DS/EN 15242

1. udgave

2007-06-22

Ventilation i bygninger – Beregningsmetoder til bestemmelse af luftvolumenstrømme i bygninger, inklusive infiltration

Ventilation for buildings – Calculation methods for the determination of air flow rates in buildings including infiltration

DANSK STANDARD
Danish Standards

Kollegievej 6
DK-2920 Charlottenlund
Tel: +45 39 96 61 01
Fax: +45 39 96 61 02
dansk.standard@ds.dk
www.ds.dk

DS/EN 15242

København
DS projekt: M204907
ICS: 91.140.30

Første del af denne publikations betegnelse er:
DS/EN, hvilket betyder, at det er en europæisk standard, der har status som dansk standard.

Denne publikations overensstemmelse er:
IDT med: EN 15242:2007.

DS-publikationen er på engelsk.

DS-publikationstyper

Dansk Standard udgiver forskellige publikationstyper.
Typen på denne publikation fremgår af forsiden.

Der kan være tale om:

Dansk standard
- standard, der er udarbejdet på nationalt niveau, eller som er baseret på et andet lands nationale standard, eller
- standard, der er udarbejdet på internationalt og/eller europæisk niveau, og som har fået status som dansk standard

DS-information
- publikation, der er udarbejdet på nationalt niveau, og som ikke har opnået status som standard, eller
- publikation, der er udarbejdet på internationalt og/eller europæisk niveau, og som ikke har fået status som standard, fx en teknisk rapport, eller
- europæisk præstandard

DS-håndbog
- samling af standarder, eventuelt suppleret med informativt materiale

DS-hæfte
- publikation med informativt materiale

Til disse publikationstyper kan endvidere udgives
- tillæg og rettelsesblade

DS-publikationsform

Publikationstyperne udgives i forskellig form som henholdsvis
- fuldtekstpublikation (publikationen er trykt i sin helhed)
- godkendelsesblad (publikationen leveres i kopi med et trykt DS-omslag)
- elektronisk (publikationen leveres på et elektronisk medie)

DS-betegnelse

Alle DS-publikationers betegnelse begynder med DS efterfulgt af et eller flere præfikser og et nr., fx **DS 383**, **DS/EN 5414** osv. Hvis der efter nr. er angivet et **A** eller **Cor,** betyder det, enten at det er et **tillæg** eller et **rettelsesblad** til hovedstandarden, eller at det er indført i hovedstandarden.
DS-betegnelse angives på forsiden.

Overensstemmelse med anden publikation:

Overensstemmelse kan enten være IDT, EQV, NEQ eller MOD
- **IDT**: Når publikationen er identisk med en given publikation.
- **EQV**: Når publikationen teknisk er i overensstemmelse med en given publikation, men præsentationen er ændret.
- **NEQ**: Når publikationen teknisk eller præsentationsmæssigt ikke er i overensstemmelse med en given standard, men udarbejdet på baggrund af denne.
- **MOD**: Når publikationen er modificeret i forhold til en given publikation.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15242

May 2007

ICS 91.140.30

English Version

Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration

Ventilation des bâtiments - Méthodes de calcul pour la détermination des débits d'air y compris les infiltrations dans les bâtiments

Lüftung von Gebäuden - Berechnungsverfahren zur Bestimmung der Luftvolumenströme in Gebäuden einschließlich Infiltration

This European Standard was approved by CEN on 26 March 2007.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 15242:2007: E

Contents

Page

Foreword

This document (EN 15242:2007) has been prepared by Technical Committee CEN/TC 156 “Ventilation for buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2007, and conflicting national standards shall be withdrawn at the latest by November 2007.

This standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/343), and supports essential requirements of EU Directive 2002/91/EC on the energy performance of buildings (EPBD). It forms part of a series of standards aimed at European harmonisation of the methodology for the calculation of the energy performance of buildings. An overview of the whole set of standards is given in CEN/TR 15615, Explanation of the general relationship between various CEN standards and the Energy Performance of Buildings Directive (EPBD) ("Umbrella document").

Attention is drawn to the need for observance of relevant EU Directives transposed into national legal requirements. Existing national regulations with or without reference to national standards, may restrict for the time being the implementation of the European Standards mentioned in this report.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This standard defines the way to calculate the airflows due to the ventilation system and infiltration. The relationships with some other standards are as follows:

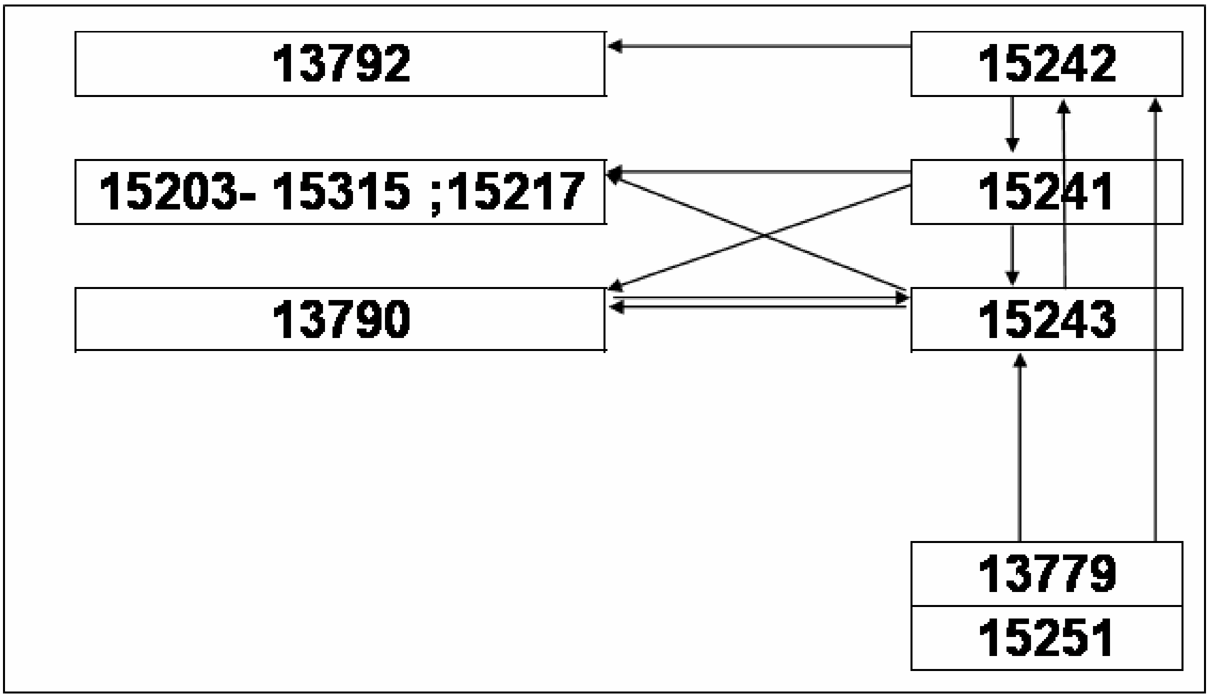


Figure 1 — scheme of relationship between standards

Table 1 — Relationship between standards

from	To	Information transferred	variables
15251	15243	Indoor climate requirements	Heating and cooling Set points
13779 15251	15242	Airflow requirement for comfort and health	Required supply and exhaust Air flows
15242	15241	Air flows	Air flows entering and leaving the building
15241	13792	Air flows	Air flow for summer comfort calculation
15241	15203- 15315 ;15217	energy	Energies per energy carrier for ventilation (fans, humidifying, precooling, pre heating), + heating and cooling for air systems
15241	13790	data for heating and cooling calculation	Temperatures, humilities and flows of air entering the building

15243	15243	Data for air systems	Required energies for heating and cooling
15243	15242	Data for air heating and cooling systems	Required airflows when of use
15243	13790	data for building heating and cooling calculation	Set point, emission efficiency, distribution recoverable losses, generation recoverable losses
13790	15243	Data for system calculation	Required energy for generation

EN titles are:

prEN 15217 *Energy performance of buildings — Methods for expressing energy performance and for energy certification of buildings*

prEN 15603 *Energy performance of buildings - Overall energy use and definition of energy ratings*

prEN 15243 *Ventilation for buildings — Calculation of room temperatures and of load and energy for buildings with room conditioning systems*

prEN ISO 13790 *Thermal performance of buildings — Calculation of energy use for space heating and cooling (ISO/DIS 13790:2005)*

EN 15242 *Ventilation for buildings — Calculation methods for the determination of air flow rates in buildings including infiltration*

EN 15241 *Ventilation for buildings — Calculation methods for energy losses due to ventilation and infiltration in commercial buildings*

EN 13779 *Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems*

EN 13792 *Colour coding of taps and valves for use in laboratories*

EN 15251 *Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*

The calculation of the airflows through the building envelope and the ventilation system for a given situation is first described (Clause 6). Applications depending on the intended uses are described in Clause 7.

The target audience of this standard is policy makers in the building regulation sector, software developers of building simulation tools, industrial and engineering companies.

1 Scope

This European Standard describes the method to calculate the ventilation air flow rates for buildings to be used for applications such as energy calculations, heat and cooling load calculation, summer comfort and indoor air quality evaluation.

The ventilation and air tightness requirements (as IAQ, heating and cooling, safety, fire protection…) are not part of the standard.

For these different applications, the same iterative method is used but the input parameter should be selected according to the field of application. For specific applications a direct calculation is also defined in this standard. A simplified approach is also allowed at national level following prescribed rules of implementation.

The method is meant to be applied to:

— Mechanically ventilated building (mechanical exhaust, mechanical supply or balanced system).

— Passive ducts.

— Hybrid system switching between mechanical and natural modes.

— Windows opening by manual operation for airing or summer comfort issues.

Automatic windows (or openings) are not directly considered here.

Industry process ventilation is out of the scope.

Kitchens where cooking is for immediate use are part of the standards (including restaurants..)

Other kitchens are not part of the standard.

The standard is not directly applicable for buildings higher than 100 m and rooms where vertical air temperature difference is higher than 15K.

The results provided by the standard are the building envelope flows either through leakages or purpose provided openings and the air flows due to the ventilation system, taking into account the product and system characteristics.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1507, *Ventilation for buildings — Sheet metal air ducts with rectangular section — Requirements for strength and leakage*

EN 1886, *Ventilation for buildings — Air handling units — Mechanical performance*

EN 12237, *Ventilation for buildings — Ductwork — Strength and leakage of circular sheet metal ducts*

EN 12792:2003, *Ventilation for buildings — Symbols, terminology and graphical symbols*

EN 13141-5, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 5: Cowls and roof outlet terminal devices*

EN 13779, *Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems*

EN 14239*, Ventilation for buildings — Ductwork — Measurement of ductwork surface area*

EN 15251*, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*

prEN 15255*, Thermal performance of buildings — Sensible room cooling load calculation — General criteria and validation procedures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12792:2003 and the following apply.

3.1
building height
height of the building from the entrance ground level to the roof top level

3.2
vertical duct
duct or shaft, including flue or chimney, which is mainly vertical and not closed

3.3
building envelope leakage
overall leakage airflow for a given test pressure difference across building

3.4
building volume
volume within internal outdoor walls of the purposely conditioned space of the building (or part of the building)

NOTE This generally includes neither the attic, nor the basement, nor any additional structural annex of the building.

3.5
building air temperature
average air temperature of the rooms in the occupied zone

3.6
iterative method
calculation method that requires a mathematical solver to solve an equation by iteration

3.7
direct method
calculation method that can be applied manually

3.8
vent (or opening)
opening intended to act as an air transfer device

3.9
reference wind speed at site
wind speed at site, at a height of 10 m, in undisturbed shielding conditions

NOTE 1 Shielding is accounted for in the wind pressure coefficients.

NOTE 2 In some countries, the reference wind speed is taken as equal to the meteo data available for the site. If not, an appropriate method to extrapolate from the meteo wind speed to the reference wind speed at site should be used (see Annex A).

3.10
shielding
effect classified according to the relative height, width and distance of relevant obstacle(s) in relation to the building

3.11
natural duct ventilation system
ventilation system where the air is moved by natural forces into the building through leakages (infiltration) and openings (ventilation), and leaves the building through leakages, openings, cowls or roof outlets including vertical ducts used for extraction

3.12
mechanical ventilation system
ventilation system where the air is supplied or extracted from the building or both by a fan and using exhaust air terminal devices, ducts and roof /wall outlets

NOTE In single exhaust mechanical systems, the air have entered the dwelling through externally mounted air transfer devices, windows and leakages

3.13
airing
natural air change by window opening

NOTE In this standard, only single sided ventilation effects are considered which means that the ventilation effect due to this window opening is considered to be independent of other open windows or additional ventilation system flows.

3.14
ventilation effectiveness
relation between the pollution concentrations in the supply air, the extract air and the indoor air in the breathing zone (within the occupied zone). It is defined as

$$\varepsilon_{\mathrm{v}} = \frac{c_{\mathrm{ETA}} - c_{\mathrm{SUP}}}{c_{\mathrm{IDA}} - c_{\mathrm{SUP}}}$$

where: ε_{v} is the ventilation effectiveness

c_{ETA} is the pollution concentration in the extract air

c_{IDA} is the pollution concentration in the indoor air (breathing zone within the occupied zone)

c_{SUP} is the pollution concentration in the supply air

NOTE 1 The ventilation effectiveness depends on the air distribution and the kind and location of the air pollution sources in the space. It may therefore have different values for different pollutants. If there is complete mixing of air and pollutants, the ventilation effectiveness is one.

NOTE 2 Another term frequently used for the same concept is “contaminant removal effectiveness”.

3.15
hybrid ventilation
hybrid ventilation switches from natural mode to mechanical mode depending on its control

4 Symbols and abbreviations

Symbol	Unit	description
A	m²	area
Asf	ad	Airtightness split factor (default value or actual)
$C_{ductleak}$	ad	Coefficient taking into account lost air due to duct leakages
C_p	ad	wind pressure coefficient
C_{rec}	ad	Recirculation coefficient
C_{syst}	ad	coefficient taking into account the component and system design tolerances
C_{use}	ad	Coefficient taking into account the switching on and off of fans
C_{cont}	ad	coefficient depending on local air flow control
irp	Pa	Internal reference pressure in the zone
Osf		Opening split factor (default value or actual)
q_v(dP)	curve or formula	airflow/pressure difference characteristic
q_v (dP)	curve or formula	partial air openings for altitude (z), orientation (or), tilt angle (Tilt)
q_v 4Pa,n or n50,n	L/s or m^3/h	external envelope airtightness expressed as an airflow for a given pressure difference, exponent
q_v 4Pa,n or n50,n	L/s or m^3/h	partial air tightnesss for altitude (z), orientation (or), tilt angle (Tilt)
$q_{v\text{-}exh}$	L/s or m^3/h	exhaust air flow according to EN 13779 (not extract)
$q_{v\text{-}exh\ \text{-}req}$	L/s or m^3/h	required exhaust air flow
$q_{v\text{-}sup}$	L/s or m^3/h	Supply air flow
$Q_{v\text{-}sup\text{-}req}$	L/s or m^3/h	required outdoor air flow
θe	°C	external (outdoor) temperature
θi	°C	internal (indoor) temperature
ρair	kg/m^3	Air volumetric mass
ρair ref	kg/m^3	Air volumetric mass at reference temperature
T	K	Absolute temperature
v_{meteo}	m/s	wind as defined by meteo at 10 m height
v_{site}	m/s	wind at the building
z_o	m	depends on terrain class

Indices used in the documents

Index	Explanation	Index	Explanation
sup	Concerns supply air as defined in EN 13779	comb	Concerns combustion
exh	Concerns exhaust air as defined in EN 13779	comp	Concerns each component
req	“required” : values required to be achieved	inlet	Concerns each air inlet
leak	Values of the variable for leakages	passiveduct	Concerns passive duct
outdoorleak	Values of the variable for outdoor leakages	airing	Concerns airing through windows
AHUleak	Values of the variable for leakages in the Air Handling Unit (AHU)	stack	Concerns stack effect
ductleak	Values of the variable for leakages in ductwork	duct	Values of the variable for the duct
inf	Concerns infiltrations	wind	Values of the variable due to wind
diff	Difference between supply and exhaust	sw	Stack and wind
infred	Infiltration reduction		

5 General approach

The air flows are calculated for a building, or a zone in a building.

A building can be separated in different zones if:

— The different zones are related to different ventilation systems (e.g. one ventilation system is not connected to different zones).

— The zones can be considered as air flow independent (e.g. the air leakages between two adjacent zones are sufficiently low to be neglected, and there is no possibility of air transfer between two zones).

The most physical way to do the calculation is to consider the air mass (dry air) flow rate balance. Nevertheless it is also allowed to consider the volume flow rate balance when possible.

Cases where using the mass flow rate is mandatory are:

— air heating systems,

— air conditioning systems.

The formulas in Clause 6 and 7 are given for volume flow rates.

The input data are the ventilation system air flows and the airflows vs pressure characteristics of openings (vents) and leakages.

The output data are the airflows entering and leaving the building through

— Leakages,

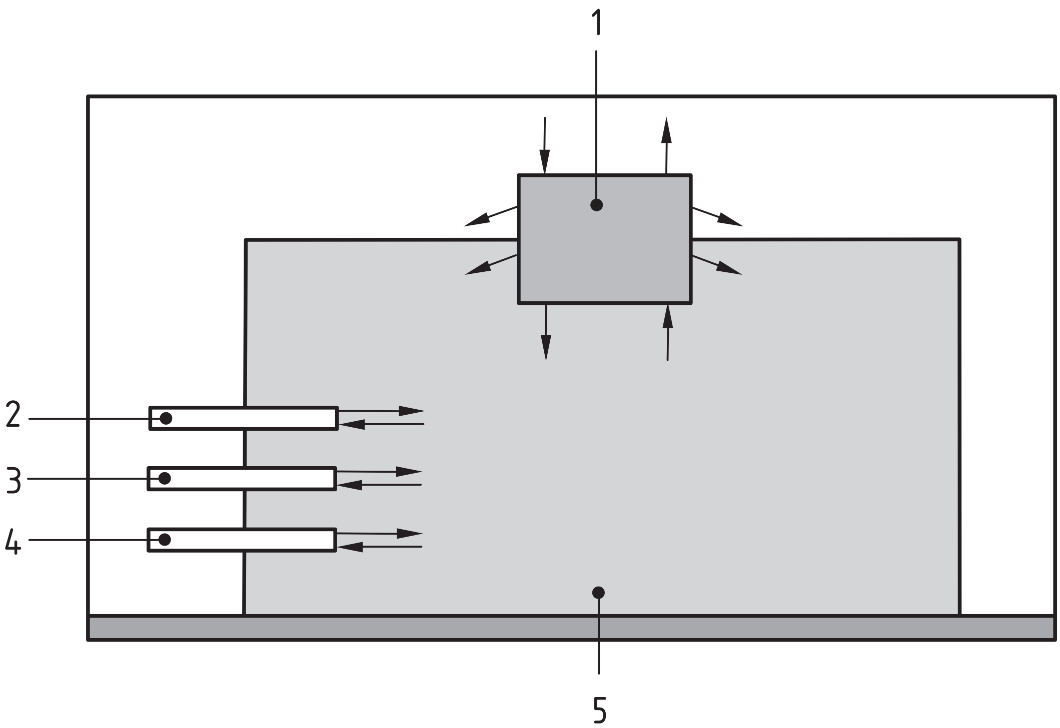
— Openings (vents…),

— Windows opening if taken into account separately,

— Ventilation system, including duct leakages.

Air entering the building/zone is counted positive (air leaving is counted negative).

The general scheme is shown in Figure 2:



Key

1 ventilation
2 window opening
3 opening
4 leakage
5 internal reference pressure

Figure 2 — General scheme of a building showing the different flows involved

The resolution scheme is as follows:

1. Establish the formulas giving the different air flows for a given internal reference pressure
2. Calculate the internal reference pressure *irp* balancing air flows in and air flow out
3. Calculate the air flows for this internal reference pressure

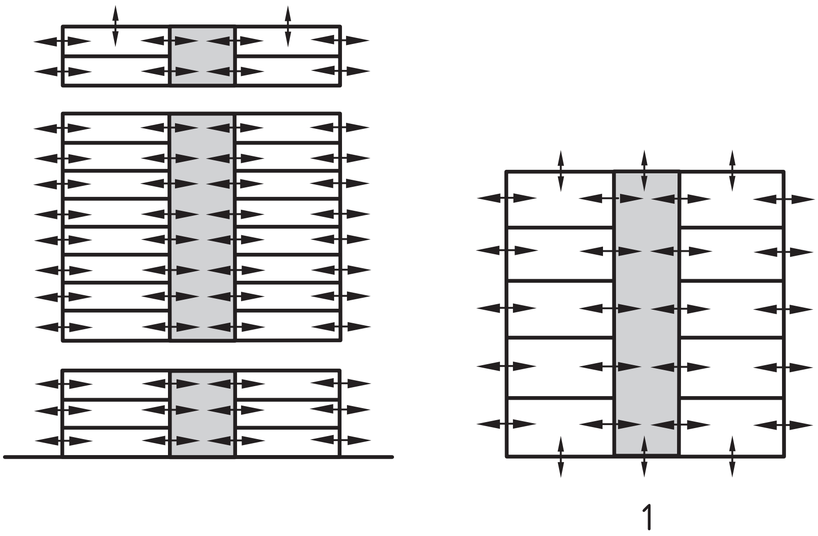
The internal partition of a building is based in general on the following:

i) divide the building between zones

Different zones are considered as having no, or negligible air flow between them

ii) Describe each zone as sub zones connected to a common connection sub zone (in general it will be the circulations and hall spaces) if necessary (a zone can be also only one room)

The general scheme (called afterwards the n+1 approach) is shown in Figure 3.



Key

1 map

Figure 3 — General scheme for air flow pattern description

This scheme is a simplification of the more general one taking into account all possible connections.

It can be furthermore simplified depending on the application (see application clauses).

6 Instantaneous calculation (iterative method)

6.1 Basis of the calculation method

An iterative method is used to calculate the air handling unit air flow, and air flow through envelope leakages and openings for a given situation of:

— Outdoor climate (wind and temperature),

— Indoor climate (temperature),

— System running.

This clause explains the different steps of calculation.

1. Calculation of mechanical ventilation

2. passive duct for residential and low size non-residential buildings
3. Calculation of infiltration/exfiltration
4. combustion air flow fire places both for residential and non residential if necessary. Combined exhaust for ventilation and heating appliance ? Laundry
5. Calculation of additional flow for window openings
6. Overall airflow

6.2 Mechanical air flow calculation

6.2.1 Introduction

The ventilation is based on required air flow (either supplied or extract in each room) which is defined at national level, assuming in general perfect mixing of the air.

To pass from these values to the central fan, the following coefficients (and impacts) shall be taken into account:

1) $C_{\mathbf{use}}$: coefficient corresponding to switching on (C_{use}=1) or off (C_{use}=0) the fan
2) ε_{V}: local ventilation efficiency
3) $C_{\mathbf{cont}}$: coefficient depending on local air flow control
4) $C_{\mathbf{syst}}$: coefficient depending on inaccuracies of the components and system (adjustment…etc)
5) $C_{\mathbf{leak}}$: due to duct and AHU leakages
6) $C_{\mathbf{rec}}$: recirculation coefficient, mainly for VAV system

6.2.2 Required air flow $q_{\mathrm{v\text{-}sup\text{-}req}}$ and $q_{\mathrm{v\text{-}exh\text{-}req}}$

For each room, $q_{\mathrm{v\text{-}sup\text{-}req}}$ and $q_{\mathrm{v\text{-}exh\text{-}req}}$ are respectively the air flow to be provided or exhausted according to the building design, and national regulations.

6.2.3 C_{use} coefficient

This coefficient simply describes the fact of switching on-off the fan (or eventually different level from design one).

It is related to health and energy issues, and to the building or room occupation and occupant behaviour. For health issues, and for building where ventilation can be stopped or reduced during unoccupied periods, it is recommended (and can be mandatory at national level), to start the ventilation before the start of the occupancy period in order to purge the building, and to keep it for some time and the beginning of the unoccupied period. For energy issues, it can be useful to keep the ventilation during unoccupied period (night cooling) if it is energy efficient.

6.2.4 Ventilation effectiveness ε_{V}

It is related to the concentration in the extract air, and the one in the breathing zone.

For efficient system ε_{V} can be higher than 1.

In case of short circuit system ε_{V} can be lower than 1.

The default value for ε_V is 1 corresponding to a perfect mixing.

6.2.5 Local air flow control Coefficient C_{cont}

For system with variable air flow, (demand controlled ventilation, VAV systems), the C_{cont} coefficient is the ratio for a given period of the actual air flow divided by the $q_{v\text{-sup-req}}$ or $q_{v\text{-exh-req}}$ values when this last one are defined as design values.

The C_{cont} coefficient has to be calculated according to the control system efficiency and can be related to the overall room energy balance.

NOTE It could possibly vary with month, external conditions etc.

6.2.6 C_{syst} coefficient

The C_{syst} coefficient (≥ 1) takes into account the accuracy of the system design in relationship with the component description. It expresses the fact that it is not possible to provide the exact required amount of air when this value is required as a minimum.

6.2.7 Duct leakagecoefficient $C_{ductleak}$

The air flow through the duct leakage is calculated

$$q_{vductleak} = \frac{A_{duct}.K.dP_{duct}^{\ 0,65}}{3600}$$

$q_{vductleak}$ (m³/h) : air through the duct leakages

A_{duct}: duct area in m². Duct area shall be calculated according to EN 14239.

dP_{duct}: pressure difference between duct and ambient air in Pa – unless otherwise specified, this is:

In supply air ductwork: the average between the pressure difference at the AHU outlet and the pressure difference right upstream of the air terminal device.

In extract air ductwork: the average between the pressure difference right downstream of the air terminal device and the pressure difference at the AHU inlet

K airtightness of duct in m³/(s.m²) for 1 Pa – the duct leakage shall be determined according to EN 12237 (circular ducts), EN 1507 (rectangular ducts)

The $C_{ductleak}$ coefficient is therefore calculated by

$$C_{ductleak} = 1 + \frac{q_{vductleak}}{\dfrac{q_{vreq} C_{cont} C_{syst}}{\varepsilon_v}}$$

This equation can be applied either with $q_{v\text{-req}}$ equal to $q_{v\text{-sup-req}}$ or to $q_{v\text{-exh-req}}$

6.2.8 AHU leakage coefficient $C_{AHUleak}$

This coefficient corresponds to the impact of the air leakages of the Air handling unit.

$$C_{AHUleak} = 1 + \frac{q_{vAHUleak}}{\dfrac{q_{vreq} C_{cont} C_{syst}}{\varepsilon_v}}$$

With

$q_{v\text{-}AHUleak}$: airflow lost by the AHU determined according to EN 1886.

6.2.9 Indoor and outdoor leakage Coefficient

If the AHU is situated indoor

$C_{indoor\ leak} = C_{duct\ leak}\ C_{AHUleak}$

$C_{outdoorleak} = 1$

If the AHU is situated outdoor

$C_{indoorleak} = 1 + R_{indoorduct}\ (1- C_{duct\ leak})$

$C_{outdoorleak} = 1 + (1- C_{ductleak})(1 - R_{indorrduct})\ C_{AHUleak}$

With $R_{indoorduct} = A_{indoor\ duct} / A_{duct}$

$A_{indoor\ duct}$ = area of duct situated indoor

NOTE In dimensioning of fans and calculating the air flows through the fans, the air leakages of ducts and air handling units (sections downstream of supply air fans and upstream of the exhaust air fans in the AHU) should be added to the sum of air flows into/from the rooms. This because these leakages do not serve the ventilation needed for the targeted indoor air quality.

6.2.10 Recirculation Coefficient *Crec*

The recirculation coefficient (≥ 1) is used mainly for VAV system with recirculation. It takes into account the need to supply more outdoor air than required. Annex C provides a calculation method for it.

6.2.11 Mechanical air flow to the zone q_v supply q_v extra

The mechanical air flows supplied to or exhausted from the zone are calculated by

$$q_{v\sup} = \frac{q_{v\sup req}.C_{cont}.C_{indoorleak}.C_{rec}}{\varepsilon_v}$$

$$q_{vexh} = \frac{q_{vexhreq}.C_{cont}.C_{indoorleak}.C_{rec}}{\varepsilon_v}$$

6.2.12 Mechanical air flow to the AHU

The mechanical air flows supplied to or exhausted from the Air handling unit are calculated by

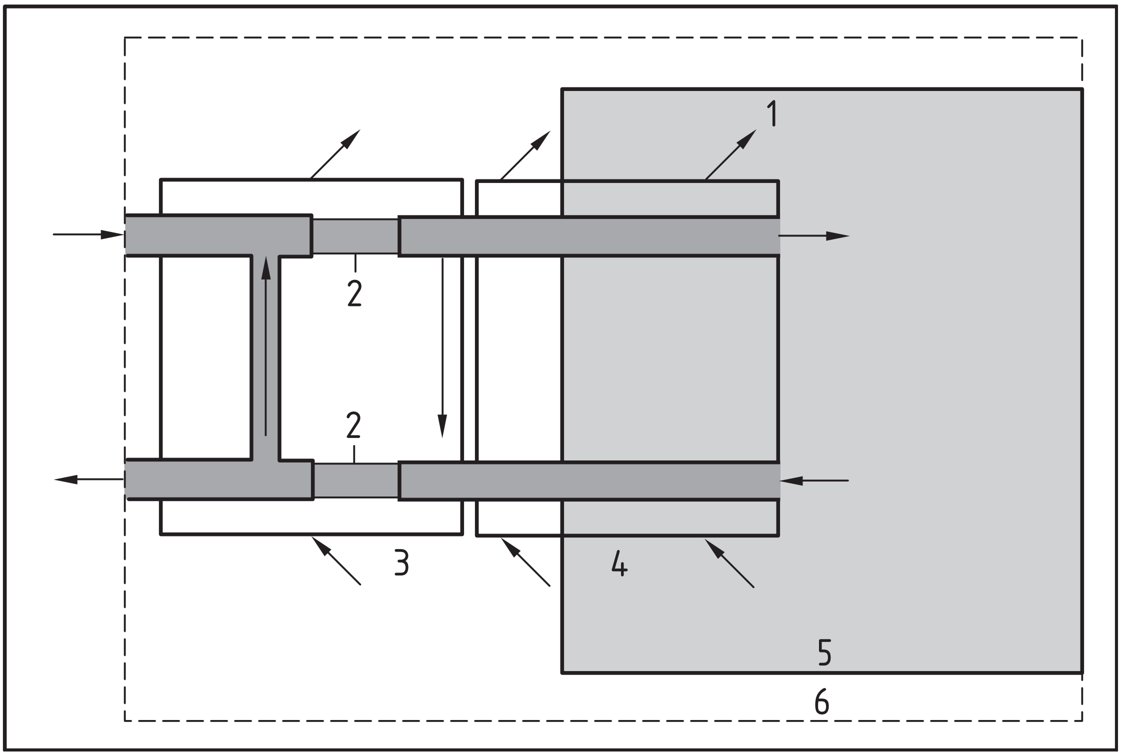
$$q_{v\sup AHU} = \frac{q_{v\sup req}.C_{cont}.C_{leak}.C_{rec}}{\varepsilon_v}$$

$$q_{vexhAHU} = \frac{q_{vexhreq}.C_{cont}.C_{leak}.C_{rec}}{\varepsilon_v}$$

with $C_{\mathrm{leak}} = C_{\mathrm{indoorleak}} + C_{\mathrm{outdoor\ leak}}$

Two situations are taken into account depending on the position of the air handling unit in or out the heated/air conditioned area. For the ventilation calculation, it impacts only on the duct leakage effect but afterwards; it will have to be considered for heat losses.

The different air flows to the AHU are shown in Figure 4. Case 2 corresponds to the situation when the AHU is in the conditioned area, case 1 when it is out of the conditioned area. This has to be taken into account for the whole calculation process.



Key

1 duct leakages
2 fan
3 ventilation plant
4 duct system
5 building or zone case 1
6 building or zone case 2

Figure 4 — Air flows to the Air Handling Unit

6.3 Passive and hybrid duct ventilation

6.3.1 General

A ducted natural ventilation system is composed of

1. Air inlets,
2. Cowl,
3. Duct,
4. Air outlets

The aim of the calculation is to calculate the air flow in the system taking into account outdoor and indoor conditions.

Hybrid ventilation switches from natural mode to mechanical mode depending on its control. The control strategy is part of the design phase and may be also described at national level.

For existing buildings, and only in case of a quick inspection and/ or if more detailed information cannot be obtained quickly, national default values may be used instead.

6.3.2 Cowl air flow

6.3.2.1 Cowl characteristics

The cowl is characterized according to EN 13141-5 by:

— pressure loss coefficient ζ;

— wind suction effect which depends of the wind velocity and the air speed in the duct. It is expressed by a C coefficient as follows:

$$C\,(V_{\mathrm{windref}}, V_{\mathrm{duct}}) = dP\,/\,p_{\mathrm{d}}$$

where : $p_{\mathrm{d}} = 0{,}5\ \rho\ V_{\mathrm{windref}}^{2}$

V_{duct} is the air velocity in the duct

With no wind, the pressure loss through the cowl dP_{cowl} is

$$dP_{\mathrm{Cowl}}\,(V_{\mathrm{wind}}=0, V_{\mathrm{duct}}) = 0{,}5\ \zeta\ \rho\ V_{\mathrm{duct}}^{2}$$

For the reference wind V_{windref} (in general 8m/s),

$$dP_{\mathrm{Cowl}}\,(V_{\mathrm{windref}}, V_{\mathrm{duct}}) = 0{,}5\ \ C(V_{\mathrm{windref}}, V_{\mathrm{duct}})\ \rho\ V_{\mathrm{windref}}^{2}$$

For any wind, it is possible to use the similitude law as follows:

For a different wind speed V_{windact}, the C coefficients remains the same if the V_{duct} if multiplied by $V_{\mathrm{windact}}/V_{\mathrm{windref}}$, which enables to calculate

$$C(V_{\mathrm{windact}},\ V_{\mathrm{duct}}\ V_{\mathrm{windact}}/V_{\mathrm{windref}}\ ) = C(V_{\mathrm{windref}}\ ,\ V_{\mathrm{duct}})$$

Example of application :

$V_{\mathrm{windref}} = 8$ m/s

$V_{\mathrm{duct}} = 2$ m/s

$C(8,2) = -0{,}12$

For a wind $V_{\mathrm{windact}} = 4$ m/s the corresponding V_{duct} is equal to 2 . 4/8 = 1m/s

Which gives:

$C(4,1) = C(8,2) = -0{,}12$

The corresponding dP is

$$dP_{\mathrm{Cowl}} = C(4,1)\ ½\ \rho\ V_{\mathrm{windact}}^{2}$$

6.3.2.2 Continuous and monotonous curve of dP_{Cowl} as function of V_{duc})

The limitation of the above formulas is that for a wind speed lower than the reference one, the suction impact can only be calculated for low air speed in the ducts.

On the other hand, for low wind speed and high duct air speed, the pressure drop is equal to the one given by the pressure loss coefficient.

The methodology to be applied is than as follows:

The actual wind speed V_{wind} is known.

The similitude law can be applied until an air duct velocity V_{duct1} with

$$V_{duct1} = V_{ductmax}\ V_{wind} / 8$$

Where $V_{ductmax}$ is the maximum value of duct air velocity for the test

1) For air duct speeds lower then V_{duct1}, dP_{Cowl} is calculated by using the similitude law and by interpolation between the different points issued from the tests.

2) For air duct speeds higher than V_{duct1}, it is important to make a transition with the curve with no wind (if not, convergence issues can arise) by keeping a monotonous curve.

To do so it is recommended to search a point V_{duct2} for which $dP_{Cowl}(0, V_{duct2})$ is higher than dP_{Cowl} (V_{wind}, V_{duct1}).

This can be done by first trying $V_{duct2} = 2\ V_{duct1}$ then $V_{duct2} = 3\ V_{duct1}$ ….

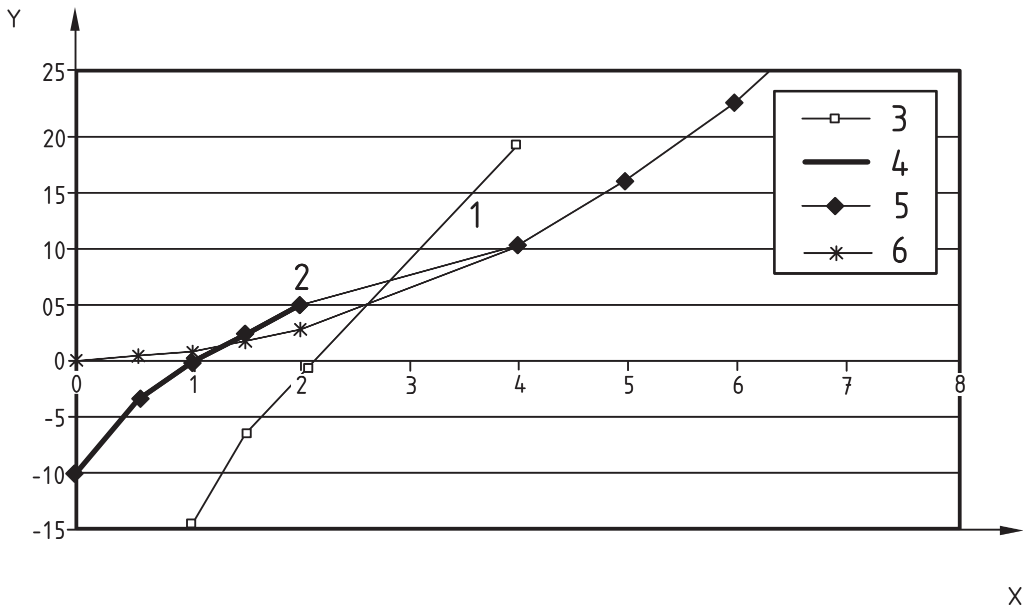
For $V_{duct\ 2}$, dP_{cowl2} is calculated using $dP_{Cowl}(0, V_{duct2})$…

3) for V_{duct} between V_{duct1} and $V_{duct\ 2}$, the curve is a linear interpolation between the two points.

4) for V_{duct} higher than $V_{duct\ 2}$: the curve is the $dP_{Cowl}(0, V_{duct})$ one.

6.3.2.3 Example of application

For this cowl, the duct airflow was tested only for a maximum V_{duct} of 4m/s



Key

X V_{duct} (m/s)

Y dP curve for V wind = 4 m/s

1 V_{duct} 1

2 V_{duct} 2

3 dP V wind = 8 m/s (from test)

4 dP V wind = 4 from test at V wind = 8 m/s

5 dP final

6 dP for V wind = 0

Figure 5 — dP_{cowl} curve for V_{wind} = 4 m/s

For V_{wind} = 4m/s.

From V_{duct} = 0 to V_{duct1}(2m/s) : the dP_{cowl} is calculated using the similitude law.

For V_{duct} = 4m/s, dP for V_{wind} = 0 is higher than $dP(V_{wind}=4, V_{duct1})$. Then V_{duct2} = 4m/s.

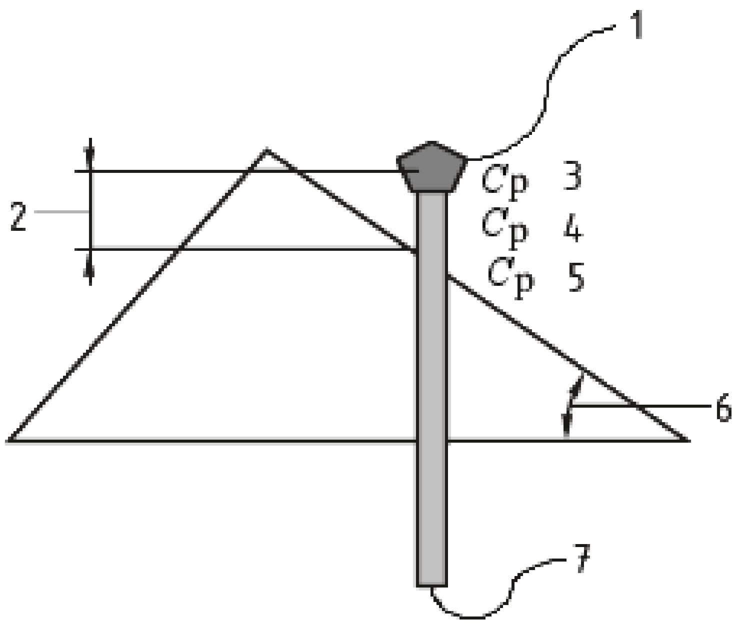
For $V_{duct} > V_{duct2}$, the $dP(V_{wind}= 0, V_{duct})$ is applied.

A linear interpolation is made between $V_{duct\ 1}$ and V_{duct2}.

6.3.2.4 Correction factor according to roof angle and position and height of cowl

6.3.2.4.1 General

Normally roof outlets and cowls are not as the same level but about 0,1 to 2 m above roof level. The wind pressure on a roof outlet or cowl is also depending on the roof slope.



Key

1 roof outlet or cowl
2 height above rooflevel
3 $C_{p\ cowl}$
4 $C_{p\ height}$
5 $C_{p\ roof}$
6 roof slope
7 passive duct

Figure 6 — Cowl or outlet C_p impacts

6.3.2.4.2 Calculation method

The pressure taken at the roof outlet or cowl $C_{cowltot}$ is a function of C_{pcowl}, corresponding to a free wind condition, and C_{proof} if the cowl is close to the roof.

Where:

$C_{\mathrm{proof}} = C_{\mathrm{proof0}} + dCp_{\mathrm{height}}$

$C_{\mathrm{p\ roof}}$ is the pressure coefficient at roof level taking into account the height of the cowl above the roof level.

C_{proof0} is the pressure coefficient close to the roof

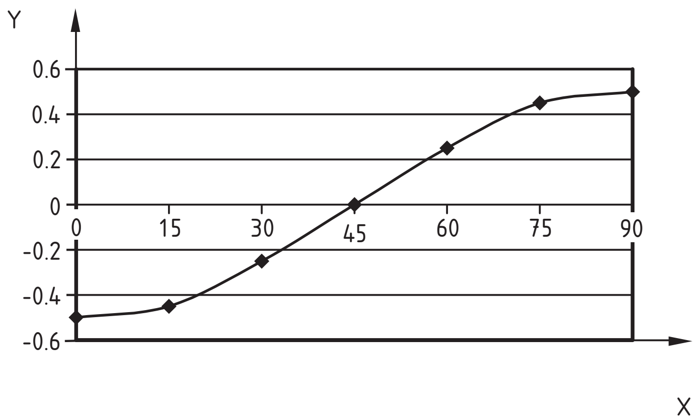
dCp_{height} is a correction coefficient for the height above roof level

C_{pcowl} is the value calculated from 6.3.2

Depending on the cowl position C_{p} effect of the roof can differ a lot. Designers have then to make assumptions for design and dimensioning. The Cp_{roof} has then to be defined at national level taking into account rules of installation. If nothing is defined, Cp_{roof} is taken to 0.

3 Examples of values for Cp_{roof} and Cp_{height}

Figure 7 provides examples of values for Cp_{roof}.



Key

X roof slope in °

Y Cp_{roof}

Figure 7 — C_{p} roof

Table 2 provides examples of dCp_{height} values.

Table 2 — Examples of dCp_{height} values

Above roof height of the roof outlet in m	dCp_{height}
< 0,5 m	- 0,0
0,5 –1,0 m	- 0,1
> 1 m	- 0,2

NOTE The real pressure is also depending on the distance to the roof top and the wind angle of attack. The values taken here are average values.

6.3.3 Duct

Duct pressure drop has to be estimated as accurately as possible. For this, pressure drop of linear ducts, take-off and singularities have to be calculated. If they are unknown, they may be measured according to CR 14378.

6.3.4 Overall calculation

An iterative procedure shall be used having as unknown variable $q_{\text{v-passiveduct}}$,air flow in the duct.

6.4 Combustion air flows

The additional flow from outside needed for the operation of the combustion appliance $q_{\text{v-comb}}$ shall be calculated from the following:

$$q_{vcomb} = 3{,}6.F_{as}.F_{ff}.P_{hf} \quad (14)$$ if the appliance is on

With:

q_{vcomb} (m^3/h) : additional combustion flow

F_{as} (ad.): appliance system factor

P_{hfi} (kW) : appliance heating fuel input power

F_{ff} (l/(s.kW) : fuel flow factor

and $q_{v\ comb}$ = 0, if the appliance is off

The appliance system factor takes account of whether the combustion air flow is separated from the room or not, and uses values given in Table 3.

The fuel flow factor depends on the specific air flow per fuel type required for the combustion process (air flow normalized to room temperature condition) and uses values given by national standards or values given in Annex E.

For the case “Appliance off”, the flue shall be considered as vertical shaft.

NOTE The reference temperature for $q_{\text{v comb}}$ is the zone temperature.

Table 3 — Data for appliance system factor

Combustion air supply situation	Flue gas exhaust situation	Typical combustion appliance system	Appliance system factor Fas
Combustion air is taken from room air	Flue gases are exhausted into room	• Kitchen stove • Gas appliance according to CEN/TR 1749	0
Combustion air is taken from room air	Flue gases are exhausted into separate duct	• Open fire place • Gas appliance according to CEN/TR 1749	1
Combustion air is taken from room air	Flue gases are exhausted in duct simultaneously with mechanical ventilation exhaust air	• Specific gas appliance	See note
Combustion air is delivered directly from outside in a separate duct, sealed from room air	Flue gases are exhausted into a separate duct	• Gas appliance according to CEN/TR 1749 Type C (room air sealed systems) • Closed fire place (wood, coal or wood/coal-effect gas fire)	0

NOTE Considered as a mechanical extraction system, but with variable air flow, depending of both the exhaust and the combustion appliance.

6.5 Air flow due to windows opening

6.5.1 Airing

6.5.1.1 Airflow calculation

For single side impact, the airflow is calculated by

$$q_{\text{vairing}} = 3.6 \,.\, 500\, Aow\, V^{0,5}$$

$$V = Ct + Cw \,.\, Vmet^{2} + Cst \,.\, Hwindow \,.\, \text{abs}\,(\theta i - \theta e)$$

with:

Qv (m³/h):	air flow
Aow(m²)	window opening area
Ct =0,01	takes into account wind turbulence
Cw= 0,001	takes into account wind speed
Cst= 0,0035	takes into account stack effect
$Hwindow$ (m)	is the free area height of the window
$Vmet$ (m/s)	meteorological wind speed at 10 m height
Ti :	room air temperature
Te :	outdoor air temperature.

For bottom hung window, the ratio of the flow through the opened area and the totally opened window is assumed to be only depending on the opening angle α and independent on the ratio of the height to the width of the window.

$$Aow = C_k(\alpha)\, Aw$$

Where Aw is the window area is totally opened.

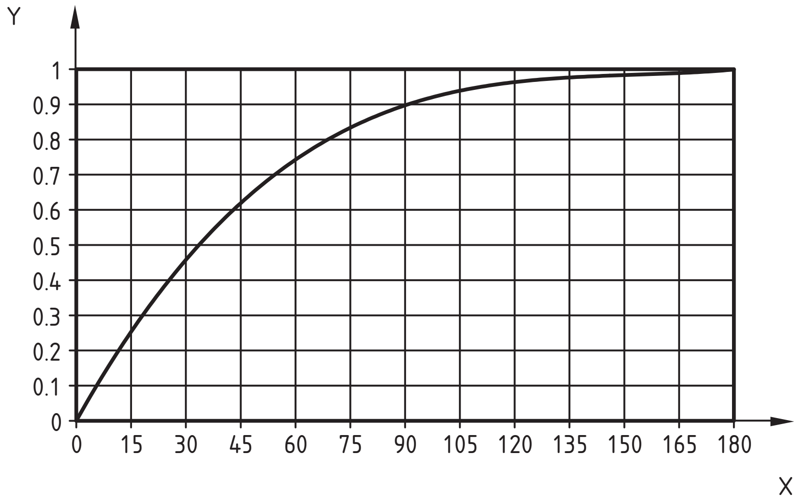
(14)

For $C_k(\alpha)$ a polynomial approximation can be given (see Figure 6) :

Update VD: Eq. (15) rewritten for better readability

$$C_k(\alpha) = 2.60 \cdot 10^{-7} \cdot \alpha^3 - 1.19 \cdot 10^{-4} \cdot \alpha^2 + 1.86 \cdot 10^{-2} \cdot \alpha \quad (15)$$

()



α [°] (X)	$C_k(\alpha)$ [-] (Y)
0	0.00
5	0.09
10	0.17
15	0.25
20	0.33
25	0.39
30	0.46
45	0.62
60	0.74
90	0.90
180	1.00

Figure 8 — Ratio of the flow through a bottom hung window and the totally open window

The approximation given applies to window sizes used for residential buildings, for windows with sill (not to windows with height close to full room height), and for height to width geometries of the tilted window section of approx 1:1 to 2:1.

In the measurements, the variation of height/width ration resulted in flow variation of less than 1 % in relation to flow through the totally open window, this means that e.g. for 8° opening angle the error of the calculated flow is within 10 %. About the same error band applies in regard to temperature difference (which was in the range of 10 to 39 K in the measurements).

6.5.1.2 Simplified calculation

When the indoor air quality only relies on windows opening, it is taken into account that the user behaviour leads to air flow rates higher than the required ones. The Cairing coefficient takes this point into account:

$q_{\text{v-airing}}$ = Cairing . max ($q_{\text{v-sup-req}}$, $q_{\text{v-exh -req}}$)

The Cairing takes into account the occupant opening efficiency regarding windows opening (but assuming the required air flow rates are fulfilled) but also the occupancy pattern of the room.

This coefficient has to be defined at national level especially if a window opening is considered as a possible ventilation system alone.

6.5.2 Air flow for summer comfort

Cross ventilation has to be taken into account, either with iterative method or direct to be defined.

6.5.3 Typical use of windows openings

The ratio of opening of a given window R_{opw} is:

$R_{opw} = Y_{wind}.Y_{temp}$

where

R_{opw} is the opening of the window in ratio of the maximum opening

Y_{wind} is the factor for wind

Y_{temp} is the factor for outdoor temperature

The factors are defined by

$Y_{wind} = 1\text{-}0,1\ V_{met}$

$Y_{temp} = \theta e / 25 + 0,2$

Y_{wind} and Y_{temp} are limited to a minimum value of 0 and a maximum value of 1

Where:

V_{met} (m/s) is the meteorological windspeed

θe (°C) is the outdoor temperature

The windows considered as possibly opened, as the time schedule for that, shall be defined at national level.

6.6 Exfiltration and infiltration using iterative method

6.6.1 C_p values

$\boldsymbol{C_p}$ values are determined according to orientation and height of the component, building and zone characteristics, shielding and building location. A procedure is defined in Annex A and specific applications are defined in the application clause.

6.6.2 Pressure difference for each external envelope component

Each component is characterized by

its $\boldsymbol{C_p}$ value: C_{comp}

its height difference with the zone floor level h_{comp}

For each component

$dP_{comp} = P_{ext\ comp} - P_{int\ comp}$

with:

$$p_{ext,comp} = \rho_{air,ref}\left(0{,}5.Cp_{comp}.V_{site}{}^{2} - h_{comp}.g\frac{T_{e,ref}}{T_e}\right)$$

$$p_{\text{int,comp}} = \text{irp} - \rho_{\text{air,ref}} . h_{\text{comp}} . g \frac{Tref}{Ti}$$

with:

irp is the internal reference pressure

NOTE External pressure at the floor level is taken equal to 0.

h_{comp} is the altitude difference between component and zone floor level

g = 9,81 m/s^2

$\rho_{\text{air-ref}}$ =1,22 kg/m^3

$Tref$ = 283 K

6.6.3 Description of external envelope component

Each external envelope component (leakage, air inlet …) is characterized by

$q_{\text{v-comp}} = f_{\text{comp}} (dP_{\text{comp}})$

For leakages $q_{\text{v-leak}} = C_{\text{leak}}$. sign (dP) . $|dP|^{0,667}$

For air inlet $q_{\text{v-inlet}} = C_{\text{inlet}}$. sign(dP) . $|dP|^{0,5}$

For air inlet or other purpose provided components, the equation can be replaced by a more accurate one, if the component is tested according to EN 13141-1 (air inlet).

6.6.4 Calculation of infiltred and exflitred air flows

Solve the equation,

$q_{\text{v-sup}} + q_{\text{v-exh}} + \Sigma\, q_{\text{v-comp}} + q_{\text{v-passiveduct}} + q_{\text{v-comb}} = 0$

Where the unknown value is *irp*

Once irp has been determined to solve this equation, calculate each individual value of $q_{\text{v-comp}}$

$q_{\text{v-inf}} = \Sigma\, q_{\text{v-comp}}$ for positive values of $q_{\text{v-comp}}$

$q_{\text{v-exh}} = \Sigma\, q_{\text{v-comp}}$ for negative values of $q_{\text{v-comp}}$

6.7 Exflitration and infiltration calculation using direct method

6.7.1 General

When it can be assumed that there is no interaction between the ventilation system and the leakages impact (e.g. mechanical system); a simplified approach can be used to calculate the exfiltered and unfiltered values as follows:

— passive ducts shall be calculated only with the iterative approach

The direct method has the following steps:

1. Calculate air flow through the envelope due to stack impact and wind impact without considering mechanical or combustion air flows

$q_{v\text{-stack}}$ = 0,0146 Q_{4Pa} (h_{stack} . abs (θe-θi)) ^{0,667} **)**

Conventional value of h_{stack} is 70 % of the zone height H_z

$q_{v\text{-wind}}$ = 0,0769 Q_{4Pa} (dcp $v_{site}^{\ 2}$) ^{0,667}

Conventional value of dcp (C_p difference between windward and leeward sides) is 0,75

2. Calculate the resulting air flow

$q_{v\text{-sw}}$ = max($q_{v\text{-stack}}$, $q_{v\text{-wind}}$) + 0,14 $q_{v\text{-stack}}$. $q_{v\text{-wind}}$ / Q_{4Pa}

As a first approximation, the infiltred part $q_{v\text{-inf}}$ is equal to the sum of $q_{v\text{-sw}}$ and the difference between supply and exhaust air flows (calculated without wind or stack effect).

$q_{v\text{-inf}}$ = (max (0; - $q_{v\text{-diff}}$)+ $q_{v\text{-sw}}$

With $q_{v\text{-diff}}$ = $q_{v\text{-supply}}$ + $q_{v\text{-extr}}$ + $q_{v\text{-comb}}$

NOTE Air flows entering the zone are counted positive.

This simplified approach does not take into account the fact that if there is a difference between supply and exhaust, the zone is underpressured or overpressured, which reduces the $q_{v\text{-sw}}$ value.

The reduction of the infiltred air flows due to this phenomena $q_{v\text{-infred}}$ can be estimated by:

$q_{v\text{-infred}}$ = max($q_{v\text{-sw}}$, [$q_{v\text{-stack}}$. abs($q_{v\text{-diff}}$ /2) + $q_{v\text{-wind}}$. 2 abs($q_{v\text{-diff}}$) /3)/($q_{v\text{-stack}}$+ $q_{v\text{-wind}}$)])

$q_{v\text{-inf}}$ = max(0; $q_{v\text{-sw}}$ – q_{v_infred})

6.7.2 Determination of average flow values

$$q_{v\ \text{total}\ v} = \sum all\ \ states\ \ s \left(q_{v\ \text{tot,s}} \cdot f_s\right) \qquad (15)$$

Where:

$q_{v\ tot,s}$ is the air flow rate during state s

f_s is the time proportion during which the state s is active ($0 \le f_S \le 1$)

Four hourly calculations, only one state is considered (e.g. one calculation each hour)

For monthly calculation the minimum states to be considered are:

Occupied / Non occupied periods;

Five wind speed.

NOTE Only one monthly average indoor outdoor temperature difference can be used. If set point during occupancy and non occupancy periods are known, it is advised to use theses values.

7 Applications

7.1 General

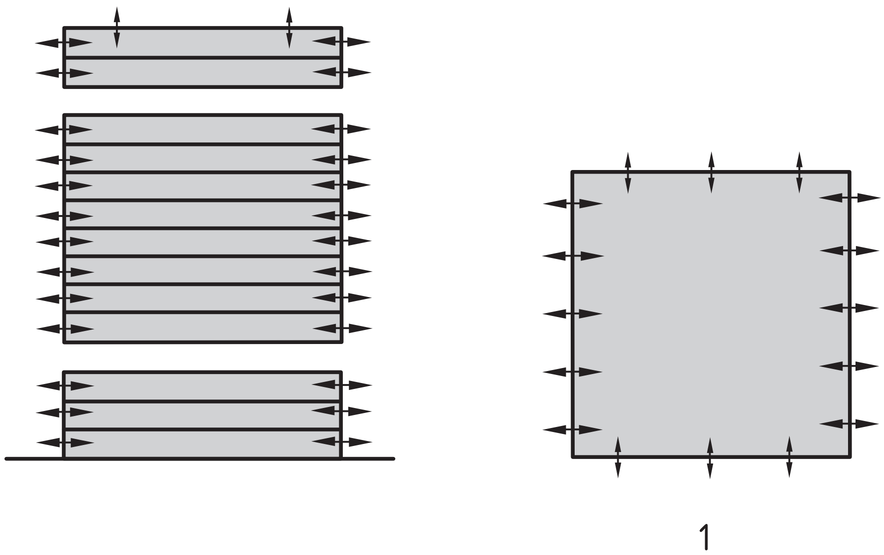
The general fields of application are as follows:

1. energy calculation (yearly);
2. heating load;
3. cooling load;
4. summer comfort;
5. IAQ.

7.2 Energy

7.2.1 General requirements

For energy calculation, it is allowed to neglect the internal partition in each zone.



Key

1 map

Figure 9 — Simplified partition scheme for energy application

The building airtightness impact can be neglected if the q_{4Pa} value is lower than 15 % of the average system flow during the heating season

7.2.2 conventional and default values

7.2.2.1 Default values for ε_v, C_{cont}, C_{syst}, C_{airing}

Default values are as follows (they can be modified in national annex):

C_{use} = 1 for occupied periods, 0 for unoccupied period

NOTE For Free and night cooling there is no default value as it requires an expert approach and a specific control system and strategy.

ε_V = 1

C_{cont} = 1

C_{syst} = 1,2

C_{airing} = 1.8

7.2.2.2 Duct system air leakages

7.2.2.2.1 Indoor ducts and AHU

For energy calculation purposes, the AHU leakages may be neglected if the AHU has been tested according to EN 1886 and the class obtained is at minimum L3.

If the values of A_{duct} and dp_{duc} are not known, it is allowed to apply a default value of Cleak according to the following table:

Table 4 — Typical values for duct leakages

	K	lost/airflow %	$C_{indoorleak}$
default = 2.5.class A	0,0000675	0,150	1,15
class A	0,000027	0,060	1,06
class B	0,000009	0,020	1,02
class C or better	0,000003	0,00	1,0

Table for AHU Default values

Table 5 — AHU Default values

	K	lost/airflow %	$C_{AHUleak}$
default = 2.5.class L3	0,0000675	0,060	1,06
class L3	0,000027	0,020	1,02
class L2	0,000009	0,007	1,01
class L1 or better	0,000003	0,002	1,0

7.2.2.2.2 Outdoor duct and air handling unit

The actual duct characteristics have to be taken into account. Nevertheless it should be possible to provide criteria enabling to define situations where this impact can be neglected.

The duct leakages for exhaust air are neglected.

The duct leakages for supply air are neglected if there is no heating or cooling.

For the air handling unit the calculation should be based on the test standard EN 1886 (alternative and or neglected if no cooling or heating)

7.2.2.3 C_p values

7.2.2.3.1 C_p values for building with possible cross ventilation

C_p values will be provided for windward and leeward facades according to Annex A.

The wind direction is not taken into account. Therefore, the facades shielding class is always considered as "open".

The roof C_p value is considered as equal to the leeward facade.

7.2.2.3.2 C_p values for buildings without cross ventilation

In this case, to take into account the differences in wind pressure on a given facade overpressure as for example C_p + 0,05 to - 0,05.

7.2.2.4 Splitting of airtightness

As the positions of air leakages are not known, a conventional splitting of them between windward and leeward facades is assumed. The air leakage is defined as C_{leakzone} value for the whole zone, assuming an exponent of 0,67.

A_{roof} and A_{facades} are respectively the roof (area viewed from the zone) and facades areas.

Hz is the zone height. If the different levels of a zone can be considered as having low leakages connection, the Hz value is set equal to the average level height.

The splitting is done according to the following procedure :

$$C_{\text{leakfacades}} = C_{\text{leakzone}}\, A_{\text{facades}} / (A_{\text{facades}} + A_{\text{roof}})$$

$$C_{\text{leakroof}} = C_{\text{leakzone}}\, A_{\text{roof}} / (A_{\text{facades}} + A_{\text{roof}})$$

The leakages are considered as follows

Table 6 — Leakages

	Windward facade	Leeward facade	roof
Component height = 0,25 Hz	0,25 $C_{\text{leak facade}}$	0,25 $C_{\text{leak facade}}$	
Component height = 0,75 Hz	0,25 $C_{\text{leak facade}}$	0,25 $C_{\text{leak facade}}$	
Component height = Hz			$C_{\text{leak roof}}$

7.2.2.5 Splitting of air inlets

Same as for facades walls as orientation versus wind direction is not taken into account.

Table 7 — Air inlets

	Windward facade	Leeward facade
Component height = 0,25 Hz	0,25 C_{inlet} facade	0,25 C_{inlet} facade
Component height = 0,75 Hz	0,25 C_{inlet} facade	0,25 C_{inlet} facade

7.2.3 Air flows calculation

7.2.3.1 General

Air flow calculation can be done using iterative or direct method, or through a statistical analysis to be applied at national level.

7.2.3.2 Iterative or direct method

The calculation is done according to Clause 6 and the additional values of 7.2.2 with specification of appropriate user patterns (daily and weekly) with regard to ventilation.

7.2.3.3 Statistical analysis to be applied at national level

It is allowed to define on a national basis simplified approaches based on a statistically analysis of results.

The following rules shall be fulfilled:

— The field of application shall be specified (for example, detached houses, specified ventilation system…),

— All specific assumptions (such as indoor temperature) or data (for example climate) shall be clearly described,

— The set of cases used for the statistical analysis shall be clearly described,

— The remaining inputs data for the simplified approach shall be the same as the ones described in the steady state calculation, or part of them,

— For the input data of the steady state calculation not taken into account, the conventional value used shall be specified (for example, no defrosting in a mild climate),

— Describe clearly which input data and assumptions have been used, including user patterns;

— The results of the simplified approach shall be compared to the reference ones for the set of cases taken into account in the statistical analysis.

A report shall be provided with two parts:

1) **Description of the statistically based simplified approach defining**

The field of application,

The remaining input data,

The calculation method,

The remaining output data.

2) **justification of the results**

The main aim is to make it possible to redo and check the calculation starting from this steady state calculation:

- Definition of the cases taken into account for the statistical analysis, including:
  - Conventional values for the input data not kept in the simplified method;
  - Range of values for the input data kept in the simplified approach;
  - Results of the different test cases (called reference results);
  - Description of the simplified approach and comparison of the reference results;
  - Indication on the level of accuracy based on the comparison.

7.3 Heating load

7.3.1 Zone and room description

The general scheme has to be applied.

7.3.2 General approach

The calculation will be a steady state one (as in general in the document), and is not directly linked to the oversize for restarting heating before occupancy period, which is mainly related to the zone thermal inertia.

The problem to be solved is to calculate a safe (over-estimated) value of air flow entering a room starting from a building or zone calculation.

Two points shall be taken into account:

— Stack effect and difference of wind pressure leads to discrepancies between rooms (e.g. windward room are higher ventilated than leeward room)

— Splitting of air leakages is not known therefore a safety coefficient shall be introduced.

The proposed methodology is to:

1) calculate the air flow on the windward facade (stack effect could be introduced afterwards in the same way if necessary) for air inlets and leakages;

2) introduce a safety coefficient for air leakages C_{safe} : provisional value = 2;

3) apply these elementary flows to the different rooms according to respectively air inlets sizes and outer envelope areas.

7.3.3 Other parameters

As for energy, but for the air inlet position, which are situated in the actual rooms.

7.4 Cooling loads

It is considered that an infiltration / exfiltration calculation method shall be defined, even if the impact could sometimes be neglected (good airtightness vs. low indoor outdoor temperature difference). The basis could be the same as for heating load, but shall be used at least for an hourly calculation on a typical day according to prEN 15255.

7.5 Summer comfort

The ventilation can be used for cooling purposes by increasing the fresh flow rates (compared to hygienic values) when outdoor temperature is lower than indoor temperature.

This can be done using the different kind of ventilation and airing systems.

For mechanical systems, it is important to also consider the fan energy as the results can be inefficient, especially for low indoor outdoor temperatures differences. Risks of overcooling shall be also taken into account.

For manually operated windows, it will rely on the occupant behavior for which some assumptions has to be made at national level. For night ventilation in residential building, outdoor noise should be taken into account.

For windows opening at night, hazards e.g. security, rain etc should be considered.

NOTE In some case the control could be based on the enthalpy.

The relationship with comfort standard of EN 15251 will be as follows:

EN ISO 13791 and EN ISO 13792 air flows > indoor operative and air temperature.

prEN 15243 Outdoor climate + indoor operative and air temperature > air flows.

7.6 Indoor air quality

The calculation method shall be adapted depending on the way national regulations are defined. The following requirements can for example be taken into account:

— Overall air change for a given zone.

— Fresh air for habitable rooms.

— Exhaust air for service rooms.

— Transfer air for circulation.

— Threshold limit for pollutant (in this case, the source shall be specified).

Annex A
(normative)

Data on wind pressure coefficients

Procedure description

The different steps are as follows:

1. calculate the wind at 10 m on site,
2. determines if of use the shielding of the facades split into 3 parts (low,medium, high),
3. find the C_p values for the 3 facade parts,
4. determine the zone C_p values.

This annex describes the more detailed approach. Specific uses are described in the application clause.

Wind velocity at site v_{site} from meteo wind velocity V meteo

Correction is given for the wind velocity due to differences in terrain roughness between the site to be considered and the meteo site.

Three terrain classes are considered:

open terrain;

suburban areas;

urban/city.

The logarithmic law to correct for height is given by

$$\frac{v_1}{v_2} = \frac{\ln(h_2/z_0)}{\ln(h_1/z_0)}$$

where:

v_1 is the velocity at height 1 in m/s

v_2 is the velocity at height 2 in m/s

h_1 is height 1 in m

h_2 is height 2 in m

α is the wind velocity profile exponent

This law is strictly valid only from 60-100 m above ground (EN ISO 15927-1), but can be applied for this standard for wind speeds > 2 m/sec and for heights h > 20 • z_0 and therefore, for the common wind velocity reference height of 10 m, values for too rough areas cannot be given (shaded in Table A.1).

For example assuming an equal wind velocity at the meteo site and the site of interest at a height of 80 the following correction factors can be derived.

Table A.1 — Correction factor for v_{site} / v_{meteo} at 10 m height

Terrain class	Roughness parameter z_0 at site [m]	v_{site} / v_{meteo}
open terrain	0,03	1,0
Country	0,25	0,9
Urban/City	0,5	0,8

The values in Table A.2 are calculated with height 1 = 10 m for meteo and site and height 2 = 80 m. At this height the velocity at meteo and at site are assumed to be equal, and the roughness z_0 at meteo = 0,03 m.

Shielding classes

The facades are split into 3 parts:

1) Lower part (altitude 0 m to 15 m);

2) Medium part (altitude 15 m to 50 m);

3) High part (altitude > 50 m).

A facade part can be shielded as follows:

If Hobst ≥ 0,5 (min (H build;15)) the lower part of the facade can be shielded.

If Hobst-15 ≥ 0,5 (min(35; (H build -15) the lower part and the medium part of the facade can be shielded.

The high part is always considered as not shielded.

For a given wind direction, an obstacle is defined as any building structure or object for which B_{obst}/B_{build} > 0,5. The shielding class depends on the ratio H_{obst}/D_{ob}

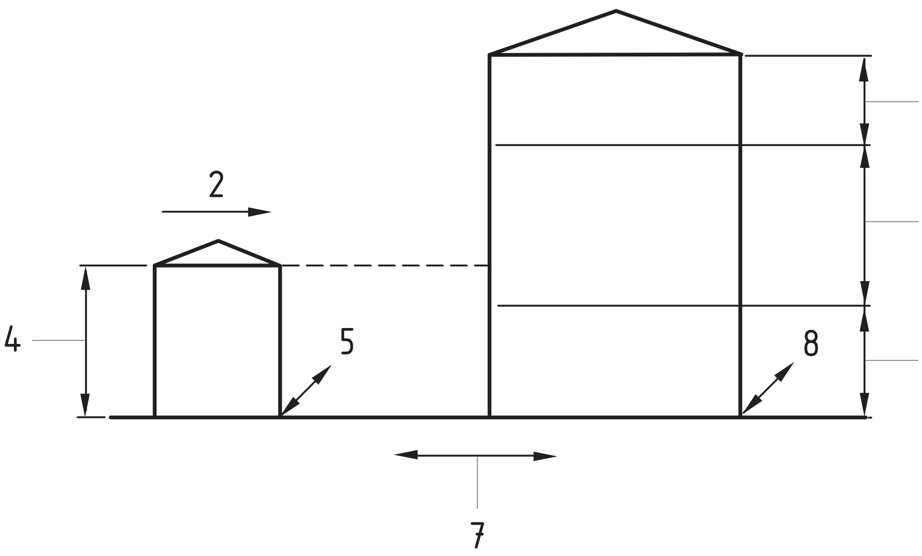
where:

H_{obst} height of the nearest obstacle (upstream);

B_{obst} width of the nearest obstacle;

B_{buidt} width of the building;

D_{ob} distance between the nearest obstacle and the building.



Key

1 high part
2 wind
3 medium part (15 m to 50 m)
4 height H_{obst}
5 width B_{obst}
6 low part (0 m to 15 m)
7 distance D_{ob}
8 width build

Figure A.1 — Obstacle and building

Table A.2 — Shielding classes depending on the obstacle height and relative distance

Shielding class	Relative distance D_{ob} / $H_{\text{obst t}}$
Open	> 4
Normal	1,5 - 4
Shielded	< 1,5

Facade C_p values

According to the faced part and the shielding class, the C_p values are as follows:

Table A.3 — Dimensionless wind pressures

Facade part	Shielding	Dimensionless wind pressures C_p				
		Windward C_{p1}	Leeward C_{p2}	roof (depending on slope) C_{p3}		
				< 10°	10°-30°°	> 30°
low	Open	+ 0,50	- 0,70	- 0,70	- 0,60	- 0,20
	Normal	+ 0,25	- 0,50	- 0,60	- 0,50	- 0,20
	Shielded	+ 0,05	- 0,30	- 0,50	- 0,40	- 0,20
medium	Open	+ 0,65	- 0,70	- 0,70	- 0,60	- 0,20
	Normal	+ 0,45	- 0,50	- 0,60	- 0,50	- 0,20
	Shielded	+ 0,25	- 0,30	- 0,50	- 0,40	- 0,20
High	Open	+ 0,80	- 0,70	- 0,70	- 0,60	- 0,20

NOTE The wind pressure coefficients given are valid for a wind sector of approx. ± 60° to the facade axis. The wind direction is not considered more specifically.

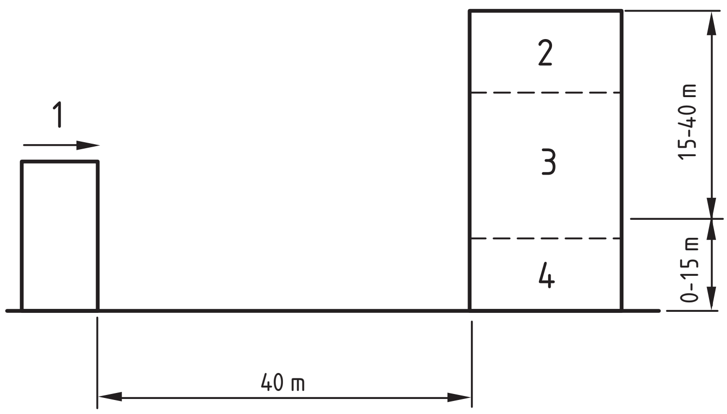
Zone C_p values

For each zone, the C_p values are taken into account considering the average height of the facades zone

— If the average height is lower than 15 m, the zone C_p are taken equal to the facade low part ones;

— If the average height is between 15 and 50 m (or equal), the zone C_p are taken equal to the facade medium part ones;

— If the average height is higher than 50 m, the zone C_p are taken equal to the facade high part ones.



Key

1 wind

2 zone 3

3 zone 2

4 zone 1

Figure A.2 — Example of application

Inputs:

V meteo = 4m/s
Country
Building height : 40 m; Building width B_{build}: 30 m
Zone 1: height 0 to 10 m
Zone 2: height 10 m to 30 m
Zone 3: height 30 m to 40 m
Obstacle height H_{obs}: 20 m Obstacle width B_{obs}: 20 m obstacle is situated north of the building
D_{ob} = 40 m

Calculation

$v_{site} = 0{,}9\ v_{meteo} = 4 \,.\, 0{,}9 = 3{,}6$ m/s

As $B_{obs} / B_{build} = 20/30 = 0{,}67$ is higher than 0,5, the obstacle can be considered for wind direction North ± 60°

For the lower part of the facade (0 to 15 m) H_{obs} = 20 m which is higher than 0,5 . 15 and can therefore be shielded.

As D_{ob} / H_{obs} = 40/20 = 2 the shielding for the lower part is therefore "normal ".

For the medium part (H_{obs} -15) = 5 is lower than 0,5 (min(35; (H build -15)) = 0,5 . 25 = 12.5 and therefore the shielding is considered as "open". It is the same for the roof.

The facade and roof C_p values to be applied are then:

Table A.4 — facade and roof C_p values

<table>
<tr><th rowspan="3">Facade part</th><th rowspan="3">Shielding</th><th colspan="5">Dimensionless wind pressures C_p</th></tr>
<tr><th rowspan="2">Windward C_{p1}</th><th rowspan="2">Leeward C_{p2}</th><th colspan="3">roof (depending on slope) C_{p3}</th></tr>
<tr><th>< 10</th><th>10 to 30</th><th>> 30</th></tr>
<tr><td rowspan="2">Low for Wind north North ± 60°
Low for other wind direction</td><td>Normal</td><td>+ 0,25</td><td>-0,50</td><td></td><td></td><td></td></tr>
<tr><td>Open</td><td>+ 0,50</td><td>-0,70</td><td></td><td></td><td></td></tr>
<tr><td>medium</td><td>Open</td><td>+ 0,65</td><td>-0,70</td><td>-0,70</td><td>-0,60</td><td>-0,20</td></tr>
</table>

The zone C_p values are then as follows:

— Zone 1 average height = 10:2 = 5 m — C_p values for low

— Zone 2: average height = (10 + 30)/2 = 20 m — C_p values for medium

— Zone 3 : average height = (30 + 40)/2 = 35 m — C_p values for medium

Annex B
(normative)

Leakages characteristics

B.1 Expression of national requirements and default values

National requirement, or default values should be defined as:

— n(vol.h) or airflow / outer envelope or Airflow / floor area;

— For a pressure difference of 50 Pa or 10 Pa or 4 Pa.

If a national regulation defines both requirement and default values, they have to be expressed in the same unit.

If nothing else is defined, a conventional value for the exponent of 0,667 will be used.

B.2 Examples of application

As an illustration the following tables compare these different ways of expression, for typical values of outer envelope/ vol and outer envelope / floor area ratios starting from values of external envelope airtightness.

The "low","average" and "high" leakages levels are not normative, and just given to illustrate the way to express the results or requirements and should not be considered as typical values due to the variety of national construction habits.

Table B.1 — examples of leakages characteristics

	leakages level		m³/h per m² of outer enveloppe (exp n = 0,667)	
		Q4Pa	Q10Pa	Q50Pa
single family	low	0,5	1	2,5
	average	1	2	5
	high	2	3,5	10
multi family ; non residential except industrial	low	0,5	1	2,5
	average	1	2	5
	high	2	3,5	10
industrial	low	1	2	5
	average	2	3,5	10
	high	4	7	20

	leakages level	n (vol.h) (exp n=0,667)			outer
		n4Pa	n10Pa	n50Pa	area/vol 1/m
single family	low	0,4	0,8	1,9	0,75
	average	0,8	1,5	3,8	0,75
	high	1,5	2,6	7,5	0,75
multi family ; non residential except industrial	low	0,2	0,4	1,0	0,4
	average	0,4	0,8	2,0	0,4
	high	0,8	1,4	4,0	0,4
industrial	low	0,3	0,6	1,5	0,3
	average	0,6	1,1	3,0	0,3
	high	1,2	2,1	6,0	0,3

	leakages level		m³/h per m² of floor area (exp n = 0,667)		outer area /
		Q4Pa	Q10Pa	Q50Pa	floor area 1/m
single family	low	0,9	1,8	4,5	1,8
	average	1,8	3,6	9,0	1,8
	high	3,6	6,3	18,0	1,8
multi family ; non residential except industrial	low	0,6	1,1	2,8	1,1
	average	1,1	2,2	5,5	1,1
	high	2,2	3,9	11,0	1,1
industrial	low	1,5	3,0	7,5	1,5
	average	3,0	5,3	15,0	1,5
	high	6,0	10,5	30,0	1,5

		m^3/h per m^2 of outer enveloppe (exp n = 0,667)		
	leakages level	Q4Pa	Q10Pa	Q50Pa
single family	low	0,5	1	2,5
	average	1	2	5
	high	2	3,5	10
multi family ; non residential except industrial	low	0,5	1	2,5
	average	1	2	5
	high	2	3,5	10
industrial	low	1	2	5
	average	2	3,5	10
	high	4	7	20

		n (vol.h) (exp n=0.667)			outer
	leakages level	n4Pa	n10Pa	n50Pa	area/vol 1/m
single family	low	0,4	0,8	1,9	0,75
	average	0,8	1,5	3,8	0,75
	high	1,5	2,6	7,5	0,75
multi family ; non residential except industrial	low	0,2	0,4	1,0	0,4
	average	0,4	0,8	2,0	0,4
	high	0,8	1,4	4,0	0,4
industrial	low	0,3	0,6	1,5	0,3
	average	0,6	1,1	3,0	0,3
	high	1,2	2,1	6,0	0,3

			m^3/h per m^2 of floor area (exp n = 0,667)		outer area /
	leakages level	Q4Pa	Q10Pa	Q50Pa	floor area 1/m
single family	low	0,7	1,4	3,4	1,8
	average	1,4	2,7	6,8	1,8
	high	2,7	4,7	13,5	1,8
multi family ; non residential except industrial	low	0,2	0,4	1,1	1,1
	average	0,4	0,9	2,2	1,1
	high	0,9	1,5	4,4	1,1
industrial	low	0,5	0,9	2,3	1,5
	average	0,9	1,6	4,5	1,5
	high	1,8	3,2	9,0	1,5

Annex C
(normative)

Calculation of recirculation coefficient C_{rec}

In case of variable airflow in different rooms and reciculated air, the recirculation coefficient takes into account the necessity for each room to have the required amount of outdoor air.

If $q_{v\text{-req(i)}}$ is the required outdoor air airflow for room i and $q_{v\text{-sup(i)}}$ the actual airflow to the room i.

One simple way to take the recirculation coefficient is to take.

C_{rec} = (1 – max ($q_{v\text{-req(i)}}$ / $q_{v\text{-sup(i)}}$)

Nevertheless, this does not take into account the fact the air is less polluted in the other rooms.

In order to maintain the equivalent amount of pollutant concentration in each room, it is possible to take

$$C_{\mathrm{rec}} = \frac{1}{1 + \dfrac{\left(\dfrac{\sum_{\mathrm{i}} q_{\mathrm{v\text{-}req(i)}}}{\sum q_{\mathrm{v\text{-}sup(i)}}}\right)}{1 - \max_i \left(\dfrac{q_{\mathrm{v\text{-}req(i)}}}{q_{\mathrm{v\text{-}sup(i)}}}\right)}}$$

NOTE This is based on the respect of a pollutant concentration threshold limit in each room.

Example of application

With: q_v

$q_{v\text{-suptot}} = \Sigma_i \, q_{v\text{-sup(i)}}$

$q_{v\text{-reqtot}} = \Sigma_i \, q_{v\text{-req(i)}}$

Table C.1 — Maximum recirculation coefficient C_{rec} allowed

Worst room		$q_{sup\ tot}/q_{reg\ tot}$								
(q_{sup}/q_{req})	local C_{rec}	1,01	1,50	2,00	2,50	3,00	3,50	4,00	4,50	5,00
1,01	0,01	0,01	0,01	0,02	0,02	0,03	0,03	0,04	0,04	0,05
1,50	0,33		0,33	0,40	0,45	0,50	0,54	0,57	0,60	0,63
2,00	0,50			0,50	0,56	0,60	0,64	0,67	0,69	0,71
2,50	0,60				0,60	0,64	0,68	0,71	0,73	0,75
3,00	0,67					0,67	1	0,73	0,75	0,77
3,50	0,71						0,70	0,74	0,76	0,78
4,00	0,75							0,75	0,77	0,79
4,50	0,78								0,78	0,80
5,00	0,80									0,80

Annex D
(normative)

Conversion formulas

D.1 l/s vs m^3/h

Depending on the different standards in relationship with this one, the volume air flow rate can be expressed in l/s or m^3/h. The conversion is

1l/s = 3,6 m^3/h

D.2 Mass flow rate vs volume flow rate

D.2.1 General

The component is described as a volume (fan) or a volume vs. pressure characteristic for a given temperature θref and therefore at ρ (mass of dry air) value ρ_{ref}. The mass flow (considering $\rho_{through}$, the ρ value of the air through the component) is calculated as follows:

D.2.2 For leakages

$q_m = q_v\ \rho_{through}$

$\rho_{through}$ depends on the air flow direction (air entering or leaving the zone)

D.2.3 For air inlets,

$q_m = q_v\ \rho_{through}^{\ 0,5}\ \rho_{ref}^{\ 0,5}$

$\rho_{through}$ depends on the air flow direction (air entering or leaving the zone)

D.2.4 For fan

$q_m = q_v\ \rho_{through}$

D.3 Calculation of C_{leak} and C_{vent}

$C_{leak} = qv_{dP} / 50^n$

With:

C_{leak} air flow (l/s) for a pressure difference of 1 Pa

qv_{dP} Airflow for a pressure difference of dP Pa

n exponent coefficient

if n50 is the air leakage characteristic under 50 Pa,

C_{leak} = 0,278 n50 Vol /(50n)

A default value for n of 0,67 can be used.

The following table gives the relation ship between the different pressure differences regarding the exponent.

Table D.1 — Conversion formulas depending on the unit

Exponant n	Q50/Q1	Q1/Q50	Q10/Q1	Q1/Q10	Q4/Q1	Q1/Q4
0,5	7,07	0,14	3,16	0,32	2,00	0,50
0,6	10,46	0,10	3,98	0,25	2,30	0,44
0,667	13,59	0,07	4,65	0,22	2,52	0,40
0,7	15,46	0,06	5,01	0,20	2,64	0,38
0,8	22,87	0,04	6,31	0,16	3,03	0,33
0,9	33,81	0,03	7,94	0,13	3,48	0,29

Exponant n	Q50/Q10	Q10/Q50	Q50/Q4	Q4/Q50	Q10/Q4	Q4/Q10
0,5	2,24	0,45	3,54	0,28	1,58	0,63
0,6	2,63	0,38	4,55	0,22	1,73	0,58
0,667	2,93	0,34	5,39	0,19	1,84	0,54
0,7	3,09	0,32	5,86	0,17	1,90	0,53
0,8	3,62	0,28	7,54	0,13	2,08	0,48
0,9	4,26	0,23	9,71	0,10	2,28	0,44

It can be noticed that in typical running conditions, the pressure difference is of some Pa.

It is also often found that for leaky building, the exponent is lower than 0,667, and higher for airtight constructions. It is therefore preferable to take into account the exponent n if the value is given at 50 Pa, as the reference pressure difference is far from the running conditions.

The leakage coefficient for the dwelling envelope leakage may be calculated from the air volume flow rate at any pressure reference *p*.Pa (exemple: 4,10 Pa) value $q_v\, p$ as follows :

$$C_{\text{inf}} = q_v p \cdot \left(\frac{1}{p}\right)^n \qquad [\text{dm}^3/\text{s at 1Pa}]$$

where:

$q_v p$ is the air flow at *p*Pa pressure difference

p is the pressure reference (4 or 10 Pa) where $Qv4 = v4 \cdot A$

n is the flow exponent with a default value of 0,67

air inlet and vent

The coefficient for vent may be calculated from the equivalent area A_{vent} value, according to EN 13141-1 and EN 13141-2, as follows:

$$C_{\text{vent}} = 1\,000 \cdot A_{\text{vent}} \cdot \left(\frac{2}{p}\right)^{0,5} \cdot \left(\frac{1}{\Delta p_{\text{ref}}}\right)^{n} \cdot C_{\text{D}} \text{ (at 1Pa)}$$

Where:

A_{vent} is the area of leakage or vent

p is the density of air (outdoor if the air enters the zone, indoor otherwise)

Δp_{ref} is the reference pressure difference for A [e.g. 4 Pa]

C_D is the discharge coefficient for opening [usually 0,6]

n is the flow exponent with a default value of 0,5

Annex E
(informative)

Examples of fuel flow factor for residential buildings

For residential buildings, the fuel flow factors for combustion air flow are given in Table F.1.

Table E.1 — Data for fuel flow factor

Fuel type	**Wood,**	**Gas**				**Oil**	**Coal**
Appliance type	open fire place	closed with built in fan	open gas with flue balancer	open gas kitchen stove	open gas wood/coal effect gas fire	closed fire	closed fire
Fuel flow factor [dm^3/s per kW]	2,8	0,38	0,78	3,35	3,35	0,32	0,52

Bibliography

[1] CEN/TR 1749, *European scheme for the classification of gas appliances according to the method of evacuation of the products of combustion (Types)*

[2] EN 13053, *Ventilation for buildings — Air handling units — Rating and performance for units, components and sections*

[3] EN 13141-1, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 1 Externally and internally mounted air transfer devices*

[4] EN 13141-2, *Ventilation for buildings — Performance testing of components/products for residential ventilation — Part 2: Exhaust and supply air terminal devices*

[5] CR 14378, *Ventilation for buildings — Experimental determination of mechanical energy loss coefficients of air handling components*

[6] EN ISO 15927-1, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 1: Monthly means of single meteorological elements (ISO 15927-1:2003)*

[7] EN ISO 13791, Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — General criteria and validation procedures (ISO 13791:2004)

[8] EN ISO 13792, Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — Simplified methods (ISO 13792:2005)

[9] prEN 15243 *Ventilation for buildings — Calculation of room temperatures and of load and energy for buildings with room conditioning systems*