PD CEN/TR 16798-6:2017



BSI Standards Publication

Energy performance of buildings - Ventilation for buildings

Part 6: Interpretation of the requirements in EN 16798-5 -1 and EN 16798-5-2 - Calculation methods for energy requirements of ventilation and air conditioning systems (Modules M5-6, M5-8, M 6-5, M6-8 , M7-5, M7-8)

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National foreword

This Published Document is the UK implementation of CEN/TR 16798-6:2017.

The UK participation in its preparation was entrusted to Technical Committee RHE/2, Ventilation for buildings, heating and hot water services.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2017

ISBN 978 0 580 85872 7

ICS 91.140.30; 91.120.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2017.

Amendments/corrigenda issued since publication

Date	Text affected

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TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 16798-6

June 2017

ICS 91.120.10; 91.140.30

English Version

Energy performance of buildings - Ventilation for buildings - Part 6: Interpretation of the requirements in EN 16798-5 -1 and EN 16798-5-2 - Calculation methods for energy requirements of ventilation and air conditioning systems (Modules M5-6, M5-8, M 6-5, M6-8 , M7-5, M7-8)

Performance énergétique des bâtiments - Ventilation des bâtiments - Partie 6 : Interprétation des exigences de l'EN 16798-5-1 et de l'EN 16798-5-2 - Méthodes de calcul des besoins énergétiques des systèmes de ventilation et de conditionnement d'air (Modules M5-6, M5-8, M6-5, M6-8, M7-5, M7-8)

Energieeffizienz von Gebäuden - Lüftung von Gebäuden - Teil 6: Interpretation der Anforderungen der EN 16798-5-1 und EN 16798-5-2 - Berechnungsmethoden für den Energiebedarf von Lüftungs- und Klimaanlagen (Module M5-6, M5-8, M6-5, M6-8, M7-5, M7-8)

This Technical Report was approved by CEN on 27 February 2017. It has been drawn up by the Technical Committee CEN/TC 156.

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European foreword

This document (CEN/TR 16798-6:2017) has been prepared by Technical Committee CEN/TC 156 "Ventilation for buildings", the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

The necessary editorial revisions were made to comply with the requirements for each EPB technical report.

This document has been produced to meet the requirements of Directive 2010/31/EU 19 May 2010 on the energy performance of buildings (recast), referred to as "recast EPDB".

For the convenience of Standards users CEN/TC 156, together with responsible Working Group Conveners, have prepared a simple table below relating, where appropriate, the relationship between the 'EPBD' and 'recast EPBD' standard numbers prepared by Technical Committee CEN/TC 156 "Ventilation for buildings".

EPBD EN Number	Recast EPBD EN Number	Title
EN 15251	EN 16798-1	Energy performance of buildings – Ventilation for buildings – Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (Module M1-6)
N/A	CEN/TR 16798-2	Energy performance of buildings – Ventilation for buildings – Part 2: Interpretation of the requirements in EN 16798-1 – Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (Module M1-6)
EN 13779	EN 16798-3	Energy performance of buildings – Ventilation for buildings – Part 3: For non-residential buildings – Performance requirements for ventilation and room-conditioning systems (Modules M5-1, M5-4)
N/A	CEN/TR 16798-4	Energy performance of buildings – Ventilation for buildings – Part 4: Interpretation of the requirements in EN 16798- 3 – For non-residential buildings – Performance requirements for ventilation and room-conditioning systems (Modules M5-1, M5-4)

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EN 15241	EN 16798-5-1	Energy performance of buildings – Ventilation for buildings – Part 5-1: Calculation methods for energy requirements of ventilation and air conditioning systems (Modules M5-6, M5-8, M6-5, M6-8, M7-5, M7-8) – Method 1: Distribution and generation
EN 15241	EN 16798-5-2	Energy performance of buildings – Ventilation for buildings – Part 5-2: Calculation methods for energy requirements of ventilation systems (Modules M5-6.2, M5-8.2) – Method 2: Distribution and generation
N/A	CEN/TR 16798-6	Energy performance of buildings – Ventilation for buildings – Part 6: Interpretation of the requirements in EN 16798-5–1 and EN 16798-5-2 – Calculation methods for energy requirements of ventilation and air conditioning systems (Modules M5-6, M5-8, M 6-5, M6-8 , M7-5, M7-8)
EN 15242	EN 16798-7	Energy performance of buildings – Ventilation for buildings – Part 7: Calculation methods for the determination of air flow rates in buildings including infiltration (Module M5-5)
N/A	CEN/TR 16798-8	Energy performance of buildings – Ventilation for buildings – Part 8: Interpretation of the requirements in EN 16798-7 – Calculation methods for the determination of air flow rates in buildings including infiltration – (Module M5-5)
EN 15243	EN 16798-9	Energy performance of buildings – Ventilation for buildings – Part 9: Calculation methods for energy requirements of cooling systems (Modules M4-1, M4-4, M4-9) – General
N/A	CEN/TR 16798-10	Energy performance of buildings – Ventilation for buildings – Part 10: Interpretation of the requirements in EN 16798-9 – Calculation methods for energy requirements of cooling systems (Module M4-1,M4-4, M4-9) – General
EN 15243	EN 16798-13	Energy performance of buildings – Ventilation for buildings – Part 13: Calculation of cooling systems (Module M4-8) – Generation
EN 15243	CEN/TR 16798-14	Energy performance of buildings – Ventilation for buildings – Part 14: Interpretation of the requirements in EN 16798-13 – Calculation of cooling systems (Module M4-8) – Generation
N/A	EN 16798-15	Energy performance of buildings – Ventilation for buildings – Part 15: Calculation of cooling systems (Module M4-7) – Storage

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N/A	CEN/TR 16798-16	Energy performance of buildings – Ventilation for buildings – Part 16: Interpretation of the requirements in EN 16798-15 – Calculation of cooling systems (Module M4-7) – Storage
EN 15239 and EN 15240	EN 16798-17	Energy performance of buildings – Ventilation for buildings – Part 17: Guidelines for inspection of ventilation and air-conditioning systems (Module M4-11, M5-11, M6-11, M7-11)
N/A	CEN/TR 16798-18	Energy performance of buildings – Ventilation for buildings – Part 18: Interpretation of the requirements in EN 16798-17 – Guidelines for inspection of ventilation and air-conditioning systems (Module M4-11, M5-11, M6-11, M7-11)

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Introduction

The set of EPB standards, Technical Reports and supporting tools

In order to facilitate the necessary overall consistency and coherence, in terminology, approach, input/output relations and formats, for the whole set of EPB-standards, the following documents and tools are available:

a) a document with basic principles to be followed in drafting EPB-standards: CEN/TS 16628:2014, *Energy Performance of Buildings - Basic Principles for the set of EPB standards* [1];

b) a document with detailed technical rules to be followed in drafting EPB-standards; CEN/TS 16629:2014, *Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards* [2]; and

c) the detailed technical rules are the basis for the following tools:

   1) a common template for each EPB-standard, including specific drafting instructions for the relevant clauses,

   2) a common template for each technical report that accompanies an EPB standard or a cluster of EPB standards, including specific drafting instructions for the relevant clauses, and

   3) a common template for the spreadsheet that accompanies each EPB standard, to demonstrate the correctness of the EPB calculation procedures.

Each EPB standard follows the basic principles and the detailed technical rules and relates to the overarching EPB-standard, EN ISO 52000-1:2017 [3].

One of the main purposes of the revision of the EPB-standards is to enable that laws and regulations directly refer to the EPB-standards and make compliance with them compulsory. This requires that the set of EPB-standards consists of a systematic, clear, comprehensive and unambiguous set of energy performance procedures. The number of options provided is kept as low as possible, taking into account national and regional differences in climate, culture and building tradition, policy and legal frameworks (subsidiarity principle). For each option, an informative default option is provided (Annex B).

Rationale behind the EPB Technical Reports

There is a risk that the purpose and limitations of the EPB standards will be misunderstood, unless the background and context to their contents – and the thinking behind them – is explained in some detail to readers of the standards. Consequently, various types of informative contents are recorded and made available for users to properly understand, apply and nationally or regionally implement the EPB standards.

If this explanation would have been attempted in the standards themselves, the result is likely to be confusing and cumbersome, especially if the standards are implemented or referenced in national or regional building codes.

Therefore each EPB standard is accompanied by an informative technical report, like this one, where all informative content is collected, to ensure a clear separation between normative and informative contents (see CEN/TS 16629 [2]):

— to avoid flooding and confusing the actual normative part with informative content;

— to reduce the page count of the actual standard; and

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— to facilitate understanding of the set of EPB standards.

This was also one of the main recommendations from the European CENSE project [5] that laid the foundation for the preparation of the set of EPB standards.

This Technical Report

This Technical Report accompanies the suite of EPB standards on the calculation of the energy performance of ventilation systems. It relates to the European standards EN 16798-5-1 and EN 16798-5-2, which form part of a set of standards related to the evaluation of the energy performance of buildings (EPB).

The role and the positioning of the accompanied standards in the set of EPB standards is defined in the Introduction to the standards.

Accompanying spreadsheet(s)

Concerning the accompanied standards EN 16798-5-1 and EN 16798-5-2, the following spreadsheets were produced:

— on EN 16798-5-1; and

— on EN 16798-5-2.

In this Technical Report, examples of each of these calculation sheets are included.

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1 Scope

This Technical Report refers to standards EN 16798-5-1 and EN 16798-5-2.

It contains information to support the correct understanding and use of these standards.

This Technical Report does not contain any normative provision.

2 Normative references

Not applicable.

NOTE More information on the use of EPB module numbers for normative references between EPB standards is given in CEN ISO/TR 52000-2:2017.

3 Terms and definitions

For the purposes of this document, the terms and definitions as mentioned and given in the EN 16798-5-1 and EN 16798-5-2 apply.

More information on some key EPB terms and definitions is given in CEN ISO/TR 52000-2:2017.

4 Symbols, subscripts and abbreviations

4.1 Symbols

For the purposes of this document, the symbols as mentioned and given in EN 16798-5-1 and EN 16798-5-2 apply.

More information on key EPB symbols is given in CEN ISO/TR 52000-2:2017.

NOTE If new symbols are needed, indeed, please refer to the EPB standards template and Annex C of EN ISO 52000-1:2017 for detailed rules.

Additional symbols are given in Table 1.

Table 1 — Symbols and units

Symbol	Quantity	Unit
u	damper position	—
γ	concentration	various

4.2 Subscripts

For the purposes of this document, the subscripts as mentioned and given in EN 16798-5-1 and EN 16798-5-2 apply.

More information on key EPB subscripts is given in CEN ISO/TR 52000-2:2017.

NOTE If new subscripts are needed, indeed, please refer to the EPB standards template and Annex C of EN ISO 52000-1:2017 for detailed rules.

Additional subscripts are given in Table 2.

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Table 2 — Subscripts

Subscript	Term
Bal	balanced
D	damper
F	fan
Fld	full load
Gas	going to the gas
R	resistance
SP	setpoint

4.3 Abbreviations

For the purposes of this document, the abbreviations as mentioned and given in EN 16798-5-1 and EN 16798-5-2 apply.

More information on key EPB abbreviations is given in CEN ISO/TR 52000-2:2017.

NOTE If new abbreviations are needed, indeed, please refer to the EPB standards template and Annex C of EN ISO 52000-1:2017 for detailed rules.

Additional abbreviations are given in Table 3.

Table 3 — Abbreviations

Abbreviation	Term
C	Central controller
CR	Zone based controller
R	Resistance
VOC	Volatile oxide components

5 Brief description of the methods and routing

5.1 Output of the methods

The accompanied EPB standards, EN 16798-5-1 and EN 16798-5-2, cover two different methods for the calculation of the energy performance of ventilation and/or air conditioning systems.

Because the scope and the applicability range of the two methods are different, it was decided to divide the description in two separate documents.

5.2 General description of the methods

5.2.1 Method 1

The method covers the calculation of:

— the volume flow rates provided to the ventilation zones served by the system, based on the required values;

— the supply air temperature and moisture content, based on the required values;

— the ventilation generation input (electric energy required by fans);

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— the humidification generation input;

— heating (including humidification in case of reheat with adiabatic humidification) and cooling input to the air handling unit (to be transferred to the connected heating and cooling distribution systems calculation);

— the recoverable heat or cold losses from ventilation/air conditioning system for heating or cooling;

— the ventilation auxiliary energy (electric energy for drives of, e.g. rotary or pumped circuit heat recovery devices, control devices, actuators, etc.);

— the electric energy required for humidification (only for specific humidifier types); and

— the humidification auxiliary energy.

The time interval of the output can be:

a) hourly, or

b) bin,

according to the application of the standard and interval of the input.

5.2.2 Method 2

The method covers the calculation of:

— the volume flow rates provided to a single ventilation zone (no multi ventilation zones modelling) served by the system, based on the required values;

— the supply air temperature, based on the required values;

— the ventilation generation input (electric energy required by fans);

— heating and cooling input to the air handling unit (to be transferred to the connected heating and cooling distribution systems calculation);

— the recoverable heat or cold losses from ventilation/air conditioning system for heating or cooling; and

— the ventilation auxiliary energy (electric energy for drives, control devices, actuators, ...).

The time interval of the output can be:

a) monthly,

b) yearly, or

c) bin,

according to the application of the standard and time interval of the input.

5.3 Selection criteria between the methods

The criteria for the selection are:

— the technologies covered by the methods; and

— the calculation interval.

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Method 1 is applicable for full air conditioning systems, including heating, cooling, humidification, dehumidification, covering different control options such as constant and variable air volume flow rates, different fan controls, different heat recovery types with different frost protection technologies, constant and variable recirculation air, and adiabatic cooling. It is mainly dedicated to larger customized air handling units and distribution networks. It can only be applied to hourly calculation intervals and – with the respective technique provided – with bins.

Method 2 is applicable for ventilation systems with heating and cooling, including heat recovery and recirculation. It does, however, not cover humidification and dehumidification. On the other hand, it covers the use of extract air heat as a source of heat for domestic hot water production and includes the heat generation by heat pumps. It is dedicated to packaged systems including heat generation and/or DHW production, as they are mainly used in residential buildings. But the application is by intention not restricted though the building use type. The method can be applied to monthly and yearly calculation intervals and bins.

5.4 Application and implementation of the methods

5.4.1 Method 1

The method contains a lot of options, the choice of which needs to be made, in order to consider:

— different air treatment stages, which may or may not be present in the system to be represented (e.g. recirculation, heat recovery, heating, cooling, humidification, dehumidification, adiabatic cooling);

— different types of components for certain treatment stages (e.g. heat recovery types, humidifier types); and

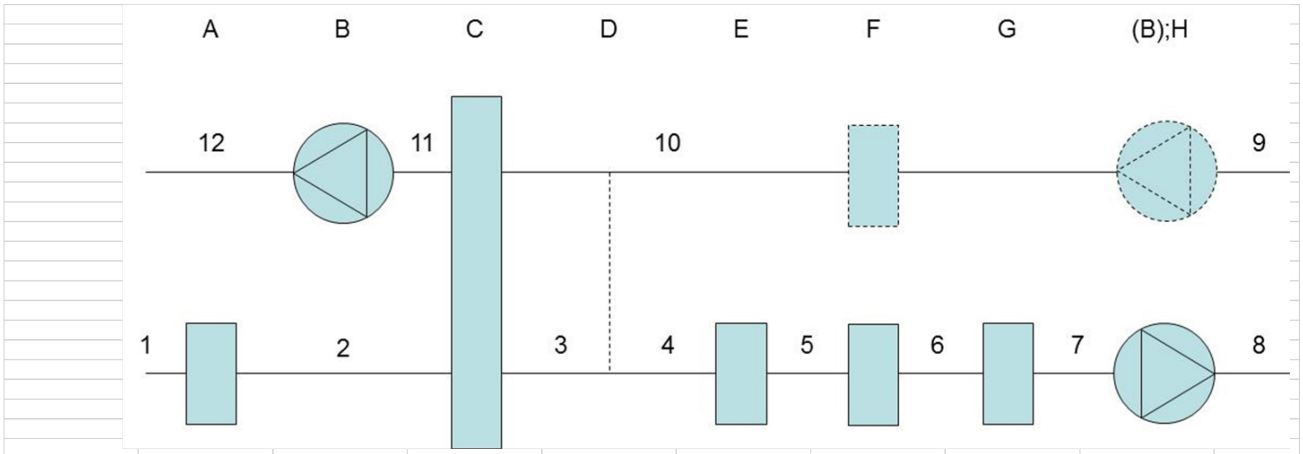
— different control options.

In the implementation of the method in the accompanying spreadsheet [3], a “system configuration” sheet was added. It allows making the relevant choices, which influence the calculation procedure, as shown in Figure 1.

The layout of the choices refers to the scheme shown above, which originates from Figure 1 in EN 16798-5-1:2017.

Some choices of the presence of principal treatment stages are controlled by the presence of the respective energy supply at the data input interface (heating, cooling), or by the presence of the respective set points at the respective data input interface (humidification, dehumidification). This means, no special keywords and identifiers are present in the standard for the choice of these options.

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General	A	B	C	D	E	F	G	H
Volume flow rates	Frost protection / ground preheating/-coo-ling	Exhaust air fan	Heat recovery	Recirculation	Cooling / dehumidification	Humidification	Heating	Supply fan
Detailed								
Air handling unit localosation	Ground air preheating and -cooling	localisation	Heat recovery type			Humidifier type		Fan motor localisation
NC	NONE	UP_HR	ROT_HYG	yes		CONTACT		OUTS_AIR
Supply air temperature control	Frost protection type		only for FLAT_PLATE and ROT_HYG	Recirculation control		humidifier control		System type for variable air volume flow rate fan energy calculation
ODA_COMP	PREH		Residential	VARIABLE		ON_OFF		SINGLE_ZONE
Control of the volume flow rate	Control of the frost protection		Control of the heat recovery device			humidification energy carrier		Control of the fan
ODA_COMP	INDIRECT		SPEED			HUM_CR_EL		DIRECT
System type						Adiabatic cooling		localisation
else						no		UP_HR

Figure 1 — System configuration table from the spreadsheet

5.4.2 Method 2

The method contains a lot of options, the choice of which needs to be made in order to consider different air treatment stages, which may or may not be present in the system to be represented (e.g. recirculation, heat recovery, heating, cooling).

In the implementation of the method in the accompanying spreadsheet, all relevant choices, which influence the calculation procedure, have their input in the “Input_series” sheet and “Method_input” sheet.

6 Calculation method 1 (EN 16798-5-1)

6.1 Output data

No further explanations.

6.2 Calculation time interval and calculation period

The method described in Clause 6 is mainly suitable for an hourly calculation interval. For the application to bins, see 6.4.1.

6.3 Input data

6.3.1 Source of data

This method covers a large variety of technologies and design options. Accordingly, the amount of required input data and option choices is also large.

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For the typical type of systems the method is designed for, the respective data may be available from design and/or maintenance documents, since these systems are usually operated by professional facility managers.

However, there may be cases where it is difficult or impossible to get the respective data in a reasonable amount of time. For these cases, the recommendation is to refer to the default values in Annex B of EN 16798-5-1:2017, or to a respective national Annex provided. The latter may be necessary due to differences in the frequency of technologies used in specific countries.

In special cases, the amount of data are reduced by the choice of a specific technology. For example, a plate heat exchanger for the heat recovery requires drastically less input data than other types. Also, the abandonment of specific technologies on a national basis may lead to a reduced amount of necessary input data.

6.3.2 Product data

6.3.2.1 Product description data (qualitative)

No further explanations.

6.3.2.2 Product technical data

6.3.2.2.1 General

No further explanations.

6.3.2.2.2 Duct leakage factors

The duct leakage factors can be precalculated according to Formulae (1) and (2), based on measured data according to product related standards (EN 14239, EN 12237 and EN 1507, depending on the form of the ducts).

In the absence of detailed information, tabled duct leakage factors can be used depending on the duct air tightness class.

6.3.2.2.3 Air handling unit leakage factors

In a similar way the air handling unit leakage factor can be precalculated in Formula (3), based on data according to EN 1886.

In the absence of detailed information, tabled duct leakage factors can be used depending on the AHU air tightness.

6.3.3 System design data

6.3.3.1 Process design

No further explanations.

6.3.3.2 Control

No further explanations.

6.3.4 Operating conditions

No further explanations.

6.3.5 Constants and physical data

No further explanations.

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6.4 Calculation procedure, method 1

6.4.1 Applicable calculation interval

This procedure has been designed and tested for an hourly calculation interval.

For the application to bins, as indicated in EN 16798-5-1, it may be necessary to provide bins for several independent operational and boundary condition parameters. For example, volume flow rate may vary with the heating/cooling load, the outdoor proportion depends on the occupation, and the system is dependent on the outdoor temperature via the heat recovery operation. This leads to a multi-dimensional matrix of bins. The process for the generation of these bins is rather complex. Therefore it may in many cases be simpler to do a sequential hourly calculation.

6.4.2 Distribution calculation

6.4.2.1 Operating conditions calculation

6.4.2.1.1 Volume flow rates

6.4.2.1.1.1 Detailed calculation

For this calculation, the supply and extract volume flow rates to and from the specific ventilation zones are required inputs from the emission calculation (module 5-5). If they are not available, the simplified calculation according to 6.4.2.1.1.2 is applied.

The required volume flow rates to be provided by the air handling unit to the distribution duct system are modified by the leakage of the duct system (Formulae (4)a) and (5a)).

The supply volume flow rate really entering the distribution system and the extract volume flow rate really leaving the distribution system are calculated further down in the generation part (Formulae (23) and (24), 6.4.3.2.1), depending on the control type. They are generally not equal to the required flow rates; for some control options they are.

The volume flow rates supplied to and extracted from specific ventilation zones served by the system are calculated by distributing the real supply/extract flow rates proportionally to the required flow rates (Formulae (6) and (7)). This is a simplification and may not occur precisely in practise, due to the different pressure drops in the different branches.

The leakage volume flow rates going to or extracted from a specific zone are calculated with Formulae (8) and (9). The zone can be a ventilation zone or a thermal zone. They are needed for the mass flow balance in the zone (module 5-5). The supply leakage flow rate is also needed to calculate the thermal losses due to the leakage, recoverable in the specific thermal zone (Formulae (21) and (22), see 6.4.2.2). Recoverable heat losses are recoverable in a thermal zone. Therefore, this term is used here. For the distinction between the ventilation zone and thermal zone see EN ISO 52000-1:2017, Clause 10 (where the ventilation zone is called a service area) and 6.4.2.1.2, including the example in Figure 2. The leakage volume flow rate going to the non-conditioned space calculated in Formula (10) leads to a non-recoverable thermal loss (Formula (21)).

The maximum volume flow rate factor $f_{V;max}$ calculated in Formula (11)a) is needed later for the fan energy calculation (6.4.4.1)

6.4.2.1.1.2 Simplified calculation

For this calculation, instead of the individual supply and extract volume flow rates to and from the specific thermal zones, only the part load factor and the diversity of the flow rates for the current time step are required inputs.

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The volume flow rates required to be provided by the air handling unit to the distribution duct system are calculated with the part load factor of the current time step and the maximum (design) supply and extract volume flow rates of the system in Formulae (4)b) and (5)b).

The maximum volume flow rate factor $f_{V;max}$ is calculated in Formula (11)b) with the current part load factor and the volume flow rate diversity Δf_V at the current time step, which is a required local input.

6.4.2.1.2 Air temperature and humidity change in the ductwork

These calculations are restricted to situations with overpressure in the supply and underpressure in the extract air system, leading to a leakage flow rate going from the supply air system to its surrounding and from the surrounding to the extract air system (not vice versa, the normal situation with balanced air systems with air handling units and ductwork).

Both the required and the real supply air temperatures are modified in the duct due to the thermal losses of the ducts (Formulae (12) and (13)).

Again, the distinction is made between the temperature drop in the non-conditioned space (Formula (14)) and the one to the conditioned thermal zones (Formula (15)). The calculation is given only for one specific zone.

Both the required and actual supply air humidity content remain unchanged (Formulae (16) and (17)).

For the extract air, only the leakage and the transmission heat exchange from the unconditioned space is taken into account. It is assumed that the extract air temperature is close enough to the conditioned zone temperatures to neglect these effects in the conditioned zones (Formulae (18) and (19)).

For the humidity content of the extract air, there is an additional contribution from the non-conditioned surroundings due to the entering leakage flow rate (Formula (20)).

There are a lot of different possible situations, with different ventilation and thermal zones. Therefore it is not possible to give a general method to cover all situations. The general method is explained with an example shown in Figure 2.

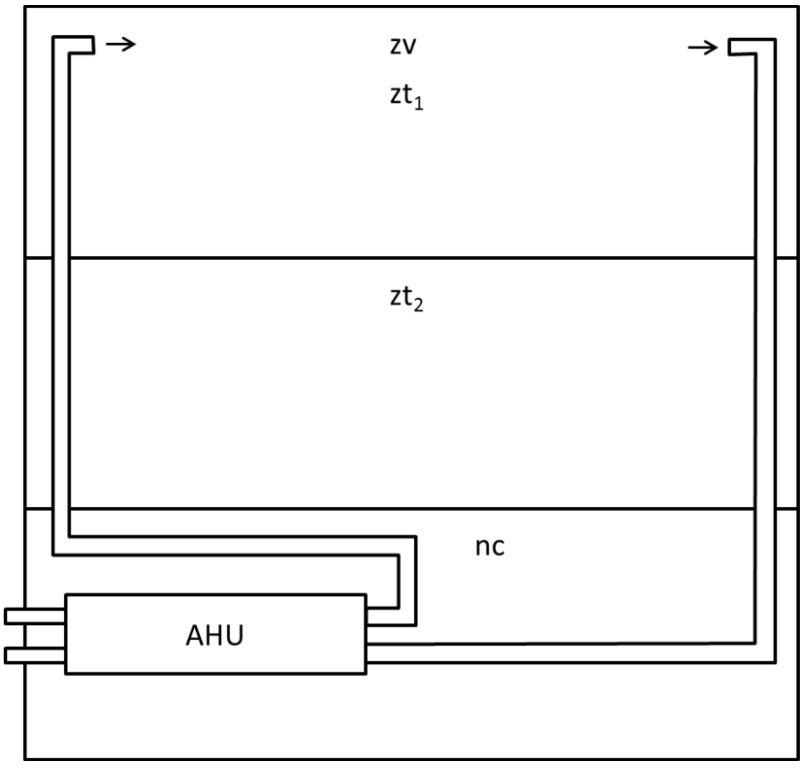


Figure 2 — Ventilation and thermal zone example

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In this example, an air handling unit (AHU) is situated in a non-conditioned space. It serves the ventilation zone zv. In EN ISO 52000-1:2017, the entity called here a ventilation zone is referred to as a ventilation service area.

The supply and extract ducts are crossing the non-conditioned space, a thermal zone zt_2, not served by the ventilation system, and finally the thermal zone zt_1, which is identical to the ventilation zone zv served by the system.

In this setup, the system has:

— a leakage flow from the AHU to the non-conditioned space; the losses associated to this are not recoverable;

— a leakage flow from the supply air duct to the non-conditioned space; the losses associated to this are not recoverable;

— thermal losses from the supply air duct to the non-conditioned space; they are not recoverable;

— a leakage flow from the supply air duct to the conditioned thermal zone zt_2; the losses associated to this are recoverable in thermal zone zt_2;

— thermal losses from the supply air duct to the conditioned thermal zone zt_2; they are recoverable in thermal zone zt_2;

— a leakage flow from the supply air duct to the ventilation zone zv (identical to the conditioned thermal zone zt_1); the flow is considered in the air flow balance of ventilation zone zv, and the losses associated to this are recoverable in thermal zone zt_1;

— thermal losses from the supply air duct to the ventilation zone zv (identical to the conditioned thermal zone zt_1); they are recoverable in thermal zone zt_1;

— thermal losses from the extract air duct to the non-conditioned space; they are not recoverable;

— a leakage flow to the extract air duct from the conditioned thermal zone zt_2; this is accounted for in the mass balance of the system, the losses associated to this are neglected;

— thermal losses from the extract air duct to the conditioned thermal zone zt_2; they are neglected;

— a leakage flow to the extract air duct from the ventilation zone zv (identical to the conditioned thermal zone zt_1); the flow is considered in the air flow balance of ventilation zone zv and of the system, and the losses associated to this are neglected; and

— thermal losses from the extract air duct to the ventilation zone zv (identical to the conditioned thermal zone zt_1); they are neglected.

In order to calculate this, the system should be considered in different parts. The leakage flow rates and temperature differences are calculated separately for each piece situated in a different ventilation or thermal zone. The temperature and moisture content entering in one piece of the system is the one leaving the preceding part. The calculation for the required flow rates and temperatures is done from the emission in ventilation zone zv backwards to the AHU, the one for the really provided values from the AHU to the ventilation zone zv.

In the simplest case, there is only one ventilation zone and one conditioned thermal zone, both being identical, and the AHU is situated in the thermal zone. In this case, zv = zt, and the flow rates entering and leaving the distribution system are those from the AHU and the ventilation zone zv.

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6.4.2.2 Energy calculation

6.4.2.2.1 Distribution heat losses

The total heat losses of the ductwork are calculated as the sum of the supply and the extract losses due to leakage flows and heat transmission in the different pieces of ductwork (Formula (21)).

6.4.2.2.2 Recoverable distribution heat losses

The recoverable heat losses of the ductwork to a specific thermal zone are calculated as the sum of the supply losses due to leakage flows and heat transmission (Formula (22)). No contribution is coming from the extract ductwork.

See the example above in 6.4.2.1.2 for the explanation of the calculation of recoverable heat losses.

6.4.3 Generation calculation

6.4.3.1 General

Figure 1 of EN 16798-5-1:2017 (see also Figure 1) shows the air treatment stages and the associated air type subscripts (in accordance with M5-1, EN 16798-3) used in this clause.

NOTE A preheating coil after the heat recovery/recirculation mixing would be necessary in the case of adiabatic humidification. This is not represented here. The associated heating energy is taken into account in the (re)heating coil.

6.4.3.2 Operating conditions calculation

6.4.3.2.1 Air flow rates in the air handling unit

The volume air flow rates supplied to and extracted from the distribution system depend on the control strategy. The following control-types are considered in Formulae (23) and (24):

— AIR_FLOW_CTRL = NO_CTRL (no flow rate control, continuous operation);

— AIR_FLOW_CTRL = ON/OFF_CTRL (time dependent flow rate control, continuous operation during occupancy time);

— AIR_FLOW_CTRL = MULIT_STAGE (multi stage variable flow rate control); and

— AIR_FLOW_CTRL = VARIABLE (continuously variable flow rate control).

These options are in line with EN 15232-1.

Figure 3 shows the different daily profiles of the volume flow rates for an example of a nominal volume flow rate of 1 000 m^3/h and a given profile for the required volume flow rate. The latter is an input from Module M5-5 and may e.g. be a result of the occupancy profile, which is expected to be provided according to M1-6. For the example it is following the occupancy profile from EN 15232-1:2017, Annex C.

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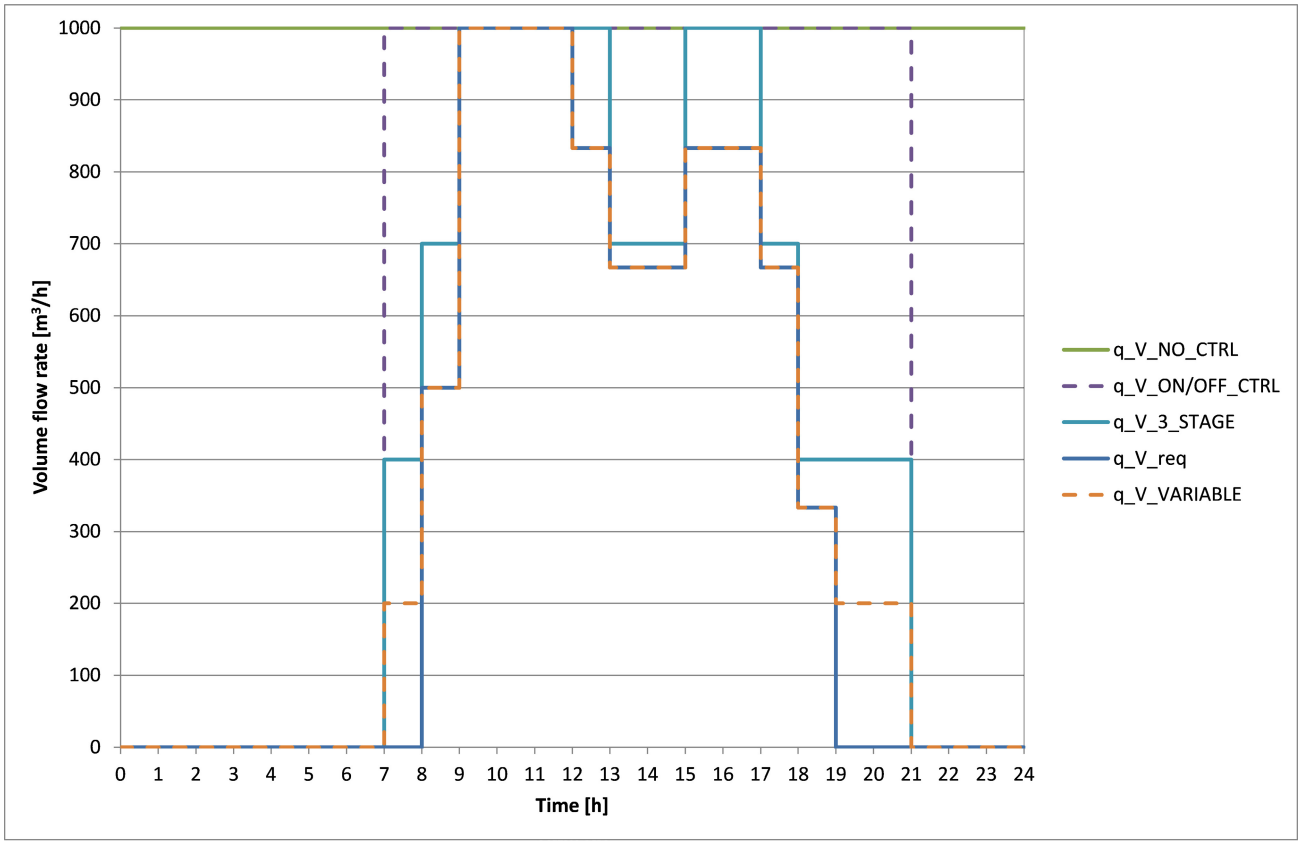


Figure 3 — Example of resulting daily volume flow rate profiles for the four control options with a given profile of required flow rates

For option NO_CTRL the system runs continuously during 24 h. For option ON/OFF-CTRL it runs during the operation time, which is defined by the $f_{op;V}$ parameter, which is a local input. For the option MULTI_STAGE, a 3 stage example is shown with flow rates of 400, 700 and 1 000 m³/h for the 3 stages. The system runs always on the stage that provides at least the required flow rate. For option VARIABLE, the profile follows the profile of the required flow rates except for the operation time with the required flow rate lowar than the minimum ratio, where the reduction is limited (at 0,2 in this example).

The air volume flow rates transported by the supply and exhaust fans in the air handling unit are enhanced by the air handling unit leakage flow rates and by the heat recovery leakage flow rates (Formulae (25) and (26)). The heat recovery leakage factors have to be taken into account, they are discussed below in 6.4.3.2.6. In these two formulae, the actual outdoor air fraction f_{ODA} should be used. Instead, the minimum outdoor air fraction $f_{ODA;min}$ is used. This is a measure to avoid the need of iterations. As discussed in 6.4.3.2.5 for the recirculation control, the heat recovery is only in operation in sequence after the recirculation. However, the heat recovery is passed also during times when the recirculation is not in operation. Therefore, the AHU flow rates and thus the fan energy consumption is underestimated during these times. The alternative would be to always consider the full leakage also during recirculation times, which in turn would lead to an overestimation. This whole effect is considered to be of minor importance, since the presence of recirculation and rotary heat recovery is a rather rare configuration.

The air handling leakage flow rates themselves are calculated in Formulae (27) and (28) and transferred to module M5-5, to be considered in the zone mass balance in the case when the air handling unit is situated in the conditioned zone.

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6.4.3.2.2 Supply temperature control

The supply air temperature depends on the control strategy. The following control-types are considered in Formula (29):

— If SUP_AIR_TEMP_CTRL = CONST (constant supply air temperature);

— If SUP_AIR_TEMP_CTRL = ODA_COMP (Variable set point with outdoor temperature compensation); and

— If SUP_AIR_TEMP_CTRL = LOAD_COMP (Variable set point with load dependent compensation).

For the option LOAD_COMP, the setpoint is defined locally in the ventilated zone and therefore an input from Module M5-5 (modified according to Formula (12)). For the other options the values are local inputs.

No formula is needed here for the option SUP_AIR_TEMP_CTRL = NO_CTRL (no supply temperature control); but this option is provided in Table 19, because it is used at different places in other formulae (see below).

6.4.3.2.3 Temperature rise in the fan

The air temperature increase in the fans is calculated in Formula (30) based on the fan pressure difference calculated in Formulae (74) and (75) in 6.4.4.1, considering the recovered ratio of the fan power, depending on the fan motor location (FAN_MOT_LOC parameter).

The air temperature leaving the extract fan depends on the location (ETA_FAN_LOC parameter): if it is upstream the heat recovery device or the recirculation, the $\Delta\vartheta_{fan;ETA}$ is considered, else not (Formula (31)).

6.4.3.2.4 Ground air preheating and -cooling

The air temperature difference reached in a ground preheating is calculated with an algorithm which is given in the informative Annex C.

There is no identifier with options “yes” or “no” used for the presence of the ground air preheating/-cooling. The absence can simply be covered by entering a default value of $\Delta\vartheta_{gnd} = 0$.

The temperature difference may be negative in the case of cooling operation. Formula (32) is given in a way that both heating and cooling are covered and the location of the supply fan is considered.

The distinction is made between a non-controlled operation and a control with the help of a bypass. The calculation of $\Delta\vartheta_{gnd}$ for the use in Formula (32) has to be done with the total flow rate running through the ground preheating/-cooling ducts. In case of a bypass control, the calculation according to Annex C should be performed again based on the actual volume flow rate proportion going through the ground preheating/-cooling ducts, because the pressure drop and therefore the influence on the fan energy is influenced by this. The respective calculation is not given here.

A temperature loss or gain is considered for the case of the outdoor air duct passing through the conditioned and/or unconditioned zones. The calculation is done in analogy to the supply/extract air heat losses in 6.4.2.1.2.

The humidity content may change in the ground air ducts due to condensation on the duct surface, Formula (33).

6.4.3.2.5 Recirculation

Recirculation is only considered if located inside the heat recovery (downstream in the supply air) or without heat recovery. If located outside (upstream in the supply air), it is considered to serve for frost protection and is treated in 6.4.3.2.7.

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According to [4], p. 67 the recirculation and the heat recovery are controlled in sequence: "Within the control range of the air dampers, the HRU is still switched off, and may even be bridged out. This means that only mixing of the two air flows occurs." Therefore the set point temperature for the heat recovery has to be calculated in consideration of the recirculation, for a fixed or variable recirculation proportion (Formula (34)).

The minimum outdoor air fraction $f_{ODA;min}$ is calculated in Formula (35) depending on the control options: if there is a control signal from the zones (e.g. based on measured CO_2 levels) to the recirculation control (feedback loop, option RCA_CTRL = VARIABLE), $f_{ODA;min}$ is set to the maximum of all required outdoor air fractions of the zones at the current time steps. This avoids insufficient air quality in every zone. If there is no feedback loop, $f_{ODA;min}$ is set to the sum of all required outdoor air flow rates *at design conditions* (usually higher than the required outdoor air flow rate at the current time step), which is assumed to be the (fixed) set point for the RCA controller.

In the case of rotary heat exchangers, the outdoor air fraction is limited due to the heat recovery leakage. For some configurations it will never become 1 because some recirculation of extract air is taking place due to the leakage.

The supply temperature after the recirculation is calculated in different ways, depending on the combination of controls of the heat recovery. If the heat recovery is uncontrolled (HEAT_REC_CTRL = NO_CTRL), the set point is ignored and the supply temperature is a result of the heat recovery and the minimum outdoor air fraction (Formula (36)a)). If it is controlled, the recirculation is controlled to the supply air set point as long as it can be reached (Formula (36)b)).

For the calculation of the supply moisture content after the recirculation, the outdoor air proportion of the current calculation interval has to be calculated (Formula (38)) and used for the air mixing (Formula (37)).

6.4.3.2.6 Heat recovery

The calculation procedure covers the most frequent types of heat recovery devices: plate heat exchangers, rotary heat exchangers with different coatings, pumped circuit systems, and a generic type "OTHER", in order to specify own types on a national basis. The choice and the associated control options are given in Tables 5 and 22, default values are given in B.16.

The heat recovery leakage factors are important for rotary heat exchangers. They do not consider the carry-over, but the flows due to leakage between the supply and extract air flows, which may be an order of magnitude larger than the carry-over. They depend strongly on the system configuration, especially the fan location. In the calculation, they have to be considered already in earlier steps of the AHU air flow rate and recirculation calculation (see above, 6.4.3.2.1 and 6.4.3.2.5). Default values for rotary heat exchangers are given in Annex B.

The supply air temperature after the heat recovery depends on the control possibility. If REC_CTRL = NO_CTRL (no heat recovery control), it becomes the temperature calculated with the η_{rec} for the calculation interval (Formula (39)a)), else it is controlled to the supply set point calculated in Formula (34). This is done by bypass for plate heat exchangers or by reducing the rotation speed of the rotary heat exchangers or hydraulic measures in pumped circuits. The control distinguishes the operational situations of heat recovery, "cool recovery" or free floating when the heat recovery operation would be disadvantageous (Formulae (39)b through d)). The effect of frost protection has to be considered in this calculation, which is calculated further down with Formula (47).

The control may be used for the limitation of the supply temperature in case of mechanical ventilative cooling.

The temperature efficiency (defined according to EN 13053) is calculated as a function of the mass flow ratio, the air velocity, and the rotation number (for rotary heat exchangers) according to product data (Formulae (40) to (43)). For simplification reasons, the volume flow ratio is used instead of the mass flow ratio. Precisely, the actual outdoor air fraction f_{ODA} should be used in Formulae (41) and (43).

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Instead, the minimum outdoor air fraction $f_{ODA;min}$ is used. This, again, is a measure to avoid the need of iterations. In this case there is no negative effect, because the heat recovery is controlled in sequence to the recirculation, as discussed above in 6.4.3.2.5.

For heat recovery devices providing moisture transfer, this is calculated with Formulae (44) and (45).

For rotary heat exchangers, the calculation of the moisture recovery efficiency as a function of the moisture difference, the mass flow ratio, the velocity and the rotation number is done with a set of factors in Formula (45)a). No formulae for these factors are given in the normative part. This provides flexibility to specify them according to Table A.7. In Table B.7, however, a default set of functions is given in form of a reference to the informative Annex D. There, a set of formulae is given, using an additional set of parameters depending on the heat recovery type based on product measurement data [5].

For generic recovery types "OTHER", just one factor is used, which has to be defined in form of a function of different parameters, to be specified on a national basis.

6.4.3.2.7 Frost protection

Preventing frosting can be done in two ways:

— Direct defrosting control based on frost formation detection which may rely on differential pressure measurement across the heat exchanger, supply and exhaust air temperature trends measurement, light transmittance measurement combined with light source or other measurement allowing detection of the frost formation intensity. In this option, defrost control action (cycle or continuous) will be operated only on demand, when the frost formation amount limit is exceeded.

— Indirect defrosting control based on measurement of frost conditions, i.e. exhaust or outdoor air temperature measurement. In this option, defrost control action is launched always when the temperature drops below the limit value.

Both defrost control options can use the same cycling or continuous defrosting mode operation depending on the specific device. Some examples are bypass, reduction of rotation speed, preheating coil, switching off or reducing the speed of supply air fan, closing some parts of heat exchanger.

If DEFR_CTRL = DIRECT:

Defrosting performance measurements are set in EN 13053:2006, Annex A. To take into account the reduced efficiency of heat recovery, defrosting heat ratio ε_D of EN 13053:2006 is used in the heating energy need calculation for supply air heating when outdoor temperature drops below the limit value of defrost control, which is by default −5 °C according to EN 13053:2006. For outdoor temperatures below the limit, ε_D replaces heat recovery efficiency η_{hr} as follows (Formula (46)):

Between the limit value of defrosting control and −10 °C outdoor temperature the ε_D value of the −7 °C duty point is used;

Below −10 °C outdoor temperature the ε_D value of the −15 °C duty point is used.

The variables $\vartheta_{ODA;fp}$ and $\vartheta_{SUP;hr;lim}$ are set to the conditions as without frost protection in this case (Formulae (47)a) and (48a)).

If DEFR_CTRL = INDIRECT:

If defrosting performance measurement data are not available, indirect defrosting control is assumed and the following default values for heat exchanger efficiency reduction can be used. In such a case, the $\vartheta_{ETA;hr}$ value is limited to a $\vartheta_{ETA;hr;lim}$ value. The following default values $\vartheta_{ETA;hr:lim}$ can be used for if no national information is available:

— Residential non hygroscopic plate exchanger: 5 °C;

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— Residential rotary or hygroscopic plate exchanger: 0 °C;

— Non-residential plate exchanger: 0 °C;

— Non-residential rotary exchanger: −5 °C;

— Non-residential without humidification rotary heat exchanger: −10 °C.

For indirect defrosting control a correction value $\Delta\vartheta_{ETA;hr}$ is applied on $\vartheta_{ETA;hr}$ (Formula (49)).

The correction is applied to the supply air side, corrected with the flow rate relation if they are different (Formulae (47) and (48)).

In the case of indirect defrosting control with a preheating coil, the outdoor air is heated up to a $\vartheta_{ODA;preh}$ value. In the other cases (bypass or recirculation) the corrected value of $\vartheta_{SUP;hr;lim}$ is lower than the one without defrosting, which corresponds to the heating penalty devoted to the defrosting. This is taken into account in Formula (39)b).

NOTE $\vartheta_{ODA;preh}$ increases when the heat exchanger efficiency increases.

In both cases an additional energy input is required. This is calculated according to 6.4.4.10.1.2, Formula (90)a).

6.4.3.2.8 Adiabatic cooling

Adiabatic cooling can generally be done in different ways. The only way which is considered here is an adiabatic humidifier in the extract air and a heat recovery device on operation.

At the presence of an adiabatic cooling, the recirculation is assumed to be off ($f_{ODA;min} = f_{ODA;hr}$. i.e. = 1 in case of no heat recovery leakage).

The extract air temperature entering the heat recovery is calculated in Formula (51), based on constant efficiency of the adiabatic cooling humidifier. This requires the knowledge of the wet bulb temperature of the air entering the humidifier, which has to be calculated through psychrometric calculation methods, e.g. according to [6], which involves iteration. The extract air moisture content entering the heat recovery is calculated in Formula (52)a), with the saturation moisture content at the extract air distribution leaving wet bulb temperature, calculated according to Formulae (51) and (52a) with $\vartheta_{wb;ETA;dis;out}$.

The recirculation supply temperature is calculated in Formula (50), assuming to be controlled to the required set point, if the adiabatic cooling provides enough power. The properties of the supply air after the heat recovery are calculated according to Formulae (39)c) and (44), at full operation of the heat recovery. This means the control is assumed to be acting on the humidifier in the extract air.

There is no identifier given for the presence of adiabatic cooling. In case of absence, the ETA air properties remain unchanged according to Formulae (51)b) and (52b).

6.4.3.2.9 Final supply air conditions

6.4.3.2.9.1 General

The supply air temperature and moisture content delivered to the distribution system is calculated through the air treatment steps, with the intermediate temperatures and moisture contents, as follows:

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6.4.3.2.9.2 Cooling and dehumidification

The required supply air temperature after the cooling coil is set (Formula (53)) to the minimum of:

— the cooling set point, if the operation of the cooling coil is on;

— the dehumidification set point, if the operation of the cooling coil is on; and

— the temperature after the recirculation mixing.

The supply air moisture content after the cooling coil is set (Formula (54)) to the minimum of:

— the dehumidification set point, if the operation of the cooling coil is on; and

— the entering moisture content minus the difference in moisture content due to uncontrolled dehumidification, if the operation of the cooling coil is on.

The difference in moisture content due to uncontrolled dehumidification in the cooling coil is calculated by using the bypass factor method with Formulae (55) to (57). The calculation in the controlled case is done the reversed way in Formulae (58) to (60).

The required water inlet temperature to the cooling coil, to be transferred to the general cooling calculation standard, M4-1, is calculated in Formula (61) on the base of a temperature efficiency of the cooling coil.

The actual supply air temperature and moisture content are calculated in Formulae (62) to (64), based on the actual heat extracted from the cooling coil and the actual cooling coil supply water temperature, which are inputs from the general cooling calculation standard, M4-1. They may or may not be the same as the required values, which are calculated in Formulae (61), and (80). This depends on the availability and on possible power restrictions of the cooling system.

6.4.3.2.9.3 Humidification

The supply air moisture content after the humidifier is set to the humidification set point in Formula (65), if the humidifier operation is on.

The change in supply air temperature in the humidifier depends on the humidifier type. If HUM_TYPE = STEAM, it is 0, else (for all other HUM_TYPE cases) the process is adiabatic and the air is cooled down (Formula (66)), causing an energy supply in the heating coil.

6.4.3.2.9.4 Heating

The required supply air temperature after the heating coil is set to the supply air temperature set point if the heating coil operation is on (Formula (67)).

The required water inlet temperature to the heating coil, to be transferred to the general heating calculation standard, M3-1, is calculated in Formula (68) on the base of a temperature efficiency of the heating coil.

The actual supply air temperature is calculated in Formula (69), based on the actual heat supplied to the heating coil, which is an input from the general heating calculation standard, M3-1. It may or may not be the same as the required extracted heat from the coil, which is calculated in Formula (84). This depends on the availability and on possible power restrictions of the heating system.

6.4.3.2.9.5 Fan

The supply air temperature after the supply fan is the final supply temperature delivered to the distribution system (Formulae (70) and (71)).

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6.4.3.3 Energy calculation

6.4.3.3.1 Fan

6.4.3.3.1.1 General

The fan energy consumption for the current calculation interval is the energy consumption for the service ventilation. It is calculated in Formula (72) for the current calculation interval, based on the current supply and extract volume flow rates, the current pressure differences of the supply and extract fans and the fan efficiencies, given as a generic function for the dependence of the efficiency of the supply / extract fan on the volume flow rate, derived from manufacturer's data, provided according to EN ISO 5801:2008, Formula (73).

The supply and extract fan pressure differences are highly dependent on the control of the fan (which is not the same as the control of the flow rates, covered in 6.4.3.2.1). For single zone ventilation systems, a lower flow rate can be controlled by closing dampers, and the fans remain uncontrolled, which means, they are pressing against a higher pressure, moving their operation point on the characteristic. Or it can be controlled by a speed control to adjust to the lower required flow rate, which in the case of single zone ventilation systems can act directly based on the zone flow rate requirement. The two versions lead to different fan energy consumption.

The problem is more complicated with variable volume flow rates in multiple zones, which are described in more detail below.

The following cases are covered:

— Single zone systems (SYS_TYPE = SINGLE_ZONE):

  — No fan control (FAN_CTRL = NO_CTRL, Formulae (74)a) and (75a));

  — Direct fan control (FAN_CTRL = DIRECT, Formulae (74)b) and (75b));

— Multi zone systems (SYS_TYPE = MULTI_ZONE):

  — No fan control (FAN_CTRL = NO_CTRL, Formulae (74)c) and (75c));

  — Constant pressure fan control (FAN_CTRL = CONST_PRES, Formulae (74)d) and (75d));

  — Minimum pressure fan control (FAN_CTRL = MIN_PRES, Formulae (74)e) and (75e)).

  The fan related input data required for this calculation is usually available on fan product data sheets. The relation with the fan related product testing standards has to be checked.

  The following description is taken from the standard control description provided by CEN TC 247 [11]. Information can also be found in [12] and [13].

6.4.3.3.1.2 Description of the considered multi zone system

Figure 4 shows an example of the considered multi zone ventilation system. It consists of two zones ($n_R = 2$) where each zone has one room. It is assumed that a controller CR1 controls the CO_2 concentration of the air in room 1 on a given set-point value by acting on an underlying air flow volume control loop. Zone 2 is controlled in the same way.

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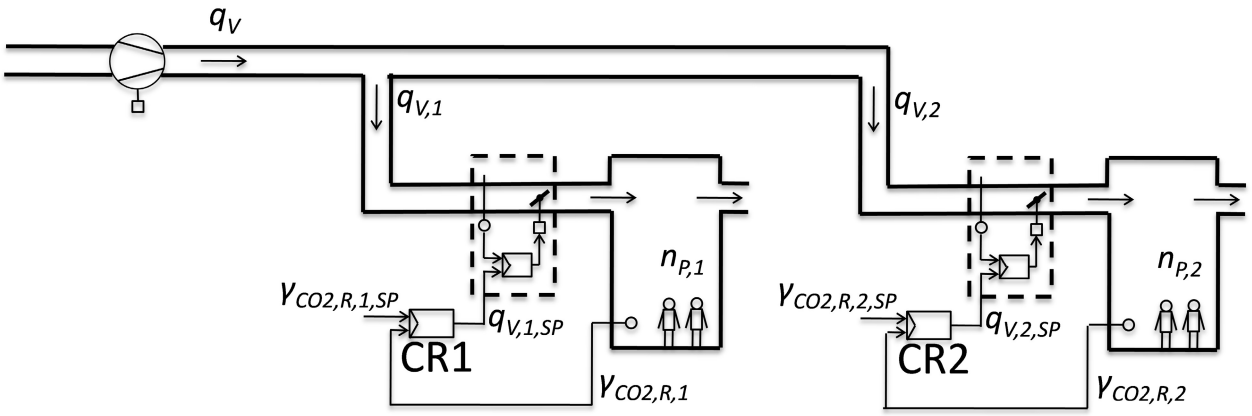


Figure 4 — Example of a multi zone ventilation system

The calculation formulae given in 6.4.3.3.1 of EN 16798-5-1:2017 are valid also for multi zone ventilation systems deviating from the system shown in Figure 4, such as

— more than two zones;

— more than one room in a zone, but only one zone controller acting on the supply air flow $q_{V;i}$ to zone i;

— zone controllers CR1 etc.: VOC (Volatile oxide components) or room temperature control, instead of CO_2 concentration;

— zone controllers CR1 etc.: Open loop instead of closed loop control, for example manual control, controller driven by time program (scheduler) or controller driven by a sensor measuring or estimating the number of persons in the room; and

— zone controllers CR1 etc.: The zone controller could act also directly on the fan drive motor, instead of an underlying air flow control loop.

6.4.3.3.1.3 The node model

Figure 5 shows the node model on the 'Volume flow rate'-Pressure-Level using an example of a ventilation system with two zones (n_R = 2), each zone with one room.

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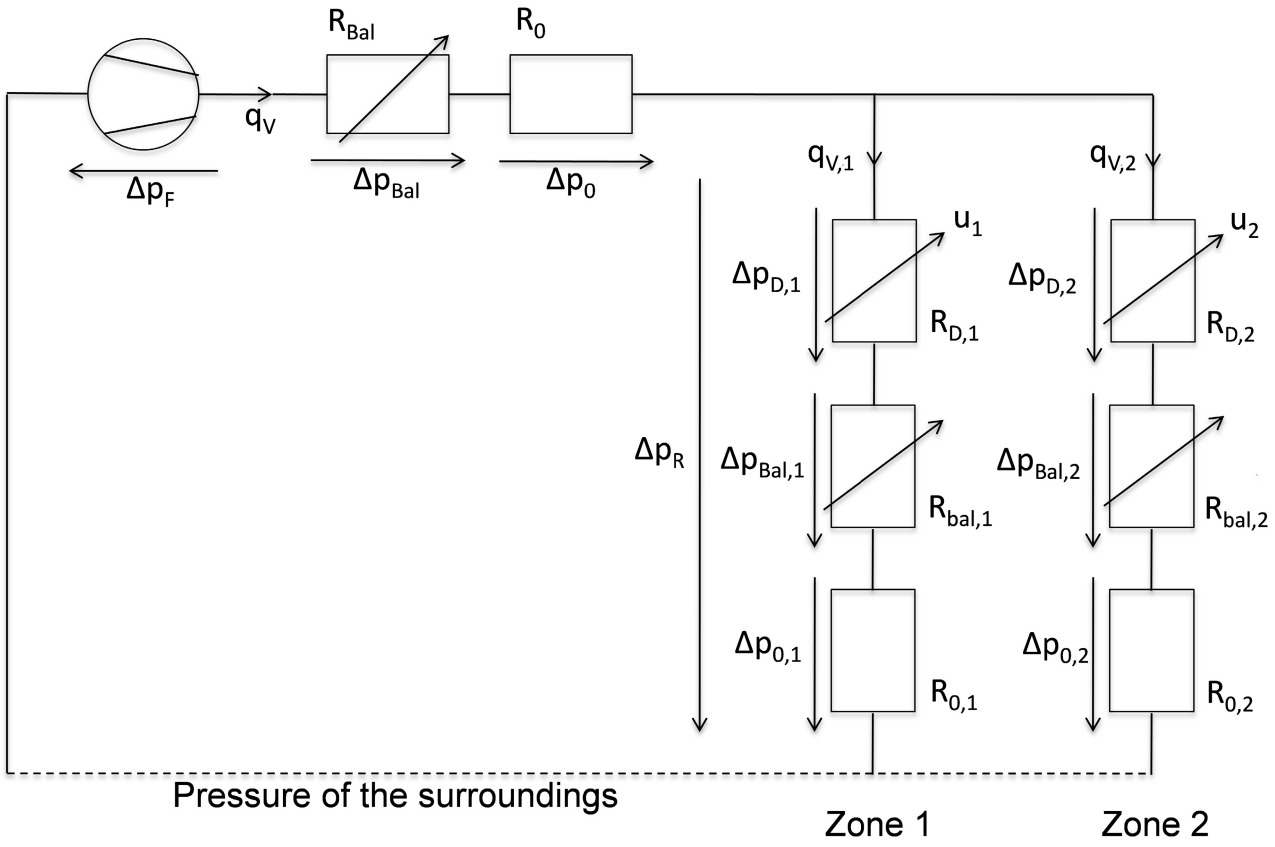


Figure 5 — The node model on the 'Volume flow rate' - Pressure-Level

6.4.3.3.1.4 Model assumptions

The model described in 6.4.4.1 is based on the following assumptions:

— The air is incompressible: It follows that the volume air flow rate is constant over the whole length of an air duct section without in- and outlet; and

— The pressure difference between the zones (rooms) and the environment (inclusive the neighbouring rooms) is zero.

6.4.3.3.1.5 Description of the fan control functions and their types

The different types of fan control functions in a multi zone ventilation system (as shown in Figure 4) are described in this section. The fan control function acts on the fan drive, for example by modulating the fan speed.

The local control functions CR1, CR2, etc. are described module M5-5. They are considered here only indirectly, because the air volume flow rates $q_{V,1}$, $q_{V,2}$, etc. are determined by these local controllers.

For FAN_CTRL = NO_CTRL (no control) see Figure 4.

For FAN_CTRL = CONST_PRES (constant pressure control) the controller C1, acting on the fan, controls the pressure in the distribution duct (i.e. the pressure difference Δp_R between duct and environment) on a constant set-point value $\Delta p_{R,SP}$. It is a closed loop control with for example the fan speed as control variable, Δp_R as controlled variable and $\Delta p_{R,SP}$ as set-point value. See Figure 6.

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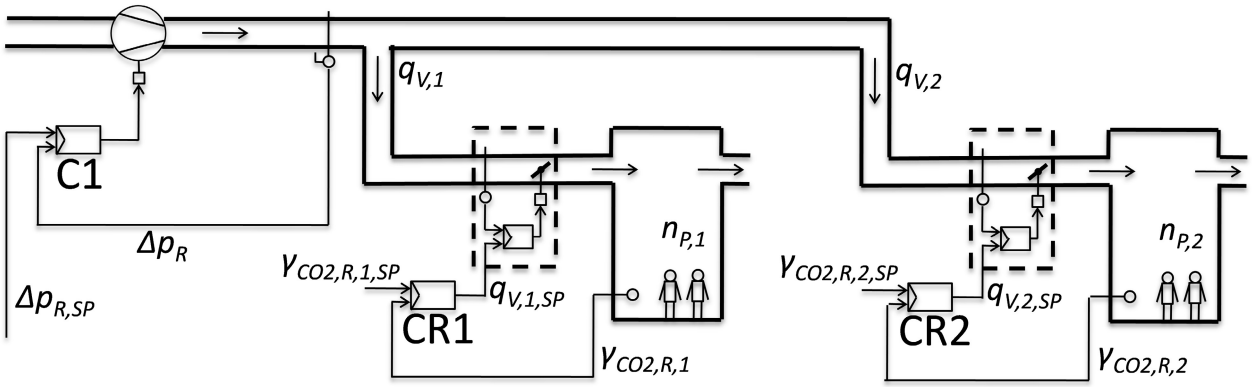


Figure 6 — FAN_CTRL = CONST_PRES – Constant pressure control

For FAN_CTRL = MIN_PRES two variants are considered.

— Version **1**: **Control to minimum pressure, acting on a pressure control loop.** Or in other words: pressure control with maximum pressure reset.

— Version **2**: **Control to minimum pressure, acting directly on fan drive.** Or in other words: maximum pressure reset acting directly on the fan drive.

For FAN_CTRL = MIN_PRES, version **1** (control to minimum pressure, acting on a pressure control loop) the controller C1, acting on the fan, controls as for type b the pressure difference Δp_R on a set-point value $\Delta p_{R,SP}$ but this set-point is reduced by a second control loop to a minimal possible value. This second control loop consists, as can be seen in Figure 7, of the controller CR2 and the functional unit "max". The inputs to the functional unit "max" are normalized values of the damper positions or control variables u_i of the two local controllers. "Normalized" means that the value is 100 % if the damper is completely open. The controller C2 is controlling the maximum u_{max} of these normalized damper positions on the set-point value $u_{max,SP}$ by acting on the set-point of controller C1. The set-point $u_{max,SP}$ of controller C2 would ideally be 100 %, but it is usually selected in practice as 90 %. This leaves to the controller C2 a margin for control deviations on both sides (negative and positive control errors), which is necessary for the proper functioning of a closed loop controller.

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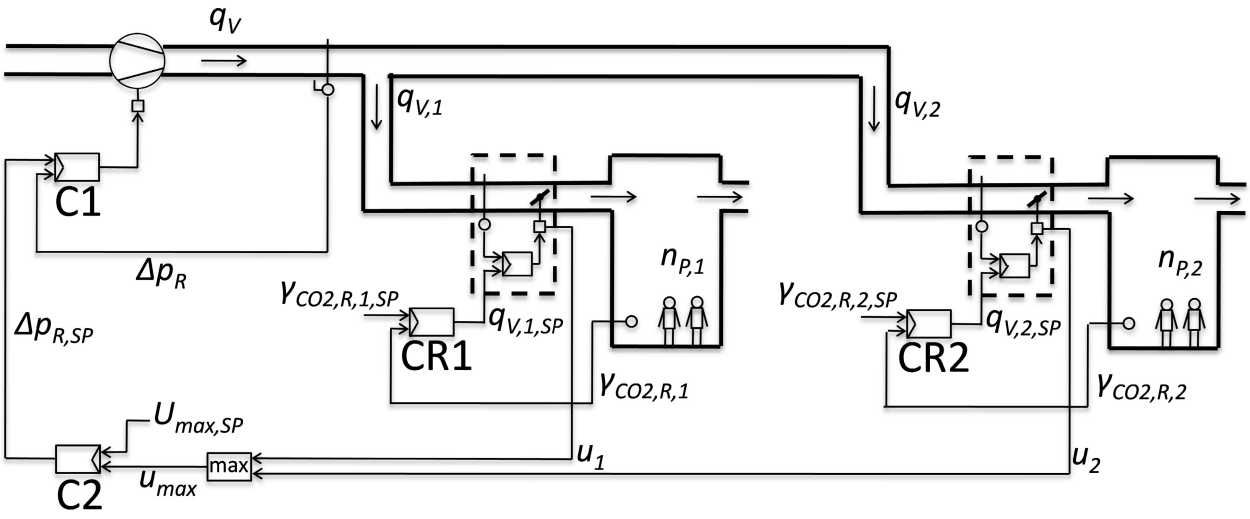


Figure 7 — FAN_CTRL = MIN_PRES, version 1 - Control to minimum pressure, acting on a pressure control loop

FAN_CTRL = MIN_PRES, version **2** (control to minimum pressure, acting directly on fan drive) is very similar to version 1, but the controller C2 is not acting on the set-point of an underlying control loop (control loop with the controller C1), but it is acting directly on the fan, making the controller C1 unnecessary. See Figure 8.

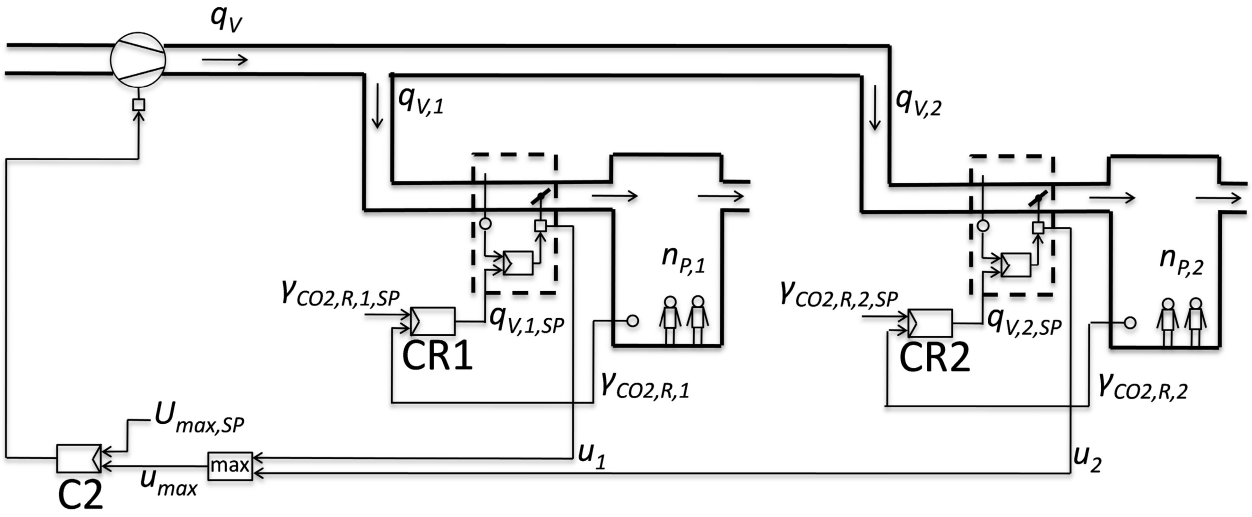


Figure 8 — FAN_CTRL = MIN_PRES, version 2 – Control to minimum pressure, acting directly on fan drive

The mathematical representation of this case (Formulae (74)e) and (75e)) accounts for one portion of the total pressure difference which is controlled to be constant (the one over the local flow control device – VAV box) and one which is varying according to the flow rate.

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6.4.3.3.1.6 Graphs showing the impact of fan control on the energy performance for multi zone ventilation systems

Fan power consumption in partial load operation for FAN_CTRL = CONST_PRES (constant pressure control).

Figure 9 shows the gas power consumption $P_{F,Gas}$ of the fan as a function of the partial load factor *f*.

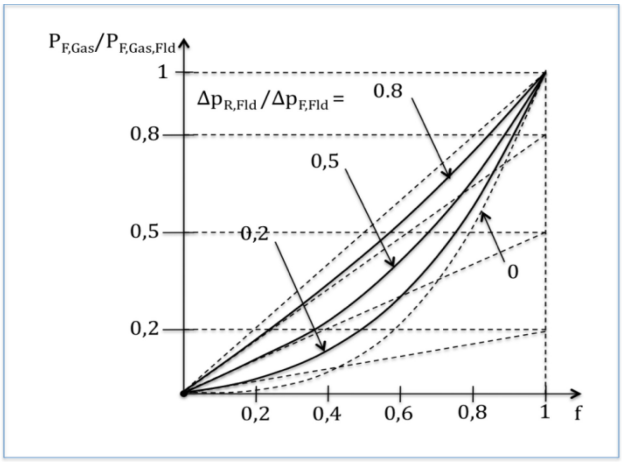
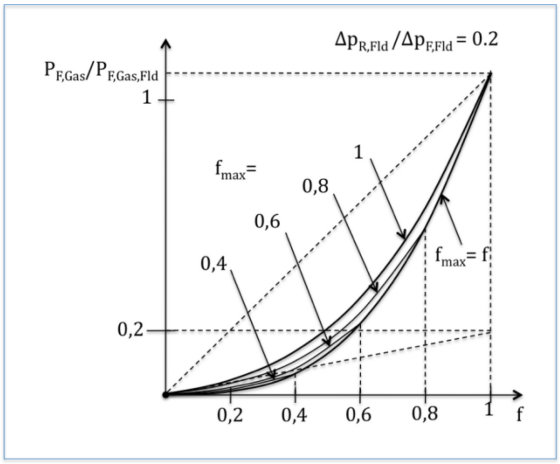


Figure 9 — Representation with the relative pressure difference over the zone branches $\Delta p_{R,Fld}/\Delta p_{F,Fld}$ as a parameter

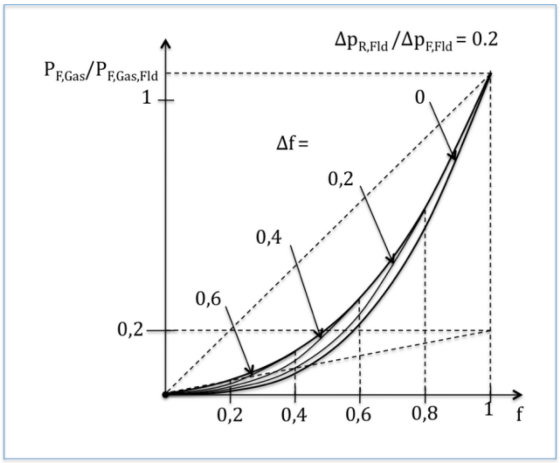
Fan power consumption in partial load operation for FAN_CTRL = MIN_PRES (control to minimum pressure).

Figures 10 to 12 show the gas power consumption $P_{F,Gas}$ of the fan as a function of the partial load factor.



a)

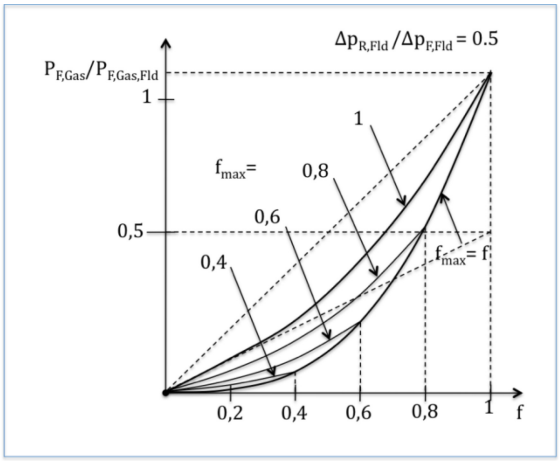
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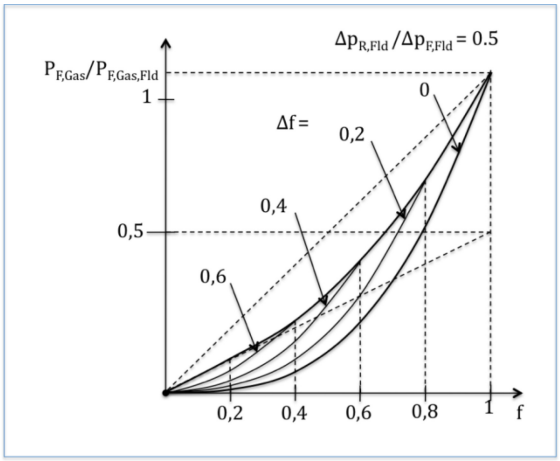
b)

Figure 10 — Pressure difference over the zone branches is small compared to that over the fan

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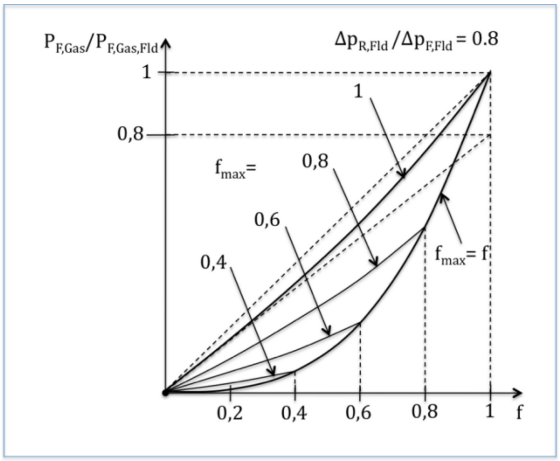
a)



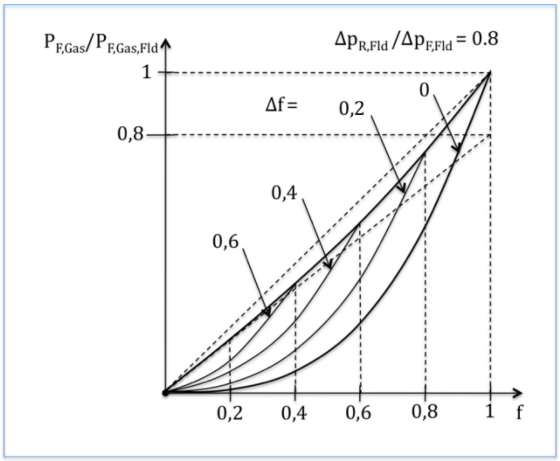
b)

Figure 11 — Pressure difference over the zone branches is medium-sized compared to that over the fan

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a)



b)

Figure 12 — Pressure difference over the zone branches is large compared to that over the fan

In this case (pressure difference over the zone branches is large compared to that over the fan) the fan control function FAN_CTRL = MIN_PRES can reduce the fan energy consumption considerably compared to the fan control function FAN_CTRL = CONST_PRES, but only if the partial load diversity is small.

NOTE The graphs are taken from [11] or [12], respectively.

6.4.3.3.2 Ground preheating and -cooling

The energy transferred by the ground preheating and precooling in the current time step is calculated with Formula (76). It is only needed for reporting purposes, for the calculation of partial performance indicators.

6.4.3.3.3 Heat recovery

The energy transferred by the heat recovery in the current time step is calculated with Formula (77). It is only needed for reporting purposes, for the calculation of partial performance indicators.

The required energy supplied by the heating coil without heat recovery in the current calculation interval is calculated with Formula (78). It is needed for the calculation of partial performance indicators.

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6.4.3.3.4 Recirculation

The energy transferred by the air recirculation in the current calculation interval is calculated with Formula (79). It is only needed for reporting purposes, for the calculation of partial performance indicators.

6.4.3.3.5 Cooling and dehumidification

The required energy to be extracted by the cooling coil in the current calculation interval is calculated with Formula (80). It covers both cooling and dehumidification. It is reported to the cooling distribution attached to the air handling unit, calculation standard M4-1.

The required energy to be extracted for dehumidification in the current calculation interval is calculated with Formula (81). It is reported to the cooling distribution attached to the air handling unit, calculation standard M4-1. It is only calculated for quality assurance reporting.

It has to be mentioned here that, although the energy required for dehumidification is calculated separately here, the energy use (final energy) for this purpose cannot be quantified separately. The reason for this is that dehumidification usually requires lower fluid temperatures, and the effect of this on the cooling generation EER would require a separate cooling generation calculation in order to correctly calculate the influence.

6.4.3.3.6 Humidification

The energy supplied for humidification in the current calculation interval depends on the humidifier type. For steam humidifiers (HUM_TYPE = STEAM) it is calculated with Formula (82)a). This is necessary because the energy carrier to produce the steam is not necessarily the same as the one for providing the heat. Therefore the energy carrier $GEN\_CR_{HU;gen}$ should be indicated.

For adiabatic humidifiers (Formula (82)b)) the energy is set to 0, and the resulting heat for reheating, due to the evaporative cooling of the air, is taken into account in the heating coil, since the temperature after the humidifier is reduced according to Formula (66)b).

The water use for humidification in the current calculation interval is calculated in Formula (83). This is not needed for energy performance calculation, but is calculated for the purpose of quality assurance.

6.4.3.3.7 Heating

The required energy supplied by the heating coil in the current calculation interval is calculated in Formula (84) and reported to the heating distribution system connected to the air handling unit, calculation standard M3-1.

6.4.3.3.8 Generation heat losses

The heat losses of the air handling units are calculated in Formula (85), depending on the location of the air handling units. They consist of the heat transfer losses and the air leakage losses.

Simplification assumptions are made:

— The air temperatures in the air handling units are changing from outdoor to supply conditions and from extract to exhaust conditions. It is not possible to exactly determine the average air temperatures in the AHU's. As a compromise the supply temperature after the heat recovery and the extract air temperature entering the heat recovery are used.

— For the AHU location in the conditioned zone, the leakage losses are only taken into account for the supply air side, since the extract air temperature is assumed to be close enough to the thermal zone air temperature.

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6.4.3.3.9 Recoverable generation heat losses

The recoverable heat losses of the air handling units are calculated in Formula (86), depending on the location of the air handling units. They consist of the heat transfer losses and the air leakage losses going to the conditioned zone. In case of the AHU location in the non-conditioned zone they are zero.

6.4.3.3.10 Auxiliary energy

6.4.3.3.10.1 Ventilation

The auxiliary energy of the ventilation system at the current calculation interval is the sum of the auxiliary energies for the heat recovery, the preheating for frost protection and control equipment, Formula (87).

The auxiliary energy required by the heat recovery system at the current calculation interval consists of the electric energy used for the drive of the rotor or of the circulation pump in case of the respective heat recovery types. It is calculated with Formula (88).

The energy needed for the additional pressure drop due to the heat recovery is considered by Formula (89). It is included in the total fan energy consumption, but separately calculated for the purpose of partial performance indicators. Differences in pressure drop due to bypass etc. are not considered.

The energy supplied for frost protection in the current calculation interval in case of frost protection with preheating is considered as auxiliary energy and calculated with Formula (90)a). This is done in the assumption that the preheating energy source is electric in all cases, which is a restriction, but true for most cases.

The auxiliary energy consumption of the control components at the current time step is calculated with Formula (91). It includes the electric power consumption of the control devices (sensors, actors, controllers), which in some cases is considerable, especially for actors, where the "idle" position is often the power consuming position, leading to long operation times.

6.4.3.3.10.2 Humidification

The power consumption of the humidification pump at the current calculation interval depends on the humidifier type. For steam humidifiers, where the energy for the steam production is calculated with Formula (82)a), it is zero. For the other cases, it is the energy for the circulation (spray) pump and calculated depending on the control of the pump with Formulae (92)b) and (93).

Additional energy needed, e.g. for the water preparation is not considered or included in the specific pump energy.

7 Calculation method 2 (EN 16798-5-2)

7.1 Output data

No further explanations.

7.2 Calculation interval

The method described in Clause 6 is designed for a monthly calculation interval. With the respective input values it can also be applied for the following calculation intervals:

— yearly; or

— bin.

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