Ventilation for non-residential buildings

– Performance requirements for ventilation and room-conditioning system

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Over almost 10 years, EN 13779 ventilation for nonresidential buildings – performance requirements for ventilation and room-conditioning systems is used as a basic standard for the design of ventilation systems within Europe (draft in 2003 and EN in 2007). The standard specifies a common understanding of ventilation systems in Europe and provides a classification system for key performance data.

Main changes in EN 13779 / EN 16798-3

Within EPBD-Mandate M480, EN 13779 was identified as a key standard used in the building regulations of many EU member states. The current revision reflects the needs to update some aspects and to clarify some borderlines with other standards. There have been made some editorial changes. First the standard was renumbered to EN 16798-3, which is little helpful, because this standard is one of the most used in ventilation segment and second, the standard was split into a normative part and an supporting Technical Report CEN/TR 16798-4, containing all informative annexes of former EN 13779 (**Figure 1**). As in all revised EPBD standards, the normative EN 16798-3 offers the possibility of a national annex to clarify the national needs.

All indoor air quality aspects in EN 16798-3 (IDA classes etc.) have been deleted or shifted to EN 16798-1. The main focus of the current standard is on the performance of the technical system and its impact on energy efficiency and supply air quality.

- Design and definition aspects will mainly be kept and updated
  - o Agreement of design criteria
  - o Specifications of air

- All aspects of indoor air quality and indoor environment will be handled in EN 16798-1
  - o Based on the needs of human beings and buildings
  - o Ventilation rate (based on fully mixed airflows)
  - o Temperature, humidity, draft risk, etc. CO_2

- All aspects of the system of non-residential ventilation will be kept in EN 16798-3
  - o Outdoor Air Quality
  - o Supply Air Quality
  - o System performance
  - o System design

Ecodesign Directive

In November 2014 the "EU 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" was published, specifying minimum performance requirements for ventilation units. The key performance requirements are:

- **Internal specific fan power** of ventilation components (SFP_{int}) is the ratio between the internal pressure drop of ventilation components and the fan efficiency, determined for the reference configuration

- **Thermal efficiency of a non-residential heat recovery** (η_{t_nrvu}) means the ratio between supply air temperature gain and the exhaust air temperature loss, both relative to the outdoor temperature, measured under dry reference conditions, with balanced mass flow, an indoor-outdoor air temperature difference of 20 K, excluding thermal heat gain from fan motors and from **internal leakages**

EN 16798-3 was updated to specify calculation procedures and a link between EPBD and ErP.

Basic System Types and Configurations

Air-conditioning and room conditioning systems may or may not be combined with ventilation systems. **Table 1** shows a definition of principle ventilation systems based on the air volume flow.

Based on ventilation and thermal functions, ventilation or air-conditioning system can be specified by functions as shown in **Table 2**. Systems may also be combined to provide more functions.

Outdoor Air, Supply Air

In the process of system design, consideration needs to be given to the quality of the outdoor air (ODA) around the building or proposed location of the building. The classification was updated to the current guidelines (WHO 2005) and regulations.

Table 1. Basic system types of ventilation systems.

Description	Name of the system type
Ventilation system with a fan assisted air volume flow in only one direction (either supply or exhaust) which is balanced by air transfer devices in the building envelope.	Unidirectional ventilation system
Ventilation system with a fan assisted air volume flow in both direction (supply and exhaust)	Bidirectional ventilation system
Ventilation relying on utilisation of natural driving forces (further guidance in CEN/TR 16798-4)	Natural ventilation system
Ventilation relying to both natural and mechanical ventilation in the same part of a building, subject to control selecting the ventilation principle appropriate for the given situation (either natural or mechanical driving forces or a combination thereof).	Hybrid ventilation

As a starting point for ODA classification, EN 16798-3 proposes the following procedure:

- ODA 1 applies where the WHO (2005) guidelines and any National air quality standards or regulations for outdoor air are fulfilled.
- ODA 2 applies where pollutant concentrations exceed the WHO guidelines or any National air quality standards or regulations for outdoor air by a factor of up to 1,5.
- ODA 3 applies where pollutant concentrations exceed the WHO guidelines or any National air quality standards or regulations for outdoor air by a factor greater than 1,5.

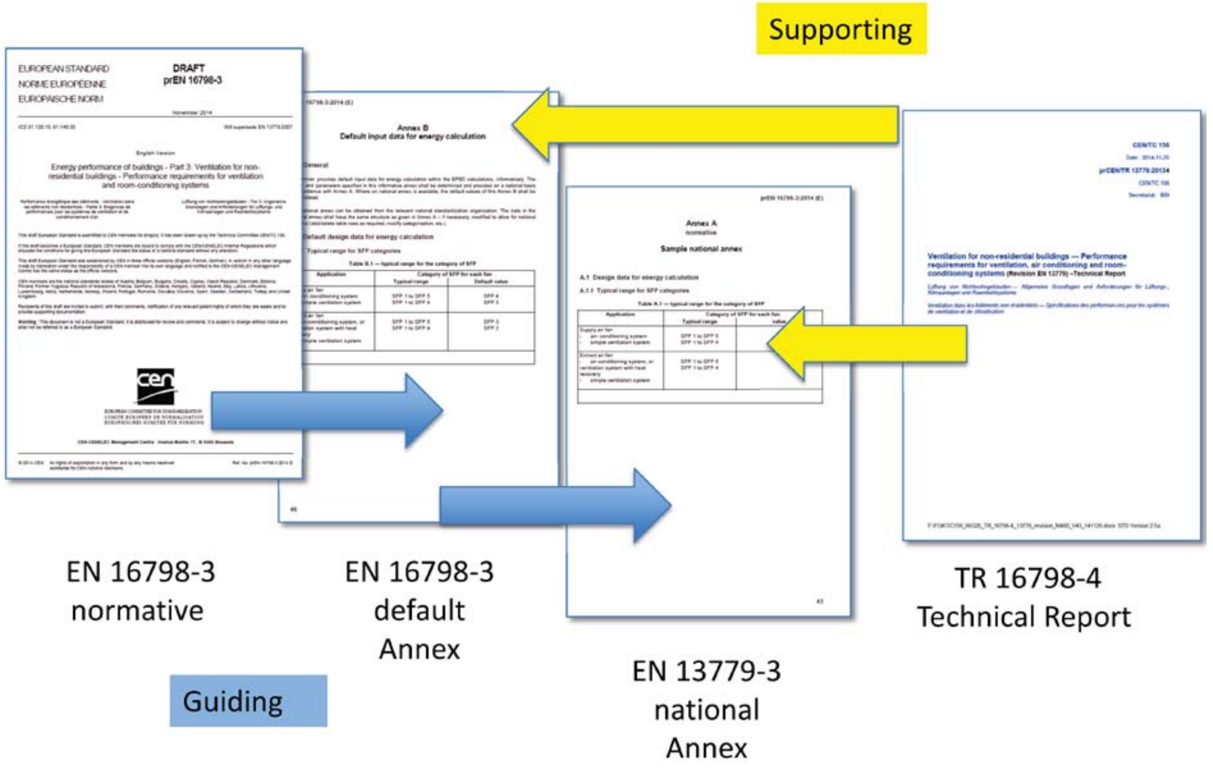

Figure 1. Structure of EN 16798-3 and -4.

The classification shall be divided into two categories: ODA (G) for gaseous components and ODA (P) for particle components.

For Supply air classification, the following approach is suggested.

- SUP1 applies where the supply air fulfils the WHO (2005) guidelines limit values and any National air quality standards limit values or regulations with a factor x 0,25
- SUP2 applies where the supply air fulfils the WHO (2005) guidelines limit values and any National air quality standards limit values or regulations with a factor x 0,5
- SUP3 applies where the supply air fulfils the WHO (2005) guidelines limit values and any National air quality standards limit values or regulations with a factor x 0,75
- SUP4 applies where the supply air fulfils the WHO (2005) guidelines limit values and any National air quality standards limit values or regulations.

Filtration

The dimensioning of filter sections has been updated and clearly linked to the revision of EN 779. Depending on outdoor particle pollution level (ODA (P)) and desired supply air quality (SUP) different levels of filtration will be required (**Table 3**).

Table 3. Minimum filtration efficiency based on particle outdoor air quality.

Outdoor air quality	**Supply air class**			
	SUP 1	**SUP 2**	**SUP 3**	**SUP 4**
ODA (P) 1	88%*	80%*	80%*	80%*
ODA (P) 2	96%*	88%*	80%*	80%*
ODA (P) 3	99%*	96%*	92%*	80%*

* Combined average filtration efficiency over a single or multiple stage filtration an accordance to average filtration efficiency specified in EN 779

The required total filtration efficiency can be achieved by using single or multiple stage filtrations depending on the individual design process. In case of multiple stage filtrations, the combined filtration efficiency shall be calculated as follows:

$$E_t = 100 \cdot \left(1 - \left(\left(1 - \frac{E_{s1}}{100}\right) \cdot \left(1 - \frac{E_{s2}}{100}\right) \cdot \ldots \cdot \left(1 - \frac{E_{sn+1}}{100}\right)\right)\right)$$

Where:
E_t = the total filter efficiency
E_{sn+1} = the efficiency of each filter step

To maintain a good hygiene level in the ventilation system the minimum combined filtration efficiency needs to meet filtration class F7 in accordance with EN 779.

Table 2. Types of Ventilation-, Air-conditioning-, and Room Conditioning-Systems based on functions.

System	**Supply Air Fan**	**Exhaust Air Fan**	**Secondary Fan**	**Heat Recovery**	**Waste heat pump**	**Filtration**	**Heating**	**Cooling**	**Humidification**	**Dehumidification**
Unidirectional supply air ventilation system (Positive pressure ventilation)	x	-	-	-		o	o	-	-	-
Unidirectional exhaust air system	-	x	-		o	-	-	-	-	-
Bidirectional ventilation system	x	x	-	x	o	x	o	-	-	-
Bidirectional ventilation system with humidification	x	x		x	o	x	o	-	x	-
Bidirectional air-conditioning system	x	x		x	o	x	o	(x)	o	(x)
Full air-conditioning system	x	x		x	o	x	x	x	x	x
Room air conditioning system (Fan-Coil, DX-Split-Systems, VRF, local water loop heat pumps, etc.)	-	-	x	-	-	o	o	x	-	(x)
Room air heating systems	-	-	x	-	-	o	x	-	-	-
Room conditioning system	-	-	-	-	-	-	o	x	-	-

x equipped with (x) equipped with, but function might be limited - not equipped with o may or may not equipped with

In cases where supply air level of SUP 1 or 2 is required and where the outdoor air quality based on gaseous components is of level ODA (G) 2 or ODA (G) 3 the particle filtration shall be optional complemented with suitable gas phase filtration to reduce harmful levels of gaseous components like CO, NOx, SOx, VOC and O_3.

Specific Fan Power and AHU related SFP values

The specific fan power of fans (*SFP*) is a well introduced value and implemented in many national building regulations. Although the value seems to be quite simple, there are many options how to calculate. The different ways to calculate have been clarified and the new *SFP* internal has been introduced.

ErP Regulation EU 1253/2014 uses the SFP_{int} to limit the electricity demand for ventilation functions. Three parts of *SFP* (internal, additional and external pressure loads) are defined separately (**Figure 2**).

The **specific fan power,** $\boldsymbol{SFP_{\mathrm{int}}}$ is the electric power, in kW, supplied to a fan and related to the internal pressure of all ventilation components (Filters, heat recovery and related casing) divided by the air flow expressed in m³/s under design load conditions.

The **specific fan power,** $\boldsymbol{SFP_{\mathrm{add}}}$ is the electric power, in kW, supplied to a fan and related to the internal pressure of all internal additional ventilation components (coolers, heaters, humidifier, etc.) divided by the air flow expressed in m³/s under design load conditions.

The **specific fan power,** $\boldsymbol{SFP_{\mathrm{ext}}}$ is the electric power, in kW, supplied to a fan and related to the external pressure divided by the air flow expressed in m³/s under design load conditions.

$$P_{SFP,\,SUP} = P_{SFP,\,SUP,\,int} + P_{SFP,\,SUP,\,add} + P_{SFP,SUP,\,ext}$$

$$P_{SFP,\,EXT} = P_{SFP,\,EXT,\,int} + P_{SFP,\,EXT,\,add} + P_{SFP,EXT,\,ext}$$

$$P_{SFP} = \frac{\Delta p_{\mathrm{int}\ tot}}{\eta_{tot}} + \frac{\Delta p_{add\ tot}}{\eta_{tot}} + \frac{\Delta p_{ext\ tot}}{\eta_{tot}} = \frac{\Delta p_{\mathrm{int}\ stat}}{\eta_{stat}} + \frac{\Delta p_{add\ stat}}{\eta_{stat}} + \frac{\Delta p_{ext\ stat}}{\eta_{stat}}$$

$$P_{SFP,int} = P_{SFP,\,SUP,\,int} + P_{SFP,\,EXT,\,,int}$$

Where:

$\Delta p_{\mathrm{int\ tot}}$ = total internal pressure rise from the ventilation components (fan casing, heat recovery, and filters) in Pa
$\Delta p_{\mathrm{add\ tot}}$ = total additional pressure rise from the additional components (cooler, heat exchanger, humidifier, silencer, etc.) in Pa
$\Delta p_{\mathrm{ext\ tot}}$ = total external pressure rise from the ductwork and external components in Pa
$\Delta p_{\mathrm{int\ stat}}$ = static internal pressure rise from the ventilation components (fan casing, heat recovery and filters) in Pa
$\Delta p_{\mathrm{add\ stat}}$ = static additional pressure rise from the additional components (cooler, heat exchanger, humidifier, silencer, etc.) in Pa
$\Delta p_{\mathrm{ext\ stat}}$ = static external pressure rise from the ductwork and external components in Pa
η_{tot} = $\eta_{\mathrm{fan\ tot}} \cdot \eta_{\mathrm{tr}} \cdot \eta_{\mathrm{m}} \cdot \eta_{\mathrm{c}}$ based on total pressure
η_{stat} = $\eta_{\mathrm{fan\ stat}} \cdot \eta_{\mathrm{tr}} \cdot \eta_{\mathrm{m}} \cdot \eta_{\mathrm{c}}$ based on static pressure
$P_{SFP,\,SUP}$ = the SFP-value on supply air side
$P_{SFP,\,EXT}$ = the SFP value on extract air side
$P_{SFP,int}$ = the internal SFP value of the bidirectional air handling unit.

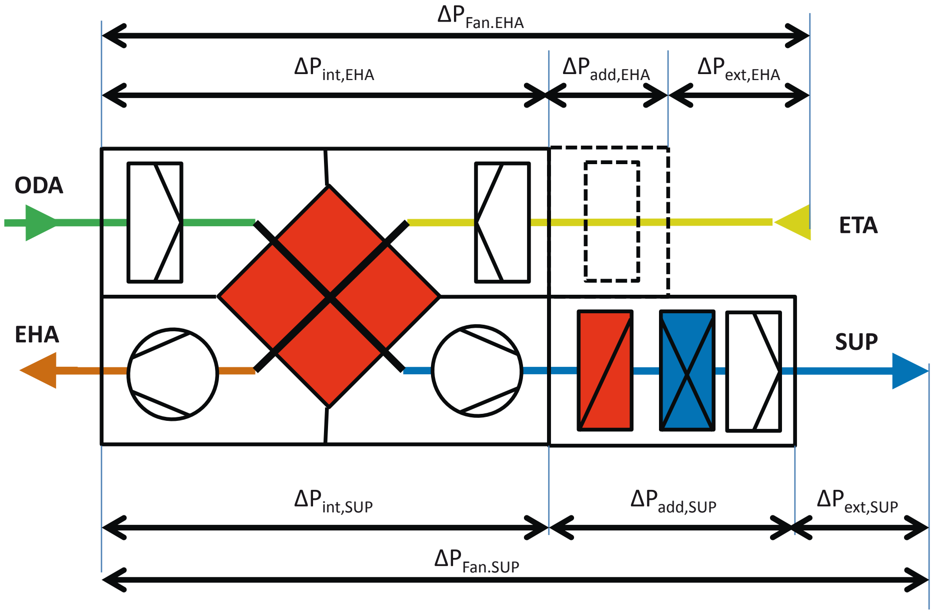

Figure 2. AHU related SFP values.

Leakages in ventilation systems and heat recovery

Leakages impact hygiene aspects, energy efficiency in ventilation systems, and functional problems. There are three different leakages types which have to be considered:

- leakages in heat recovery;
- leakages of the AHU casing;
- leakages of the air distribution (ducts).

Two new criteria to specify the leakages in heat recovery have been introduced:

- Exhaust Air Transfer ratio (EATR) [%]:
- Outdoor Air Correction Factor (OACF) [–]:

EATR provides information on the level of carry-over of the supply air by the exhaust air in the heat recovery component.

$$EATR = \frac{a_{SUP,HR} - a_{ODA,HR}}{a_{EXT,HR}}$$

Where:

$a_{SUP,HR}$ = the concentration in supply air leaving the HR component
$a_{ODA,HR}$ = the concentration in outdoor air entering the HR component
$a_{EXT,HR}$ = the concentration in extract air entering the HR component

The Outdoor Air Correction Factor (OACF) is the ratio of the entering supply mass airflow rate and the leaving supply mass airflow rate:

$$OACF = \frac{q_{m,ODA,HR}}{q_{m,SUP,HR}}$$

Where:

$q_{m,ODA,HR}$ = the air mass flow of outdoor air entering HR component
$q_{m,SUP,HR}$ = the air mass flow of supply air leaving the HR component

Further detailed specifications will be made in EN 308 revision and TR 16798-4.

- If OACF>1: air is transferred from the supply to the exhaust air
- If OACF<1: air is transferred from exhaust to supply air (air recirculation)

EATR and OACF shall be calculated and classified by the heat recovery manufacturer for the nominal design condition of the air handling unit (**Table 4**).

Table 4. Classification of Outdoor air correction factor.

	OACF	
Class	**Supply to exhaust air**	**Exhaust to supply air**
1	1,03	0,97
2	1,05	0,95
3	1,07	0,93
4	1,10	0,9
5	Not classified	

Energy rating of ventilation systems

Energy performance calculations for the entire building includes many different processes and energies. To allow designing engineers an overview, process orientated index are needed. For ventilation systems, the following benchmarks have been introduced.

Heat recovery efficiency

The annual energy efficiency of the heat recovery is calculated based on recovered energy and heating need of ventilation

$$\varepsilon_{SUP} = 1 - \frac{Q_{H;V;in;req}}{Q_{H;V;tot}}$$

Where:

ε_{SUP} = annual energy efficiency of heat recovery (–)
$Q_{H;V;in;req}$ = annual heating energy of ventilation supply (or/and intake) air (kWh)
$Q_{H;V;tot}$ = annual heating energy of supply (or/and intake) air without heat recovery (kWh)

Annual heating energy of ventilation may be calculated for one ventilation system or for all ventilation systems in the building.

Coefficient of performance of heat recovery shall be calculated according EN 13053:

$$\varepsilon = \frac{Q_{hr}}{E_{V;hr;gen;in;el}}$$

Where:

ε = coefficient of performance (–)
Q_{hr} = heat transferred by heat recovery (kW)
$E_{V;hr;gen;in;el}$ = Electric energy of the heat recovery section required by fans and auxiliaries (kW)

Primary energy use of ventilation

Electrical energy for air transportation and thermal energy for heating, humidification and possibly cooling and dehumidification are linked somehow, because components with a higher thermal efficiency may have a higher pressure drop. A low SFP values might lead to a low heat recovery performance or heating coil performance, or the other way round.

A combined value of thermal and electrical energy demand might be helpful to benchmark the ventilation system within a specified building. The primary energy use of ventilation systems shall be calculated as follows:

$$E_{P;V} =$$

$$q_{H;V;in;req} \cdot f_{H} \cdot f_{P,H} + e_{V;gen;in;el} \cdot f_{P,E} +$$

$$e_{HU;cr} \cdot f_{P;cr} + (w_{V;aux} + w_{HU;aux}) \cdot f_{P,E}$$

Where:

$E_{P;V}$ = Primary energy use of ventilation in Wh/(m³/h·a)
$q_{H;V;in;req}$ = Specific required AHU heating coil input in Wh/(m³/h·a)
f_{H} = Delivered energy factor for heat (taking into consideration distribution and generation)
$e_{HU;cr}$ = Specific humidification generation input in Wh/(m³/h·a)
$f_{P;cr}$ = Primary energy factor of carrier required by the humidifier
$f_{P,E}$ = Primary energy factor for electricity
$f_{P,H}$ = Primary energy factor for heat
$e_{V;gen;in;el}$ = Specific electrical energy requirement for supply and extract air delivery in Wh/(m³/h·a)
$w_{V;aux}$ = Specific ventilation auxiliary energy in Wh/(m³/h·a)
$w_{HU;aux}$ = Specific humidification auxiliary energy in Wh/(m³/h·a)

Conclusion

In the first months of 2015, the enquiry for EN 16798-3 will be launched. Parallel to the enquiry, the Technical Report CEN/TR 16798-4 will be finished. This report will additionally give some guidance to natural ventilation systems. ■

Literature

EN 16798-3: prEN 16798-3 - Energy performance of buildings - Part 3: Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems.

CEN/TR 16798-4: Draft CEN/TR 167798-4: Ventilation for non-residential buildings — Performance requirements for ventilation, air conditioning and room-conditioning systems (Revision EN 13779) –Technical Report (currently available at CENTC156 CEN Livelink as document CEN/TC 156/WG 20 N 83 or CEN/TC 156 N 1303).

EN 16798-1: prEN16798-1 Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.

Current drafts of EPBD Technical reports of TC 156 will be available soon for public information on www.normen.fgk.de