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Smoke and heat control systems - Part 6: Specification for pressure differential systems - Kits

Rauch- und Wärmefreihaltung - Teil 6: Festlegungen für Differenzdrucksysteme - Bausätze

Systemes pour le contrôle des fumées et de la chaleur - Partie 6: Spécifications relatives aux systemes a différentiel de pression - Kits

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Smoke and heat control systems - Part 6: Specification for pressure differential systems - Kits

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Anlagen zur Kontrolle von Rauch- und Wärmesströmungen - Teil 6: Anforderung an Differenzdrucksysteme - Bausätze

This European Standard was approved by CEN on 17 January 2005.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

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

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Foreword

This document (EN 12101-6:2005) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, 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of an identical text or by endorsement, at the latest by December 2005, and conflicting national standards shall be withdrawn at the latest by December 2005.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 89/106/EEC.

For relationship with EU Directive(s), see informative Annex ZA which is an integral part of this document.

This European Standard has the general title "*Smoke and heat control systems"* and consists of the following eleven parts:

Part 1: *Specification for smoke barriers*;

Part 2: *Specification for natural smoke and heat exhaust ventilators*;

Part 3: *Specification for powered smoke and heat exhaust ventilators*;

Part 4: *Fire and smoke control installations – Kits*;

Part 5: *Design and calculation for smoke and exhaust ventilation systems (published as CR 12101-5)*;

Part 6: *Specification for pressure differential systems – Kits*;

Part 7: *Smoke control ducts*;

Part 8: *Specification for smoke control dampers*;

Part 9: *Control panels and emergency control panels*;

Part 10: *Power supplies*;

EN 12101 is included in a series of European Standards planned to cover also:

a) Gas extinguishing systems (EN 12094 and EN ISO 14520);

b) Sprinkler systems (EN 12259);

c) Powder systems (EN 12416);

d) Explosion protection systems (EN 26184);

e) Foam systems (EN 13565);

g) Hose reel systems (EN 671);

h) Water spray systems (EN 14816).

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

0 Introduction

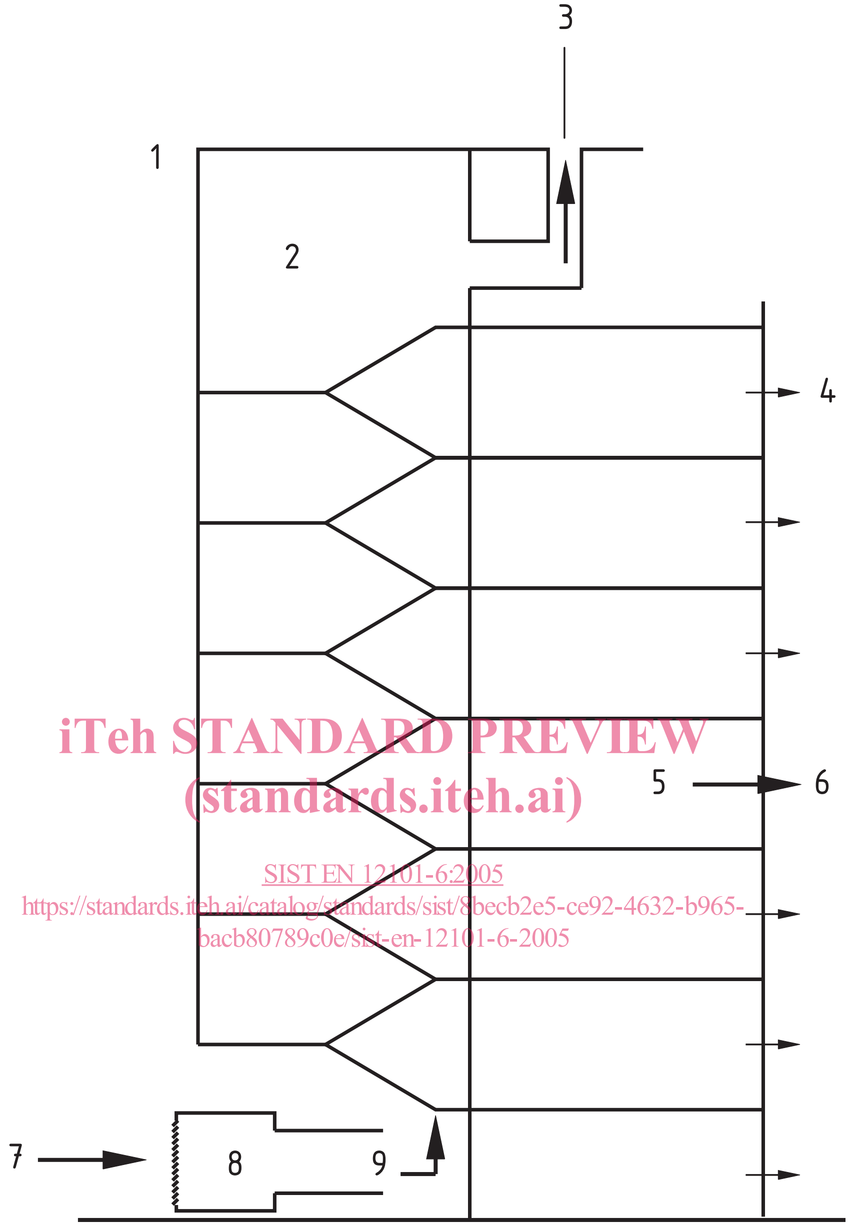
0.1 Smoke movement in the building

This document covers information and requirements on the design, calculation methods, installation and testing of systems intended to limit the spread of smoke by means of pressure differentials.

Pressure differential systems can be achieved by two methods:

i) pressurization – maintaining a positive pressure within the protected spaces (see Figure 1a), or

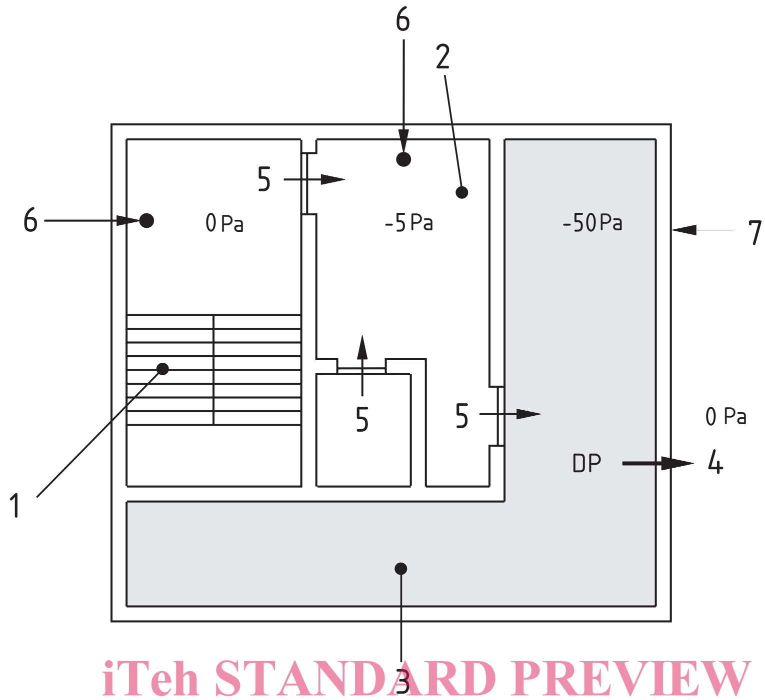
ii) depressurization – removing hot gases from the fire zone at a lower pressure than the adjacent protected space (see Figure 1b).



Key

1 Outside
2 Pressurized space
3 Overpressure relief
4 External leakage
5 Fire zone
6 Air release vents
7 Air intake
8 Supply fan
9 Supply ductwork

Figure 1 a) — Examples of pressurization and depressurization systems



Key

1 Stair

2 Lobby

3 Accommodation (DP Depressurized space)

4 Exhaust (Depressurize)

5 Leakage path through doors etc.

6 Replacement air

7 Fire-resisting construction

Figure 1 b) — Example of a depressurization system – basements or other spaces with no external windows

In the event of fire, the smoke produced follows a pattern of movement arising from the following main driving forces.

Buoyancy experienced by hot gases on the fire storey. Within the fire zone, smoke produced by the fire experiences a buoyancy force owing to its reduced density. In a building this can result in upwards smoke movement between storeys if leakage paths exist to the storey above. In addition, this buoyancy can cause smoke to spread through leakage paths in vertical barriers between rooms, e.g. doors, walls, partitions. The pressure differential typically causes smoke and hot gases to leak out of gaps at the top of a door and cool air to be drawn in through gaps at the bottom.

Thermal expansion of hot gases in the fire zone. Fire induced expansion of gases can result in a build up of pressure, accompanied by a flow of hot gases out of the compartment. However, in most cases the initial expansion forces may dissipate quickly and may be ignored.

Stack effect throughout the building. In cold ambient conditions, the air in a building is generally warmer and less dense than the external air. The buoyancy of the warm air causes it to rise within vertical shafts in the building, and a pressure gradient is set up in the column such that cold air is drawn into the bottom of the shaft and warm air is forced out at the top. In warm ambient conditions, when the air inside the building can be cooler than that outside, the reverse condition may exist, i.e. air is forced out at the bottom of the stack and drawn in at the top. In either case, at some intermediate point a neutral pressure plane is formed where the pressures of the external and the internal air are equal.

Wind pressure forces. When wind blows towards the side of a building, it is slowed down, resulting in a build-up of pressure on the windward face. At the same time the wind is deflected and accelerated around the side walls and over the roof, creating a reduction in pressure on the leeward side of the building, i.e. suction in these areas. The greater the speed of the wind, the greater the suction. The main effect of these pressures is to produce a horizontal movement of air through the building from the windward to the leeward sides. If the building envelope is leaky, e.g. with openable doors and windows, then the effect will be more pronounced. In a fire, if a broken window exists on the windward side of the building, the wind can force the smoke through the building horizontally or in some circumstances vertically. It can be difficult to predict accurately the wind pressures that will be exerted on buildings or the resultant internal airflows, and computer or wind tunnel analysis may be necessary for a full understanding.

NOTE Guidance on wind loading is given in prEN 1991-2-4.

HVAC systems. HVAC systems can supply air to the fire zone and aid combustion, or transport smoke rapidly to areas not within the zone of the source of the fire, and are often shut down in the event of fire. However, such systems can often be modified to assist in restricting smoke spread or be used in conjunction with pressure differential system air supply and/or release systems.

0.2 Objectives of pressure differential systems

The objective of this document is to give information on the procedures intended to limit the spread of smoke from one space within a building to another, via leakage paths through physical barriers (e.g. cracks around closed doors) or open doors.

Pressure differential systems offer the facility of maintaining tenable conditions in protected spaces, for example escape routes, firefighting access routes, firefighting shafts, lobbies, staircases, and other areas that require to be kept free of smoke. This document offers information with regard to life safety, firefighting and property protection within all types of buildings. It is necessary to determine not only where the fresh air supply for pressurization is to be introduced into a building but also where that air and smoke will leave the building and what paths it will follow in the process. Similar considerations apply to depressurization schemes, i.e. the route for the exhaust air, plus consideration for the inlet replacement air and the paths it will follow.

The aim therefore is to establish a pressure gradient (and thus an airflow pattern) with the protected escape space at the highest pressure and the pressure progressively decreasing in areas away from the escape routes.

Pressure differential systems provide one means of improving the level of fire safety within a building. A decision as to whether such a system is appropriate to a particular project should be taken in context with the overall design strategy for means of escape, firefighting and property protection within the building. This will lead to design assumptions which are expected to be appropriate to the particular project, especially in regard of the most likely leakage paths caused by simultaneous open doors as outlined in Clause 5.

Drawings that accompany the text in this document are intended only to clarify points made in the text. It should be assumed that the arrangements shown are informative only.

When the designer is unable to comply with this document in full, an alternative fire safety engineered approach can be adopted. The engineered solution should adopt the functional requirements set out in this document wherever appropriate.

0.3 Smoke control methods

The effect of the air movement forces described above is to create pressure differentials across the partitions, walls and floors which can add together and can cause smoke to spread to areas removed from the fire source. The techniques most commonly used to limit the degree of smoke spread, or to control its effects, are:

a) smoke containment using a system of physical barriers to inhibit the spread of smoky gases from the fire affected space to other parts of the building, e.g. walls and doors;

b) smoke clearance, using any method of assisting the fire service in removing smoky gases from a building when smoke is no longer being produced, i.e. post extinction;

c) smoke dilution, deliberately mixing the smoky gases with sufficient clean air to reduce the hazard potential;

d) smoke (and heat) exhaust ventilation, achieving a stable separation between the warm smoky gases forming a layer under the ceiling, and those lower parts of the same space requiring protection from the effects of smoke for evacuation of occupants and firefighting operations. This normally requires the continuous exhaust of smoke using either natural or powered ventilators, and the introduction of clean replacement air into the fire affected space beneath the smoke layer;

e) pressurization, see 3.1.27;

f) depressurization, see 3.1.10.

This document provides guidance and information on smoke control using pressure differentials, i.e. only the techniques given in items e) and f).

Items a) - d) are not discussed further within this document.

Smoke control using pressure differentials generally requires lower ventilation rates than b) or c) above but is limited to the protection of enclosed spaces adjacent to spaces being smoke logged in the event of a fire.

0.4 Analysis of the problem

The purpose of a pressure differential system, whether used for the protection of means of escape, firefighting operations or property protection, can have a significant influence on the system design and specification. It is, therefore, essential that the fire safety objectives are clearly established and agreed with the appropriate authorities at an early stage in the design process.

The acceptability of any system ultimately depends upon whether the necessary pressure differential levels and the airflow rates are achieved. Guidance on the means of calculating the air supply rates to achieve these levels are given within this document. However, providing that the functional objectives of the systems (see subclauses a), b) and c) below) are met then the designer may choose to use other calculation procedures, as appropriate, in substantiation of their design.

The objectives addressed in this document are as follows:

a) **Life safety**. It is essential that tenable conditions for life safety are maintained in protected spaces for as long as they are likely to be in use by the building occupants.

b) **Dedicated firefighting routes**. To enable firefighting operations to proceed efficiently, protected firefighting access routes (e.g. firefighting shafts) should be maintained essentially free of smoke so that access to the fire affected storey can be achieved without the use of breathing apparatus. The pressure differential system should be designed so as to limit the spread of smoke into the dedicated firefighting route under normal firefighting conditions.

c) **Property protection**. The spread of smoke should be prevented from entering into sensitive areas such as those containing valuable equipment, data processing and other items that are particularly sensitive to smoke damage.

1 Scope

This document specifies pressure differential systems designed to hold back smoke at a leaky physical barrier in a building, such as a door (either open or closed) or other similarly restricted openings. It covers methods for calculating the parameters of pressure differential smoke control systems as part of the design procedure. It gives test procedures for the systems used, as well as describing relevant, and critical, features of the installation and commissioning procedures needed to implement the calculated design in a building. It covers systems intended to protect means of escape such as stairwells, corridors and lobbies, as well as systems intended to provide a protected firefighting bridgehead for the Fire Services.

The systems incorporate smoke control components in accordance with the relevant Parts of EN 12101 and kits comprising these and possibly other components (see 3.1.18). This document gives requirements and methods for the evaluation of conformity for such kits.

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 1505, *Ventilation for buildings —Sheet metal air ducts and fittings with rectangular cross section — Dimensions*

EN 1506, *Ventilation for buildings —Sheet metal air ducts and fittings with circular cross section — Dimensions*

prEN 12101-4, *Smoke and heat control systems — Part 4: Fire and smoke installations — Kits*

prEN 12101-7, *Smoke and heat control systems — Part 7: Smoke control ducts*

prEN 12101-9, *Smoke and heat control systems — Part 9: Control panels*

prEN 12101-10, *Smoke and heat control systems — Part 10: Power supplies*

prEN 13501-3, *Fire classification of construction products and building elements — Part 3: Classification using data from fire resistance tests on products and elements used in building service installations: fire resisting ducts and fire dampers*

prEN 13501-4, *Fire classification of construction products and building elements — Part 4: Classification using data from fire resistance tests on components of smoke control systems*

EN ISO 9001:2000, *Quality management systems — Requirements (ISO 9001:2000)*

EN ISO 13943:2000, *Fire safety — Vocabulary (ISO 13943:2000)*

3 Terms, definitions, symbols and units

3.1 General terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 13943:2000 and the following apply.

3.1.1
accommodation
any part of the construction works which is not directly pressurized and does not form part of a protected escape route or firefighting shaft

3.1.2
air inlet
connection to outside air to allow the entry of air from outside the construction works

3.1.3
air release
means by which pressurizing air is able to escape from the accommodation or other unpressurized space to outside the building

3.1.4
atrium (plural atria)
enclosed space, not necessarily vertically aligned, passing through two or more storeys in a construction works

NOTE Lift wells, escalator shafts, building services ducts, and protected stairways are not classified as atria.

3.1.5
authorities
organisations, officers or individuals responsible for approving SHEVS, pressure differential and sprinkler systems as appropriate, equipment and procedures, e.g. the fire and building control authorities, the fire insurers, or other appropriate public authorities

3.1.6
circulation space
space mainly used as a means of access between a room and an exit from the building or compartment

3.1.7
commissioning
act of ensuring that all components, kits and the system are installed and operating in accordance with the manufacturer's instructions and this document

3.1.8
control panel
device containing control and/or release devices, manual and/or automatic, used to operate the system

3.1.9
Defend in Place
means of escape design criterion in flats and maisonettes based on operational firefighting tactics where, owing to the high degree of compartmentation provided, the spread of fire from one dwelling to another is unusual. It is therefore not assumed in the event of a fire that it is necessary to evacuate the whole building, whole floors or even dwellings adjacent to the fire

3.1.10
depressurization
smoke control using pressure differentials where the air pressure in the fire zone or adjacent spaces is reduced below that in the protected space

3.1.11
depressurized space
fire compartment from which air and smoke are exhausted for the purposes of depressurization

3.1.12
firefighting lift
lift designed to have additional protection, with controls that enable it to be used under the direct control of the fire service in fighting a fire

3.1.13
firefighting lobby
protected lobby providing access from firefighting stair to accommodation area and to any associated firefighting lift

3.1.14
firefighting shaft
protected enclosure containing a firefighting stair, firefighting lobbies and, if provided, a firefighting lift, together with its machine room

3.1.15
firefighting stair
protected stairway communicating with the accommodation area only through a firefighting lobby

3.1.16
fire zone
room or compartment in which the fire is assumed to occur for the purposes of design

3.1.17
fully-involved fires
another term for fully-developed fires, which is the state of total involvement of combustible materials, within an enclosure, in a fire

3.1.18
kit
set of at least two separate components that need to be put together to be installed permanently in the works to become an assembled system. The kit needs to be placed on the market allowing a purchaser to buy it in a single transaction from a single supplier. The kit may include all, or only a subset of, the components necessary to form a complete pressure differential system

3.1.19
leakage paths
gaps or cracks in the construction or around doors and windows which provide a path for air to flow between the pressurized/depressurized space and the exterior of the building or the construction works

3.1.20
life safety systems
systems that need to remain operational for a specific period of time, where the occupant of the premises need to be alerted to a fire situation, and then be able to exit the premises in the time period calculated, with the systems maintaining operational status for the means of escape situation. These systems would include fire protection systems, control systems for smoke ventilation and pressure differential systems

3.1.21
lift shaft
space through which the lift and the counterweight (if any) move. This space is materially enclosed by the bottom of the pit, the approximately vertical walls and the ceiling

3.1.22
means of escape
structural means whereby a safe route is provided for persons to travel from any point in a building to a place of safety

3.1.23
mixed-use development
structural combination of a number of premises that can include areas providing common access/egress within a building, for example a premises containing a multiplex cinema, shops, residential areas and offices

3.1.24
over-pressure relief
provision for releasing excess pressurizing air from the pressurized space

3.1.25
over-pressure relief vent
device which opens automatically at a certain pressure difference (design pressure difference) to give a free flow path from a pressurized space (e.g. staircase or lift shaft) to a space of lower pressure (e.g. lobby, accommodation) or to the open air

3.1.26
pressure differential system
system of fans, ducts, vents, and other features provided for the purpose of creating a lower pressure in the fire zone than in the protected space

3.1.27
pressurization
smoke control using pressure differentials, where the air pressure in the spaces being protected is raised above that in the fire zone

3.1.28
pressurized space
shaft, lobby, corridor, or other compartment in which the air pressure is maintained at a higher value than that of the fire zone

3.1.29
protected escape routes
route from the accommodation to a final exit, comprising one or more of the following:

– protected stairwell,

– protected lobby and/or

– protected corridor

3.1.30
refuge
area which is both separated from a fire by a fire-resisting construction and provided with a safe route to a storey exit, thus constituting a temporarily safe place during evacuation

3.1.31
replacement air
see air inlet

3.1.32
residential accommodation
accommodation where each dwelling is a fire-compartment in its own right, such as apartments or maisonettes

3.1.33
simple lobby
lobby which does not give access to lifts, shafts, or ducts that could constitute an appreciable leakage path for smoke to spread to other levels within the building. A lobby connected to a lift well or other shaft is still a simple lobby if all such shafts are pressurized. A simple lobby may be either unventilated or naturally ventilated

3.1.34
smoke control
management of the movement of smoky gases within a building to ensure adequate fire safety

3.1.35
stack effect
pressure differential resulting from a difference in density between two interconnected columns of air at different temperatures

3.2 Symbols and units

For the purposes of this document, mathematical and physical quantities are represented by symbols, and expressed in units, as given below.

A_1, A_2, A_3, A_4, A_N	m^2	leakage areas of *N* parallel paths;
A_D	m^2	total effective leakage area of all doors out of the pressurized space with the prescribed doors open;
A_d	m^2	leakage area of one lift door;
A_{door}	m^2	area of the opening through which pressurizing air will pass when a door is open;
A_e	m^2	total effective leakage area of a path through which air from a pressurized space passes;
A_F	m^2	total leakage area between a lift well and the external air;
A_{Floor}	m^2	area of the floor as defined in Table A.6;
A_G	m^2	door leakage area including area of any airflow grilles or large gaps for air transfer. Used to calculate the value of *K*;
A_{LF}	m^2	total leakage area through the floor as defined in Table A.6;
A_{LW}	m^2	total leakage area through the walls as defined in Table A.5;
A_{PV}	m^2	area of the pressure operated relief vent;
A_{rem}	m^2	leakage area from the lobby other than through the open door;
A_t	m^2	total leakage area between all lift doors and the lift well;
A_{VA}	m^2	air release vent area per storey;
A_{VS}	m^2	net vent area per storey maintained throughout the route to the outside of the building i.e. from the accommodation into a shaft, the shaft cross sectional area and the top vent area (shaft to atmosphere);
A_W	m^2	total effective leakage area of all windows out of the space;
A_{Wall}	m^2	area of the walls as defined in Table A.5;