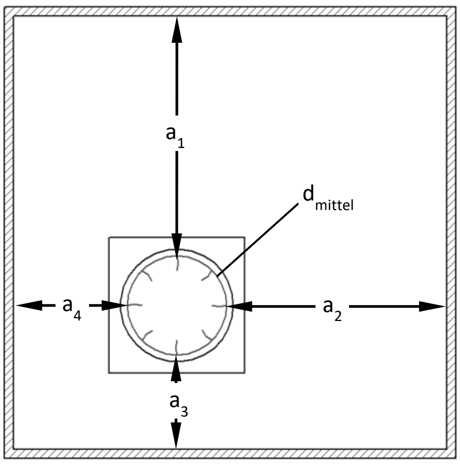

Figure 2 Display of the edge distances of the fan inside the AHU housing

$$a = \frac{a_1 + a_2 + a_3 + a_4}{4}$$

Where

a	Average distance to the nearest mounting part or wall in [mm]
a_{1-4}	Separate distance to the nearest mounting part or wall in [mm]

Definition of the dynamic fan pressure

The dynamic fan pressure (Δp_{dyn}) has to be defined on downstream side in general.

a) Directly driven free running fans

The dynamic fan pressure refer to the shell surface of the truncated cone, which is spanned by the connection of the diameters from the blade trailing edge on cover and support disc (d_{sd} and d_{st}, see **figure 1**).

Suction situation:

Normal suction (at $a < 0.5 \times d_{nenn}$) => not permissible
Normal suction (at $a \geq 0.5 \times d_{nenn}$) => no effect
Suction protection => $k_1 = 0.5 \times \Delta p_{dyn}$

Blow out situation:

$a \geq 0.6 \times d_{nenn}$ => $k_2 = 0.1 \times \Delta p_{dyn}$
$a \geq 0.3 \times d_{nenn}$ => $k_2 = \left(-6{,}8 \cdot \left(\frac{a}{d_{nenn}}\right)^3 + 16{,}9 \cdot \left(\frac{a}{d_{nenn}}\right)^2 - 13{,}9 \cdot \left(\frac{a}{d_{nenn}}\right) + 3{,}82\right) \cdot \Delta p_{dyn}$
$a < 0.3 \times d_{nenn}$ => not permissible

Installation losses = $k_1 + k_2$

b) Belt driven spiral housing fan

Suction situation:

$a \geq 0.5 \times d_{nenn}$ => $k_3 = 0.5 \times \Delta p_{dyn}$
$a \geq 0.4 \times d_{nenn}$ => $k_3 = 0.6 \times \Delta p_{dyn}$
$a \geq 0.3 \times d_{nenn}$ => $k_3 = 0.8 \times \Delta p_{dyn}$
$a \geq 0.2 \times d_{nenn}$ => $k_3 = 1.2 \times \Delta p_{dyn}$
$a < 0.2 \times d_{nenn}$ => not permissible

Suction protection => $k_4 = 0.3 \times \Delta p_{dyn}$
Belt protection 3 side closed => $k_5 = 0.4 \times \Delta p_{dyn}$
Belt protection 4 side closed => $k_5 = 0.6 \times \Delta p_{dyn}$

Blow out situation:

Blow out in chamber with baffle plate => $k_6 = 1.0 \times \Delta p_{dyn}$
Blow out in chamber => $k_6 = 0.5 \times \Delta p_{dyn}$
Blow out in channel => $k_6 = 0.0 \times \Delta p_{dyn}$

Installation losses = $k_3 + k_4 + k_5 + k_6$

c) Axial fans

Inlet nozzles are obligatory, when axial fans are installed.

Suction situation:

Normal suction (at $a \geq 0.5 \times d_{nenn}$) => no effect
Suction $a < 0{,}5 \times d_{nenn}$ => not permissible

Suction protection: => $k_7 = 0.5 \times \Delta p_{dyn}$

Blow out situation:

Blow out in chamber without or with diffuser (with $L_{Diffusor} < 4 \times d_{nenn}$) => $k_8 = 0.5 \times \Delta p_{dyn}$
Blow out in chamber with diffuser (with $L_{Diffusor} \geq 4 \times d_{nenn}$) => $k_8 = 0.3 \times \Delta p_{dyn}$
Blow out in channel => $k_8 = 0$

Installation losses = $k_7 + k_8$

d) Fan walls

An even as possible design of the free cross section for fan walls is recommended (see **figure 3**).

Following points should be mentioned hereby:

Only the same size of fans with equal rotational speed are installed (fans with same type and performance)
Distances to the wall, ground and roof: Minimal distance for a is not to be undercut
Distances between the fans of 2× a is not to be undercut
The mounting pressure lost are calculated by the assigned k_2 - values (related to the corresponding a- value)
For the calculation of the unit, the amount of air, as well as the absorption of electricity and performance of the single fans are added up
Furthermore the laws from the parallel connection of fans (pressure increase and mounting pressure losses) apply

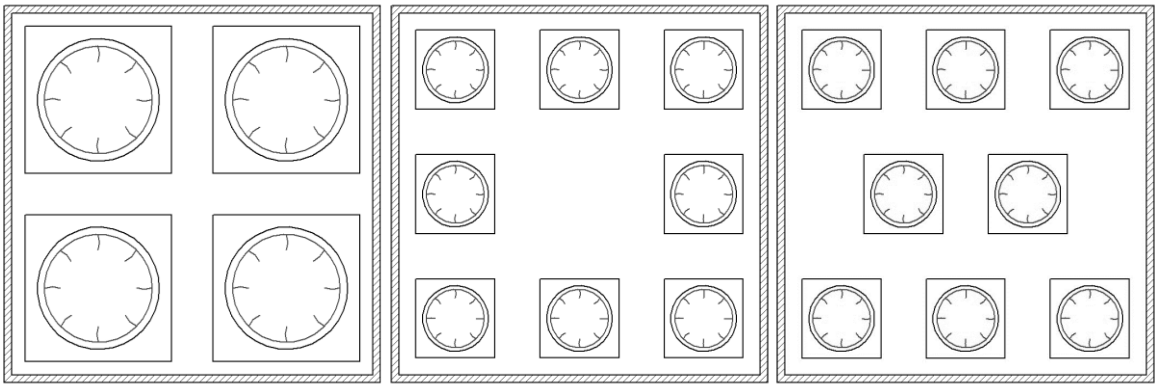

Figure 3 Examples for horizontal and vertical symmetric design of the cross-sectional area of the AHU at fan walls

Suction situation:

Suction $a < 0,5 \times d_{nenn}$	=> not permissible
Normal suction (at $a \geq 0.5 \times d_{nenn}$)	=> no effect
Suction protection:	=> $k_1 = 0.5 \times \Delta p_{dyn}$

Blow out situation:

$a \geq 0.6 \times d_{nenn}$	=> $k_2 = 0.1 \times \Delta p_{dyn}$
$a \geq 0.2 \times d_{nenn}$	=> $k_2 = \left(-6,8 \cdot \left(\frac{a}{d_{nenn}}\right)^3 + 16,9 \cdot \left(\frac{a}{d_{nenn}}\right)^2 - 13,9 \cdot \left(\frac{a}{d_{nenn}}\right) + 3,82\right) \cdot \Delta p_{dyn}$
$a < 0.2 \times d_{nenn}$	=> not permissible

Installation losses = $k_1 + k_2$

Where

a	Average distance to the nearest mounting part or wall in [mm]
d_{nenn}	Nominal diameter of the blade in [mm]
$L_{Diffusor}$	Length of diffuser in [mm]
k	Correction value in [Pa]
Δp_{dyn}	Dynamic fan pressure in [Pa]

Static fan efficiency

A plausibility test of the given fan efficiency follows. The static fan efficiency (= system efficiency as specified in **EU-Regulation 1253/2014**) can be calculated as follows, if this cannot be verified from test reports in any other way:

$\eta_{Vent,stat} = \eta_{Laufrad,stat} \times \eta_{Motor,nenn} \times f_R \times f_A \times f_M \times f_{TL} \times 1/f_G$

a) Efficiency of the control equipment (f_R)

If the device is fitted with a frequency converter (FC) or if it is clear that the device is driven by an FC the correction factor $f_R = 0.97$ on P_m must be considered. This is also the case if the FC is not contained in the delivery scope.

b) Efficiency of the motor drive (f_A)

Correction factor f_A, if not designed with a design program of a pulley manufacturer.

Flat belts:

For shaft power ≥ 44 kW with $f_A = 0.99$
For shaft power < 44 kW with $f_A = -0.00002 \times (SP)^2 + 0.0022 \times (SP) + 0.93$

V belts:

For shaft power ≥ 60 kW with $f_A = 0.97$
For shaft power 18 > (SP) < 60 kW with $f_A = 0.0006 \times (SP) + 0.936$
For shaft power ≤ 18 kW with $f_A = 0.04 \times \ln (SP) + 0.83$

Where
f_A Efficiency of the motor drive [ohne Einheit]
(SP) Shaft power [without unit]

c) Nominal efficiency of the motor (f_M)

The nominal efficiency of the motor manufacturer $\eta_{Motor,nenn}$ as specified in **EN 60034-1** shall be put in from the manufacturer's data (catalogue information). In order to consider the manufacturer's tolerances the motor efficiency should be taken with a correction factor of $f_M = 0.98$ unless the motor is included in the power measurement and software auditions of the fan manufacturer by TÜV SÜD.

d) Part load efficiency (f_{TL})

Part load efficiency of asynchronous machines:

The efficiency in the part load area has to be calculated with the following correction factors:
In the complete load range with $f_{TL} = -0.00004 \times (LR)^2 + 0.008 \times (LR) + 0.6$

Part load efficiency of synchronous machines:

The efficiency in the part load area has to be calculated with the following correction factors:
In the load range < 50% with $f_{TL} = 0.056 \times \ln(LR) + 0.78$
In the load range ≥ 50% with $f_{TL} = 1.00$

Where
(LR) Load range in [%]

e) Accuracy class of the fan units (f_G)

The static fan efficiency must be corrected in relation to the accuracy class given by the fan manufacturer in accordance with the following additions. This correction by means of an additional factor is to mention the possible deviations of the actual value from the design values. Crucial for the correction factor f_G to be used, is the worst classification from the table below.

Division into classes of the limit deviation as specified in **DIN 24166**

Operating value	Limit deviation and class deviation			
	0	1	2	3
Volume flow	± 1 %	± 2.5 %	± 5 %	± 10 %
Pressure rise	± 1 %	± 2.5 %	± 5 %	± 10 %
Drive power	+ 2 %	+ 3 %	+ 8 %	+ 16 %
Efficiency	- 1 %	- 2 %	- 5 %	N/A

Correction factors:
Class 0 and 1 $f_G = 1.00$
Class 2 $f_G = 1.05$
Class 3 or no class $f_G = 1.13$

TÜV SÜD audit by mean of a software certification, how accurately the fan software calculates the fan. The values obtained this way gives a calculation class, which only considers the calculation accuracy from the measured values on the test bench of the given software values. Differences due to production factors within a class are not tested. These consequently form a part of tolerance differences given by the manufacturer and consequently the given accuracy class.

Division into classes of the calculation accuracy

Operating value	Limit deviation and class deviation		
	B 0	B 1	B 2
Volume flow	± 1 %	± 2.5 %	± 5 %
Pressure rise	± 1 %	± 2.5 %	± 5 %
Drive power	+ 2 %	+ 3 %	+ 8 %
Efficiency	- 1 %	- 2 %	- 5 %

The class of the calculated accuracy determined by TÜV SÜD must be better by one class than the accuracy class given by the manufacturer. Otherwise the accuracy class and therefore the correction factor f_G, must be reduced.

No.	Requirements from European regulations	A+	A	B
3-3	Maximum permissible **SFP**$_{int}$ in W/(m³/s) for BVU **q_{nom} < 2 m³/s** - Circuit compound system - Rotor/plate heat exchanger/other for BVU **q_{nom} ≥ 2 m³/s** - Circuit compound system - Rotor/plate heat exchanger/other for UVU - All units **Efficiency bonus E** in [W/(m³/s)] with - Circuit compound system - Rotor/plate heat exchanger/other (With negative results from the formula E = 0) **Correction factor F** in [W/(m³/s)] - if M5- and F7-filters are installed - with missing filter or filter < M5 - with missing filter or filter < F7 - with missing 2 filter stages or filter < M5 and < F7	 1,600+E-(300×q_{nom}/2)-F 1,100+E-(300×q_{nom}/2)-F 1,300 + E - F 800 + E - F 230 E = (η_t - 0.68) × 3,000 E = (η_t - 0.73) × 3,000 F = 0 F = 150 F = 190 F = 340	 1,700+E-(300×q_{nom}/2)-F 1,200+E-(300×q_{nom}/2)-F 1,400 + E - F 900 + E - F 250 E = (η_t - 0.63) × 3,000 E = (η_t - 0.67) × 3,000 F = 0 F = 160 F = 200 F = 360	No requirement

TÜV SÜD audits the correctness of the information of the specific fan power SFP_{int} value (= $P_{SFP,int}$). For the auditing of the SFP_{int} value, depending on what validated information is available, two different methods can be used: The audit of the ratio of the internal pressure loss to the efficiency or the audit of the ratio of the fan efficiency to the volume flow. The first is better suited for the auditing by means of the design software, the second has advantages in the auditing by measurement.

$$P_{SFP,int} = \frac{\Delta p_{tot,int}}{\eta_{tot}} = \frac{\Delta p_{stat,int}}{\eta_{stat}} = \frac{P_{m,int}}{q_V} = \frac{\Delta p_{stat,int}}{\Delta p_{stat,ges}} \times P_{SFP,ges}$$

Where

$P_{SFP,int}$	Specific fan power for reference configuration in [W/(m³/s)]
$\Delta p_{tot,int}$	Total pressure rise for reference configuration in[Pa]
η_{tot}	Total system efficiency fan motor drive based on all components of the unit
$\Delta p_{stat,int}$	Static pressure increase for reference configuration in [Pa]
η_{stat}	Static system efficiency fan motor drive based on all components in the unit
$P_{m,int}$	Electrical power input for reference configuration in [W]; details including correction factors
q_V	Nominal air volume flow in [m³/s]
$\Delta p_{stat,ges}$	Static pressure increase for the complete air stream at the design point in [Pa]
$P_{SFP,ges}$	Specific fan power for complete airline in the design point in [W/(m³/s)]

The SFP_{int}-value (specific fan power) corresponds to the SVL_{int} value (internal specific fan power) and designates as specified in **EU-Regulation 1253/2014** the ratio between the inner pressure drop of ventilation components and the fan efficiency determined for the reference configuration.

BVU (bidirectional ventilation unit) is as specified in the **EU-Regulation 1253/2014** a ventilation unit, which generates an airflow between inside and outside and is fitted with both exhaust and supply air fans. BVU (bidirectional ventilation unit) corresponds to the German ZLA (Zwei-Richtung-Lüftungsanlage).

Reference configuration of a BVU designates according to **EU-Regulation 1253/2014** a product with one housing, at least two fans with speed control or multi-stage drive, a heat recovery system, a clean fine filter (at least F7) on the entry side (outdoor air) and a clean medium fine filter (at least M5) on the outlet side (extract air).

Nominal volume flow (q_{nom}) designates the given design volume flow of a non-domestic ventilation unit with air conditions of 20°C and 101,325 Pa.

For the determination of the maximum permissible value for the SFP_{int} the average of the supply- and extract air is used as nominal volume flow in the formula. For the calculation of the actual SFP_{int}-value this is determined separately for the supply- and extract air side. The values are added and the sum must comply with the requirements of the **EU-Regulation 1253/2014**.

The P_m-value is determined inclusive of all surcharges as specified in the criterion 3-2 mentioned above.

Consideration of supply and exhaust air

For the calculation of SFP_{int} the unit is designed with the complete static pressure losses (internal, additional and external). The SFP value is determined for both airways. A calculation of the pressure losses which are necessary for the SFP_{int} is carried out in accordance with the reference configuration. The resulting internal static pressure loss for the reference configuration is separately placed in the ratio for supply- and extract air with the static total pressure of the respective airway (external, additional and internal) and multiplied with the previously determined SFP value. These two products added together give the SFP_{int} value of the unit.

$$P_{SFP,int} = \frac{\Delta p_{int,SUP}}{\Delta p_{fan,SUP}} \times P_{SFP,SUP} + \frac{\Delta p_{int,EHA}}{\Delta p_{fan,EHA}} \times P_{SFP,EHA}$$

$$P_{m,int} = \frac{\Delta p_{int,SUP}}{\Delta p_{fan,SUP}} \times P_{m,SUP} + \frac{\Delta p_{int,EHA}}{\Delta p_{fan,EHA}} \times P_{m,EHA}$$

Where

$P_{SFP,int}$	Specific fan power for reference configuration in [W/(m³/s)]
$\Delta p_{int,SUP}$	Internal in [Pa]
$\Delta p_{Fan,SUP}$	Total static pressure loss related to the supply air side in [Pa]
$P_{SFP,SUP}$	Specific fan power related to the supply air side in [W/(m³/s)]
$\Delta p_{int,EHA}$	Internal static pressure lost for the reference configuration related to the exhaust air side in [Pa]
$\Delta p_{Fan,EHA}$	Total static pressure loss related to the exhaust air side in [Pa]
$P_{SFP,EHA}$	Specific fan power related to the exhaust air side in [W/(m³/s)]

For the internal pressure loss, the pressure loss of the HRS and filter has to be determined for both airways. For the HRS the pressure loss under dry conditions is used. The pressure losses for installation, protective grill and impact screen are contained in the system efficiency of the fans.

The value of the clean filter is used in the pressure losses of the filter. On the support side it is assumed that a filter of Class F7 (fine filter) is used and on the exhaust air side a filter of Class M5 (medium fine filter). If in the comparison to the reference configuration one or both filters are missing, the filter correction factor F mentioned above should be used. If fine or medium fine filters with a higher filter class than reference configuration are installed, the initial pressure losses of the installed filter are used.

In the calculation of the SFP_{int} value for UVU the initial pressure loss of the filter (F7 or higher) must be included if such a filter is available. If no filter is available in the unit, there is no specification for SFP_{int} but only the minimum system efficiency for the UVU to comply with. If only one filter with a lower filter class is installed as reference configuration then the initial pressure loss of the installed filter must be used and the SFP_{int} has to be calculated with this value.

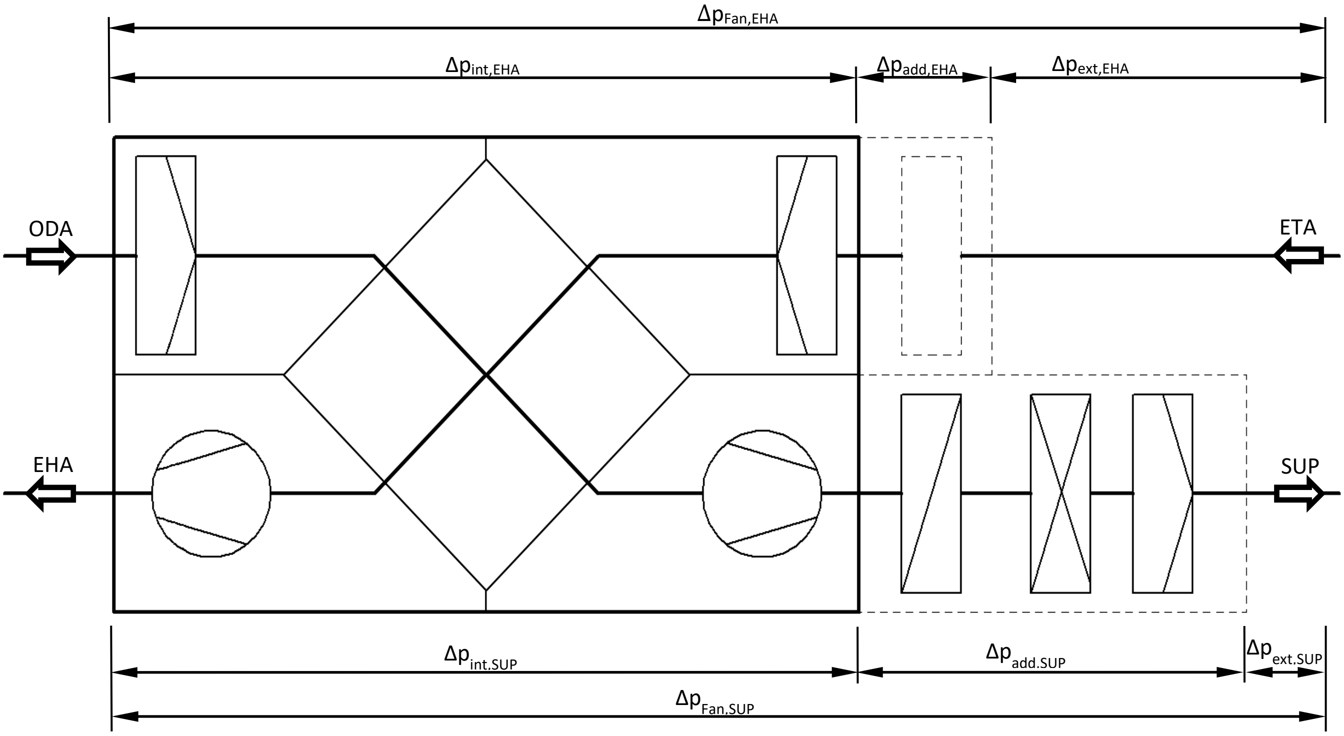

Figure 4 Display of the static pressure losses for the calculation of SFP_{int} (supply air fan inside the reference configuration)

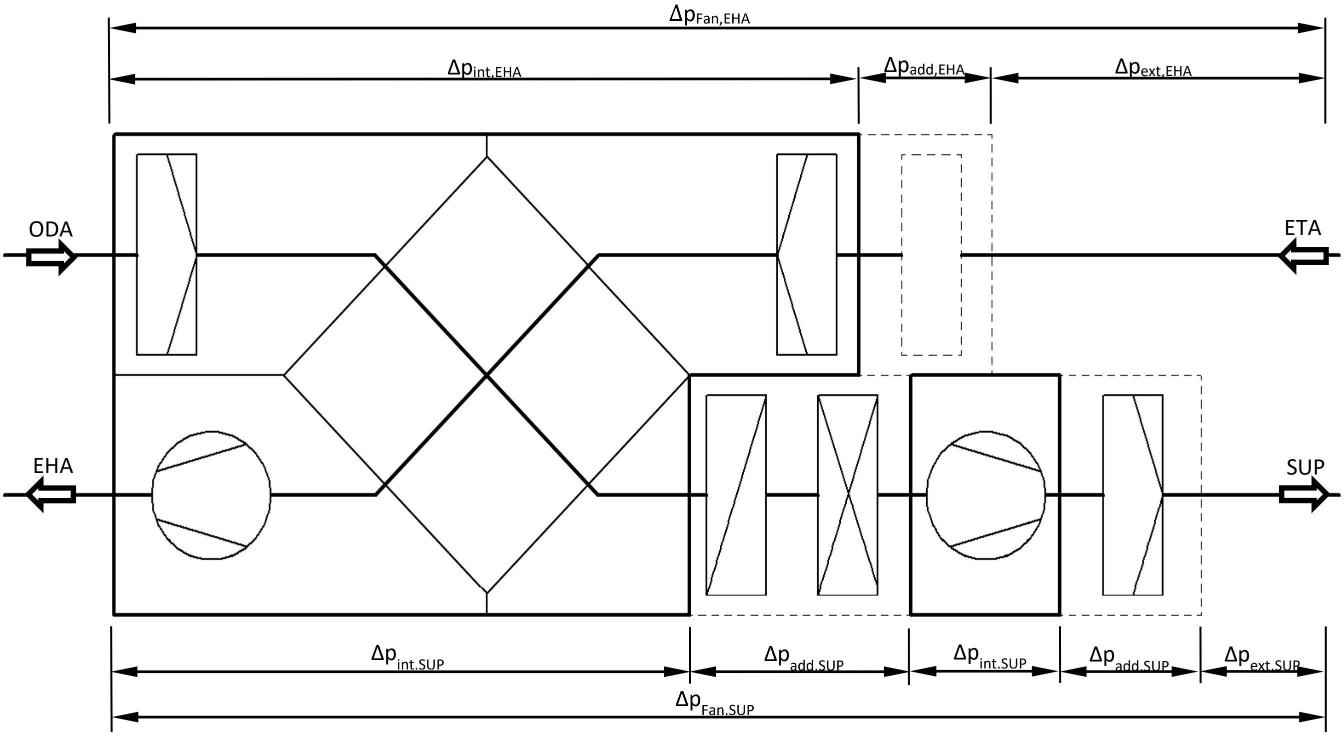

Figure 5 Display of the static pressure losses for the calculation of SFP_{int} (supply air fan outside the reference configuration)

No.	Requirements from European regulations	A+	A	B
3-4	Filter with optical differential pressure indicator or acoustic warning device in the control system	Obligation, if filters are part of the configura-tion	No requirement	No requirement

If a filter is a component of the unit, TÜV SÜD audits based on the technical data, whether all filters are fitted with an optical differential pressure indicator or acoustic warning device in the control, which is triggered as soon as the pressure loss on the filter exceeds the highest permissible value. If the differential pressure indicator/filter warning device is not included in the delivery scope of the equipment manu-facturer, the note must be included in the technical datasheet that for proper use the AHU must be fitted with a pressure difference indica-tor/filter warning device.

No.	Requirements from European regulations	A+	A	B
3-5	Regulation device	Controlled drive		No requirement

TÜV SÜD audit based on the technical data whether a regulation device (multistage drive or speed regulation) is available for the AHU. If the regulating device is not in the delivery scope of the unit manufacturer a plausibility check is carried out to see if the unit is suitable for a regulated drive. In the technical data there must be an instruction that for proper use the AHU must definitely be fitted with a regulated drive.

No.	Requirements from European regulations	A+	A	B
3-6	Heat recovery system	All BVUs have a heat recovery system with thermal by pass		A BVU has a heat recovery system

TÜV SÜD audit based on the technical data and drawings whether a heat recovery system is available in the (BVU) and whether it has a thermal bypass.

A device for the thermal bypass designates as specified in **EU-Regulation 1253/2014** any solution in which the heat exchanger is bypassed or its heat recovery power is automatically controlled or controlled by hand, for which a physical bypass airline is not essential (e.g. sum-mer box, control of the impeller speed, control of the air flow).

7.4 Checking the requirements of unit design

TÜV SÜD carries out the following investigations as part of the AHU design software test. The software must check all requirements and its compliance must be ensured.

No.	Requirements for unit design	A+	A	B
4-1	Type of fan used	Fan software (manufacturer, type, size) authorised by TÜV SÜD		

The manufacturer can only mark AHUs with an energy efficiency class according to this guideline which are fitted with fans which have a audited and certified fan design software.
Verification whether for a selectable component series ‘fan’ ‘a authorised component design software’ is available in the AHU design pro-gram, or whether for the selectable component ‘fan’ a ‘test report’ is available or whether by using a non-tested fan the granting of the energy class A+, A, or B by the AHU design program is suppressed.

The test reports only apply for the tested type and cannot be carried over to other designs.

The component design software of a fan is designated as ‘authorised’ if the calculation algorithms are based on a sufficient number of measurements for the series spectrum (at least on a small, medium and large size of the respective series). An expert report/audition re-port for fans is accepted if the audits corresponding to the current regulations **DIN EN ISO 5801** were carried out by one of the following named audition centres on a suction side chamber test bench and the component is manufactured unchanged. TÜV SÜD is responsible for carrying out the assessment.

- TÜV SÜD
- TÜV NORD
- CETIAT
- DTI, Denmark
- Accredited manufacturer (this means that the test bench is audited and accepted by TÜV SÜD)

Note: Fan characteristic lines, which were determined on a test bench accepted, certified and regularly monitored as specified in **EN ISO 5801**, are recognised.

No.	Requirements for unit design	A+	A	B
4-2	Heat recovery unit used	HRU software, (manufacturer, type, size) authorised by TÜV SÜD		

The manufacturer can only mark AHUs with an energy efficiency class according to this guideline which have been manufactured with a audited and certified heat recovery system. AHUs which cannot be fitted with a heat recovery system (e.g. only extract air units, pure recirculating air units without mixing of outdoor air, or supply air units) can also be marked with an efficiency class without installation of a heat recovery system. Inlet and exhaust air in combination necessarily need a heat recovery system in order to be marked.

Check whether for a selectable component series 'heat recovery system'

- a 'authorised component design software' is available in the AHU design program
- or whether for the selected component 'heat recovery system' a 'test report' is available
- or whether by using a non-tested heat recovery system the granting of the energy class A+, A, or B by the AHU design program is suppressed.

The test reports only apply for the tested type and cannot be carried over to other designs.

The component design software of a heat recovery system is designated as 'authorised' if the calculation algorithms are based on a sufficient number of measurements for the series spectrum (at least on 3 operating points). An expert report/audition report for heat recovery systems is accepted if the audition corresponding to the current standard (EN 308) were carried out by one of the following named audition centres and the component is manufactured unchanged. TÜV SÜD is responsible for carrying out the assessment.

- TÜV SÜD
- TÜV NORD
- CETIAT
- DTI, Denmark
- Accredited manufacturer (this means that the test bench is audited and accepted by TÜV SÜD)

The values calculated by the component design program and the values determined from the measurements must have the following maximum deviations:

- Temperature efficiency: + 3 percentage points compared with the measured value
- Air side pressure loss: - 10% compared with the measured value (min. 15 Pa)

Performance record

For each heat recovery system, each manufacturer and each design model (e.g. condensing rotor/enthalpy rotor), that is put into a labelled unit, there must be at least one test report. The design must be typical, e.g. a CC system or a heat tube must show a typical number of tubes. The test must be representative (see representative effects). For example, if the CC system can only be designed up to an efficiency of 30%, this needs to be a system with 4 tube rows. If the system is used up to an efficiency of 80%, this needs to have 20 or 30 rows. For this band width the test report or reports must be able to form the basis.

Representative effects

The following factors influence the heat recovery system:

Rotary heat exchanger

- The type of rotor (condensation, enthalpy, sorption)
- The rotor material (it determines the heat transfer mainly through the storage capacity, the thermal diffusion and the temperature penetration depth)
- The shaft height (the loads of at least one height shall be verified at random)
- The material thickness (this determines the storage ability basically through the storage capacity, the thermal diffusivity and the depth of temperature penetration)
- The depth of the rotor; here at least two sizes shall be verified at random if available
- The rotor diameter can be neglected

Plate heat exchanger

- The material of the plates, the plate thickness or coatings play a small part. Exception: Extreme variations such as plastic plates. If the relationship of d / lamda changes by the factor 200 compared with the tested plate heat exchanger, the properties of the plate heat exchanger must be measured by a separate measurement.
- The stamping of the plates - each geometry of the plates must be certified.
- The distance between plates (the rating at least one distance apart shall be verified at random)
- Edge length (here at least two sizes shall be verified at random)

CC system and thermal tube

- The material of the plates, the plate thickness or coatings play a small part. Exception: Extreme variations such as plastic plates. If the relationship of d / lamda changes by the factor 200 compared with the tested plate, the properties of this plate must be measured by a separate measurement.
- Plate shape - each geometry of the plate must be verified.
- Tube diameter (here the ratings shall be verified at random).
- Distance apart of tubes (here the ratings shall be verified at random).
- Depth/tube rows (here at least two representative models shall be determined at random).
- Height and width of the system play hardly any role.

If a coating is to be applied to the heat recovery system, for example, the manufacturer must consider the negative effect this may have. This can be done by the verification (available expert report) or by empirical correction factors. If no values are available, at least a factor of 0.97 (based on the HRU performance) must be considered.

The design software for heat recovery systems is assessed and certified by the 'Audition- and certification program for the release of design software for heat recovery systems in AHUs' of TÜV SÜD.

No.	Requirements for unit design	A+	A	B
4-3	Values given In the technical data sheet	a) Energy efficiency class A+, A or B b) V-class complied with c) Name of the manufacturer, internet address, model recognition d) Type in accordance with EU regulation (NRVU, UVU or BVU) e) Type of drive installed or to be installed f) Type of the heat recovery system (CCS, other or none) g) Temperature efficiency of the HRU η_t (in %) at validation conditions as specified in **EN 308** as well as with design conditions h) Nominal air volume flow (in m³/s) and ext. pressure increase (in Pa) i) Heating and cooling performance with temperatures j) Effective rating P_m (electrical load taken) and $P_{m,ref}$ (in kW) k) SFP_{int} (in W/(m³/s)),SFP_V and SFP_V-class l) Flow speed (in m/s) in the clear internal housing cross section m) Differential pressures of the individual components (internal and additional) n) Differential pressure of the components of the reference configuration $dp_{s,int}$ o) Static efficiency of the fans in the efficiency optimum and in the installed condition at the design point p) Maximum allowed fan speed q) Maximum external air leakage rate of the housing r) Maximum internal air leakage rate of the BVU or transfer rate of a regenerative heat exchanger (e.g. rotary heat exchanger) s) Energy properties of the filter t) Description of the optical filter warning display u) Details of the recommended filter pressure v) Sound power radiated from housing w) Channel sound power for suction- and exhaust -L_{WA} (A-weighted as sum level over complete octave band; weighted in the octave band from 63 Hz to 8 kHz)		

Check whether all sizes listed in the technical data are given.

To g)

The details of the temperature transmission grade are obtained by validating conditions as specified in EN 308 at +5°C outdoor air and +25°C extract air, at equalised air quantities, without effect of condensation energy. If the air quantities (supply and extract air) of the unit are different in the design point, then as a basis for 'equalised air quantities' the supply air mass flow should be used.

In addition the temperature efficiency at the design conditions must be given.

To j)

The efficiency should be given as specified in Chapter 2-2 (including correction values, regulation equipment if available, etc.)

To k)

Checking whether the SFP value and the SFP classes were correctly determined, put into the technical datasheet of the unit and clearly marked or named. The criteria are:

- Details of the SFPV-value. This is calculated under validating conditions, without the additions specified in this guideline, as for example, for the motor part load efficiency or for the ELCB which is not contained in the delivery scope.
- The SFP class is determined from the SFPV-value.
- Additions from **DIN EN 16798-3** Tab. 15 only change the SFP-classes interval.
- The 2nd filter stage counts as an 'additional mechanical filter stage' as specified in **DIN EN 16798-3** Tab. 15 counts the second filter stage
- A coarse dust filter (G1-G4) does not count as a filter in the sense of **DIN EN 16798-3** to adjust to the SFP class interval.

To l)

Flow velocity is the larger of the supply- and extract air speed when compared. It is a question of air speed over the clear internal housing cross section in the filter unit or in the fan unit if no filter is present. Design related fixtures which reduce the clear cross section over the complete length of the housing (e.g. internal longitudinal frame) have to be considered in the calculation of the clear internal housing cross section.

To o)

The static efficiency of fans is given both in the efficiency optimisation as specified in EU-Regulation 327/2011, and in the design point.

To q)

External leakage air rate designates the percentage of the nominal volume flow which leaks out during a pressure test of the housing or leaks in from the surrounding area. The test is carried out for non-residential ventilation unit (NRVU) at 400 Pa respectively at negative pressure and positive pressure. The measurement or calculation is done by the pressure testing method or the trace gas test method at the given equipment pressure. The details of the maximum external leakage rate can be given alternately for ±400 Pa or +400 Pa and -400 Pa.

$$f_m = f_{400} \times \left(\frac{p_{prüf}}{400}\right)^{0,65}$$

With

f_m	calculated highest leakage air rate at the given test pressure [%]
f_{400}	measured air leakage rate at the test pressure of 400 Pa in [%]
$p_{prüf}$	Test-pressure in [Pa]

To r)

Internal leakage air rate designates for units with heat recovery the percentage of the extract air volume flow which due to a leak gets into the supply air. The maximum internal leakage air rate is given for a pressure difference of 250 Pa.

$$f_m = f_{250} \times \left(\frac{p_{prüf}}{250}\right)^{0,65}$$

With

f_m	calculated highest leakage air rate at the given test pressure [%]
f_{250}	measured leakage rate at the test pressure of 250 Pa in [%]
$p_{prüf}$	Test-pressure in [Pa]

The transfer rate designates the percentage of the extract air which is mixed in the supply air by a regenerative heat exchanger (e.g. rotation heat exchanger) based on reference air volume flow. It consequently contains, for example, also the co-rotation.

To s)

The energy classification can be named as energetic classification of the filter. At least the filter initial pressure should be given with the design condition.

To u)

The recommended filtering pressures to be considered and given are as follows:

- Up to G4 => 150 Pa
- M5-F7 => 200 Pa
- F8-F9 => 300 Pa

Annex I: Calculation sample for effective power P_m

Specification from project (example)

Air volume flow	q_V	30,000 m³/h = 8.333 m³/s
External pressure losses	Δp_{ext}	800 Pa
Desity at design conditions	ρ	1.2 kg/m³
Type of fan	-	Directly driven free running fan with asynchrony machine
Suction or exhaust situation	-	Suction protection installed, blade distance to wall ≥ 0.6 × d_{nenn}

Calculation in AHU design software (specified value for fan design software)

Total pressure loss of components	Δp_{Komp}	Calculation from design of components	559 Pa
Diameter (type) of the blade	-	In dependence of volume flow and static pressure loss	900
Outside dimeter of the blade	d	Given by the selected blade type	995 mm
Depth of the blade	x	Given by the selected blade type	258 mm
Circumference of the blade	U	$= d \times \pi$ $= 0.995\ m \times 3.1416$	3.126 m
Velocity	w	$= q_V / (U \times x)$ $= (8.333\ m^3/s) / (3.126\ m \times 0.258\ m)$	10.33 m/s
Dynamic fan pressure	Δp_{dyn}	$= 0.5 \times \rho \times w^2$ $= 0.5 \times 1.2\ kg/m^3 \times (10.33\ m/s)^2$	64 Pa
Installation loss fan: free running fan, suction side	k_1	$= 0.5 \times \Delta p_{dyn}$ $= 0.5 \times 64\ Pa$	32 Pa
Installation loss fan: free running fan, exhaust side	k_2	$= 0.1 \times \Delta p_{dyn}$ $= 0.1 \times 64\ Pa$	6.4 Pa
Other installation losses	k_3 bis k_8		0 Pa
Sum installation losses	Δp_{Vent}	$= k_1 + k_2 + k_3 + k_4 + k_5 + k_6 + k_7 + k_8$ $= 32\ Pa + 6.4\ Pa$	38.4 Pa
Design pressure drop of fan	Δp	$= \Delta p_{ext} + \Delta p_{Komp.} + \Delta p_{Vent}$ $= 800\ Pa + 559\ Pa + 38.4\ Pa$	1,397.4 Pa

Output value from the fan design software

Shaft performance	P_{Welle}	15.14 kW
Nominal power of drive	$P_{Motor,nenn}$	22.00 kW
Efficiency of drive at nominal performance	$\eta_{Motor,nenn}$	0.93
Class regarding limit deviation	-	Class 2

Calculation of P_m with AHU design software

Efficiency of the control equipment	f_R	Constant	0.97
Efficiency of the motor drive	f_A	No belt drive	1.00
Nominal efficiency of the motor	f_M	Standard value, because drive was not included in performance measuring	0.98
Load range drive	LR	= Shaft performance / nominal power of drive = 15.14 kW / 22.00 kW	68.8 %
Part load efficiency of asynchronous machine	f_{TL}	$= -0.00004 \times (LR)^2 + 0{,}008 \times (LR) + 0.6$ $= -0.00004 \times (68.8\ \%)^2 + 0{,}008 \cdot (68.8\ \%) + 0{,}6$	0.961
Classes of the limit deviation	-	Assignment from TÜV certificate of fan type	Class B1
Correction factor from the limit deviation	f_G	Class 2	1.05
Efficiency of the fan (Without $\eta_{Laufrad,stat}$)	η_{Vent}	$= \eta_{Motor,Nenn} \times f_R \times f_A \times f_M \times f_{TL} \times 1/f_G$ $= 0.93 \times 0.97 \times 1.0 \times 0.98 \times 0.961 \times 1/1.05$	0.809
Effective power (Including $\eta_{Laufrad,stat}$)	P_m	$= P_{Welle} / \eta_{Vent,stat}$ $= 15.14\ kW / 0.809$	18.71 kW

The sample unit has an effective power of 19 kW

<u>Informative:</u> Calculation of P-Class regarding DIN 13053

Static pressure loss	Δp_{stat}	$= \Delta p_{ext} + \Delta p_{Komp}$ $= 800\ Pa + 559\ Pa$	1359 Pa
Reference effective power	$P_{m,ref}$	$= (\Delta p_{stat} / 450)^{0.925} \times (q_v + 0{,}08)^{0.95}$ $= (1{,}359\ Pa / 450)^{0.925} \times (8.333\ m^3/s + 0.08)^{0.95}$	21.02 kW
Verification of power consumption class	-	$P_m \leq P_{m,ref} \times 0{,}9$ $18.71\ kW \leq 21.02\ kW \times 0{,}9$ $18.71\ kW \leq 18.92\ kW$	Class P2

The sample unit has the electrical consumption class P2

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