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A review of building airtightness and ventilation standards

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Air Infiltration Centre
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Annex V Air Infiltration Centre

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PREFACE

International Energy Agency

In order to strengthen cooperation in the vital area of energy policy, an Agreement on an International Energy Programme was formulated among a number of industrialised countries in November 1974. The International Energy Agency (IEA) was established as an autonomous body within the Organisation for Economic Cooperation and Development (OECD) to administer that agreement. Twenty-one countries are currently members of the IEA, with the Commission of the European Communities participating under a special arrangement.

As one element of the International Energy Program, the Participants undertake cooperative activities in energy research, development and demonstration. A number of new and improved energy technologies which have the potential of making significant contributions to our energy needs were identified for collaborative efforts. The IEA Committee on Energy Research and Development (CRD), assisted by a small Secretariat staff, coordinates the energy research, development and demonstration programme.

Energy Conservation in Buildings and Community Systems

The International Energy Agency sponsors research and development in a number of areas related to energy. In one of these areas, energy conservation in buildings, the IEA is sponsoring various exercises to predict more accurately the energy use of buildings, including comparison of existing computer programs, building monitoring, comparison of calculation methods, etc. The difference and similarities among these comparisons have told us much about the state of the art in building analysis and have led to further IEA sponsored research.

Annex V Air Infiltration Centre

The IEA Executive Committee (Building and Community Systems) has highlighted areas where the level of knowledge is unsatisfactory and there was unanimous agreement that infiltration was the area about which least was known. An infiltration group was formed drawing experts from most progressive countries, their long term aim to encourage joint international research and to increase the world pool of knowledge on infiltration and ventilation. Much valuable but sporadic and uncoordinated research was already taking place and after some initial groundwork the experts group recommended to their executive the formation of an Air Infiltration Centre. This recommendation was accepted and proposals for its establishment were invited internationally.

The aims of the Centre are the standardisation of techniques, the validation of models, the catalogue and transfer of information and the encouragement of research. It is intended to be a review body for current world research, to ensure full dissemmination of this research and based on a knowledge of work already done to give direction and a firm basis for future research in the Participating Countries.

Current participants in this task are Belgium, Canada, Denmark, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States of America.

INTRODUCTION

Since the oil crisis of 1973, many countries have developed policies aimed at reducing energy consumption in their national building stock. Top priority has been given to additional insulation as an energy conservation measure. This has resulted in the growth in significance of ventilation heat loss from 20% to as much as 50% of the total space heating demand of buildings: energy conservationists are therefore beginning to concentrate on making buildings more airtight. To satisfy the need to both reduce energy consumption and maintain an acceptable level of indoor air quality, standards are being introduced in many countries detailing airtightness requirements and ventilation rates[1].

The aim of this technical note is to list and analyse such standards in the ten countries participating in the Air Infiltration Centre. One additional country, West Germany, has been included since German standards are often used as models in other European countries. Relevant standards produced by the European Committee for Standardisation and the International Standards Organisation are also listed. The standards reviewed are mainly concerned with energy conservation and the maintenance of indoor air quality, rather than special requirements associated with the ventilation needs of specific buildings or those related to industrial processes.

In the countries dependent on imported fuel, and therefore badly affected by the oil crisis, comprehensive energy policies have been developed to reduce energy consumption[2,3]. These countries tend to have detailed and mandatory standards concerning airtightness of buildings; Sweden and Norway are the only countries to have an airtightness standard for whole dwellings which, in both cases, is incorporated into a national building code. In other countries such as the USA and Switzerland, it is left to regional authorities to produce and apply standards though these are often based on national 'model' codes. The difference in production and degree of application of standards between countries makes comparison difficult, but there are some points of similarity. Several countries have requirements for airtightness of windows and doors but these are primarily for protection against rain rather than for energy conservation. There are also some standards for classification of windows on the basis of air permeability[4]. Airtightness is specified by the rate at which air flows through a component (or building envelope) when a given pressure difference is applied across it. This specification is widely used because, unlike most energy performance standards, it can be codified and enforced relatively easily[5].

To ensure good air quality, many countries have introduced minimum ventilation standards. These are frequently specified in terms of air change rate, air flow or area of ventilation opening. For mechanical ventilation, there are requirements for minimum flow rates and fan capacity. Natural ventilation requirements are often defined in terms of open ventilator rate, openable flaps and air flow rate. There are currently no specific requirements for the installation of mechanical ventilation systems in new houses but, where natural ventilation cannot provide the minimum stipulated air change rate, mechanical ventilation is necessary[4].

Table 1 gives a brief summary of the subject coverage of various standards in different countries. The tightness standards are generally valid only for new housing but some countries, e.g. Denmark, Sweden and Germany, are applying these standards to the retrofit of existing buildings[2,3,6].

The report is presented in two sections. In the first, standards are listed by country and the specified requirements given in them are summarised. The second section contains an analysis in tabular form of the standards according to subject and acts as an index to Section 1. An appendix gives details of the various national and international standards organisations.

REFERENCES

1. Etheridge, D.W., Nevrala, D.J.
Air infiltration in the UK and its impact on the thermal environment.
Proceedings 1st WHO International Climate Symposium, Copenhagen, 30 August - 1 September 1978
= 'Indoor Climate' Fanger P.O., Valbjorn O., Danish Building Research Institute 1979.

2. National Building Agency
Energy-conserving measures in buildings.
NBA Report, July 1982, 29pp

3. Olofsdotter, B.
Energy and the built environment.
Swedish Council for Building Research, Report D9:1982, 75pp

4. Elmroth, A., Levin, P.
Air infiltration control in housing - a guide to international practice.
Swedish Council for Building Research, Report D2:1983, 410pp

5. Ross, H.D.
Significance of air infiltration on building energy conservation design standards and codes.
In 'Building Air Change Rates and Infiltration Measurements', Proceedings ASTM Conference, Gaithersburg, 13 March 1978, C.M. Hunt, J.C. King, H.R. Treschel eds ASTM 1980, p153-161.

6. Koops, E.
Standards, guidelines, laws and regulations.
(Normen, richtlinien, gesetze und verordnungen)
TAB No.7, 1983, p561-567.

TABLE 1: Requirements and recommendations for airtightness and ventilation rates in some countries (based on Table A5.1 in "Air Infiltration Control in Housing")

	Scandinavia			Europe					America		
	Denmark	Norway	Sweden	Belgium	Netherlands	Switzerland	UK	W.Germany	Canada	USA	N.Zealand
Airtightness:											
Components	W	R	R	W	W	W+D	W	W	W+D	W+D	W
Whole buildings	N	R	R	N	N	N	N	N	N[1]	N[1]	N
Minimum ventilation rates:											
Dwellings	R	R	R	R[3]	R	N[2]	R	R	R	R	N[2]
Other (Industrial commercial)	R	R	R	-	R	R	R	R	R	R	N[4]

Key

R = Recommendation exists

N = No recommendation exists

W = Recommendation for windows only

W+D = Recommendation for doors and windows only.

[1] Draft standard in preparation

[2] Recommendations exist for kitchens, bathrooms, toilets

[3] A voluntary standard that may soon be replaced

[4] Government legislation exists for bathrooms, toilets and laundries.

SECTION 1

Review

European Committee for Standardisation

STANDARDS

Reference No.	Standard No.	Title
EC1	EN42	Methods of testing windows: air permeability

This has been given the following Standard Nos. by the countries where it has been adopted:

BS 5368 Part 1	*(UK)*	*1976*
DIN (EN42)	*(Germany)*	*1981*
DS/EN42	*(Denmark)*	*1976*

The following standards are similar:

NS 3206	*(Norway)*	*1974*
SIS 81 81 26	*(Sweden)*	*1977*

EUROPEAN COMMITTEE FOR STANDARDISATION (CEN)

CEN comprises national standards bodies of fifteen countries including Belgium, Denmark, Netherlands, Norway, Sweden, Switzerland, United Kingdom and West Germany. The committee prepares European standards which, if accepted by a significant majority of CEN members, are published as national standards in the countries approving them.

The only relevant standard concerned with airtightness is EN42 (EC1) which describes a pressure chamber method for laboratory testing the air permeability of windows. This is similar to ISO standard 6613 which requires air leakage across the window to be measured under several test pressures (see section covering ISO). Standard EN42 has been adopted as a national standard in Denmark, Germany and the UK. Very similar standards have been introduced in Norway and Sweden.

International Standards Organisation

STANDARDS

Reference No.	Standard No.	Title
IS1	ISO 6613-1980(E)	Windows and door height windows - Air permeability test. 1980
IS2	ISO 6589-1981(E)	Joints in building - Method of test for air permeability of joints. 1981

INTERNATIONAL STANDARDS ORGANISATION (ISO)

ISO is an international agency for standardisation at present comprising the national standards bodies of 87 countries. Once international ISO standards have the approval of at least 75% of the members, it can be used in its original form in any of the participating countries or incorporated into a national standard. There is generally an update every 5 years. All countries under review in this report are members of the ISO.

There are two ISO standards concerned with component leakage. ISO 6613 (IS1) covers air permeability of windows and describes a basic pressurization test in which the window is fitted to a test chamber and the air flow across it measured at different pressures. Air permeability is expressed as m^3 air flow per hour:

- per m^2 of surface area of window
- per m^2 of opening light
- per m of length of opening joint

This standard has been approved by Canada, Denmark, Germany, Netherlands, Norway, Sweden and the UK but has not been approved by Belgium or the USA.

ISO 6589 (IS2) records a similar method for testing the air permeability of joints (air flow per metre length of joint). This has been approved by Canada, Germany, New Zealand, Norway, Sweden and the UK but not by Belgium or Denmark.

A draft standard for testing the airtightness of buildings is currently in preparation. This will probably set out the method used in Norway and Sweden.

Denmark

STANDARDS

Reference No.	Standard No.	Title
DK1	-	The Danish Building Regulations (Bygningsreglement 1982), Ministry of Housing, Copenhagen. 1982
DK2	DS418	Calculations of heat loss from buildings (Beregning af bygningers varmetab). 1977
DK3	DS/EN42	Methods of testing windows. Air permeability test (Vinduesprovning Luftaehed). 1976

DENMARK

The Danish Building Regulations 1982 (DK1) give construction standards for all new buildings, to a high level of energy efficiency. These standards are also being applied to existing building stock under the 1981 Act on reduction of energy consumption in buildings, issued by the Danish government.

Chapter 8 of the Regulations, covering thermal insulation, states that windows and doors should be constructed as tightly as possible so that heat loss through air infiltration will be reduced to a minimum. It recommends that thermal transmittance co-efficients for building components requiring insulation should be calculated on the basis of DS 418 (DK2), compiled by the Danish Society of Engineers (DIF). This gives a method for calculating ventilation heat losses which assumes an air change rate of 0.4 ach for 'tight' living rooms, 0.6 ach for normal living rooms and 0.7 ach for kitchens and bathrooms. It also states that, where airtightness of doors and windows is not known, an air leakage value of 0.5 $dm^3/s/m$ length of joint at 30 Pa should be assumed.

The only other standard concerned with component leakage is DS/EN42 (DK3) (based on European Standard EN42) which describes a pressure chamber method for testing the air permeability of windows in the laboratory.

Chapter 11 of the Danish Building Regulations covers ventilation requirements in residential and non-residential buildings. For residential buildings, fresh air supply should be by natural ventilation via exterior doors and windows. Exhaust air can be removed by natural or mechanical ventilation. Fresh air supply is defined in terms of area of ventilation opening and the rate of air exhaust is expressed in air flow in dm^3/s or by cross-section area of ventilation ducts (see Table 1).

TABLE 1: Ventilation rates for rooms in residential buildings according to the Danish Building Regulations

Room	Fresh air supply in terms of ventilation opening cm^2	Exhaust air	
		Cross-section of duct (natural ventilation) cm^2	Air flow (mechanical ventilation) dm^3/s
Kitchens ($7m^2$ and over)	30	200	20
Kitchens (under $7m^2$)	30	150	15
Bathrooms and WCs	100	150	15
Living rooms	30	-	-

Norway

STANDARDS

Reference No.	Standard No.	Title
NO1	-	Chapter 54. Thermal Insulation and Airtightness (revised 1980) Building Regulations of 1st August 1969. Royal Ministry of Local Government and Labour
NO2	NS8200	Airtightness of buildings. Test method. (Bygningers lufttetthet. Prøvingsmetode) NSF 1981
NO3	NS3206	Methods of testing windows. Airtightness. (Bestemmelse av vinduers lufttetthet) NSF 1974
NO4	-	Chapter 47. Ventilation and installation. (Ventilasjon og installasjoner) Building Regulations of 1st August 1969. Royal Ministry of Local Government and Labour.
NO5	NS3031	Energy and power demands for heating of buildings. Calculation rules. (Beregning av bygningers energi-og effektbehov til oppvarming) NSF 1981

NORWAY

The national building regulations give mandatory standards for airtightness and minimum ventilation rates. Chapter 54 (N01) in the regulations gives quantified requirements for airtightness of whole buildings (see Table 1) based on a standard pressurization test method presented in NS8200 (N02). This is almost identical to the Swedish Standard SIS 02 15 51.

TABLE 1: Maximum air change rate (ach) at 50 Pa for residential buildings according to the Norwegian Building Regulations

Detached and terraced single-family houses	4.0
Other residential buildings of not more than two storeys	3.0
Residential buildings with three or more floors	1.5

In addition, requirements are included on the airtightness of building components such as windows and exterior doors (see Table 2). These are measured according to NS3206 (N03) which is similar to European Standard EN42.

TABLE 2: Air leakage at 50 Pa ($m^3/h/m^2$) for building components according to the Norwegian Building Regulations

External walls	0.4
External doors	1.7
External windows	1.7
Ceilings and floors	0.4

Chapter 47 of the building regulations covers ventilation (N04). For housing, the requirements are either a minimum sectional area of ventilation ducts from different rooms when using natural ventilation, or a specified air flow rate for rooms with mechanical ventilation (see Table 3). For other types of buildings the requirements are given as air flow rate per unit floor area. NS3031 (N05) gives an assumed air change rate of 0.5 ach for a building when calculating ventilation heat loss.

TABLE 3: Minimum ventilation rates for dwellings according to the Norwegian Building Regulations

Room	Fresh air supply	Exhaust air	
		Cross-section of duct cm^2	Air flow dm^3/s
Living rooms including bedrooms	Openable windows or unrestricted ventilation opening of $30cm^2$ in external wall	-	-
Kitchen	- as above -	200	80
Bathroom	Gap above/below door from adjacent room with unrestricted opening of $100cm^2$	150	60

Sweden

STANDARDS

Reference No.	Standard No.	Title
SE1	-	Swedish Building Regulations with Comments (Svensk Byggnorm med Kommentarer) Statens Planverk. SBN 1980
SE2	SIS 02 15 51	Thermal insulation - determination of airtightness of buildings (Värmeisolering-bestämning av byggnaders lufttäthet). SS 1980.
SE3	SIS 81 81 03	Windows. Classification with regard to function. (Fönster. Klassindelning med hänsyn till funktion). SS 1977
SE4	SIS 81 81 26	Windows. Airtightness test. (Fönster. Bestämning av Lufttäthet). SS 1977.

SWEDEN

The main document giving standards for buildings in Sweden is Svensk Byggnorm med Kommentarer (Swedish Building Regulations with Comments)(SE1) issued by Statens Planverk (National Swedish Board of Physical Planning and Building). The latest edition is SBN 1980, which was issued with a comments compendium in 1981.

Chapter 33 of SBN 1980 'Thermal insulation and airtightness' gives maximum air leakage factors for residential buildings at a pressure difference of 50 Pa (see Table 1).

TABLE 1: Maximum air change rate (ach) at 50 Pa for residential buildings according to SBN 1980

Type of building	Leakage factor (ach)
Detached and terraced, single-family houses	3.0
Other residential buildings of not more than two storeys	2.0
Residential buildings of 3 or more storeys	1.0

These results are obtained using a standard pressurization method set out in SS 02 15 51 (SE2). Before the test is performed, all openings in the exterior envelope intended for ventilation purposes must be sealed. Other openings are kept closed. All rooms which are heated to more than 10°C are included; however, rooms with separate ventilation such as boiler rooms and garages are disregarded. A door-leaf or a window is replaced by a sheet of plywood which is fixed to the frame and sealed. An air flow generating and metering system is connected through the sheet, and a sensing tube from the micromanometer continues through the sheet to approximately 10m from the house (see Figure 1). The air flow rate is recorded at a number of pressure differences, positive and negative, and the test results presented in a diagram with pressure difference and air flow/air change rate on the axes (see Figure 2). The test should not be carried out if the average windspeed 1.5m above the ground 10m from the windward side of the house is greater than 10 m/s.

In the comments compendium of SBN 1980 there are stated requirements for airtightness for parts of buildings (see Table 2).

Standard SIS 81 81 03 (SE3) classifies windows into three classes - A,B,C - where A relates to the simplest design, and airtightness requirements are stated for each class (see Figure 3). Airtightness is tested according to SIS 81 81 26 (which is similar to the European Standard EN42) using a guarded pressure box. The permissible air leakage for windows is expressed in $m^3/h/m^2$.

TABLE 2: Values of highest air leakage ($m^3/h/m^2$) for building sections and joints between parts with the same function, according to SBN 1980

Building element	Pressure difference (Pa)	Building with height in floors		
		1-2	3-8	>8
Wall exposed to outdoors	50	0.4	0.2	0.2
Windows and doors exposed to outdoors (refers to tightness of corner joints, fenestration and gaps between frame and window or door*)	50 300 500	1.7 5.6 -	1.7 5.6 -	1.7 5.6 7.9
Roof exposed to outdoors and joint structures exposed to outdoors next to ventilated space	50	0.2	0.1	0.1

* *Letter boxes and door bells constitute further sources of air leakage and higher values can be accepted as a result.*

SBN 1980 also gives minimum ventilation requirements in Chapter 36 'Air Quality'. This states required flow rates of fresh air per person for dwellings, recreational centres and hospital premises (see Table 3). Dwellings have to be equipped with ventilation installations which permit continual air change (in addition to forced flow) of at least 0.35 $dm^3/s/m^2$ of dwelling area.

TABLE 3: Minimum ventilation requirements for dwellings according to SBN 1980

Room	Air flow per person dm^3/s	Minimum ventilation openings m^2
Kitchen	10	0.02
Bathroom and WC	10	0.015

Overall building control and supervision of the enforcement of building legislation (including airtightness standards and ventilation rates) rests with Statens Planverk. Every municipality has a local Building Committee which examines drawings and calculations to check whether the building complies with the requirements in the regulations. The Committee grants a building permit and supervises the building during construction. For every building project there must be a site supervisor who is responsible for the necessary tests and inspections. In addition this is checked by random tests carried out by a building inspector.

FIGURE 1: Arrangement of test equipment according to SS 02 15 51

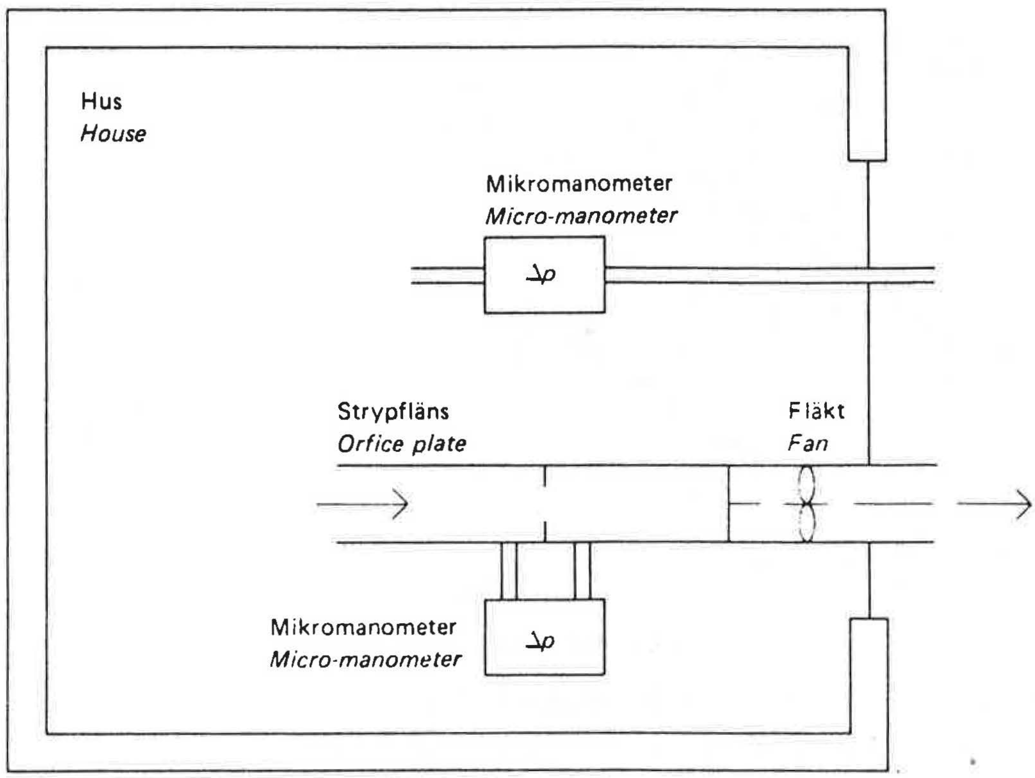


FIGURE 2: Presentation of results according to SS 02 15 51

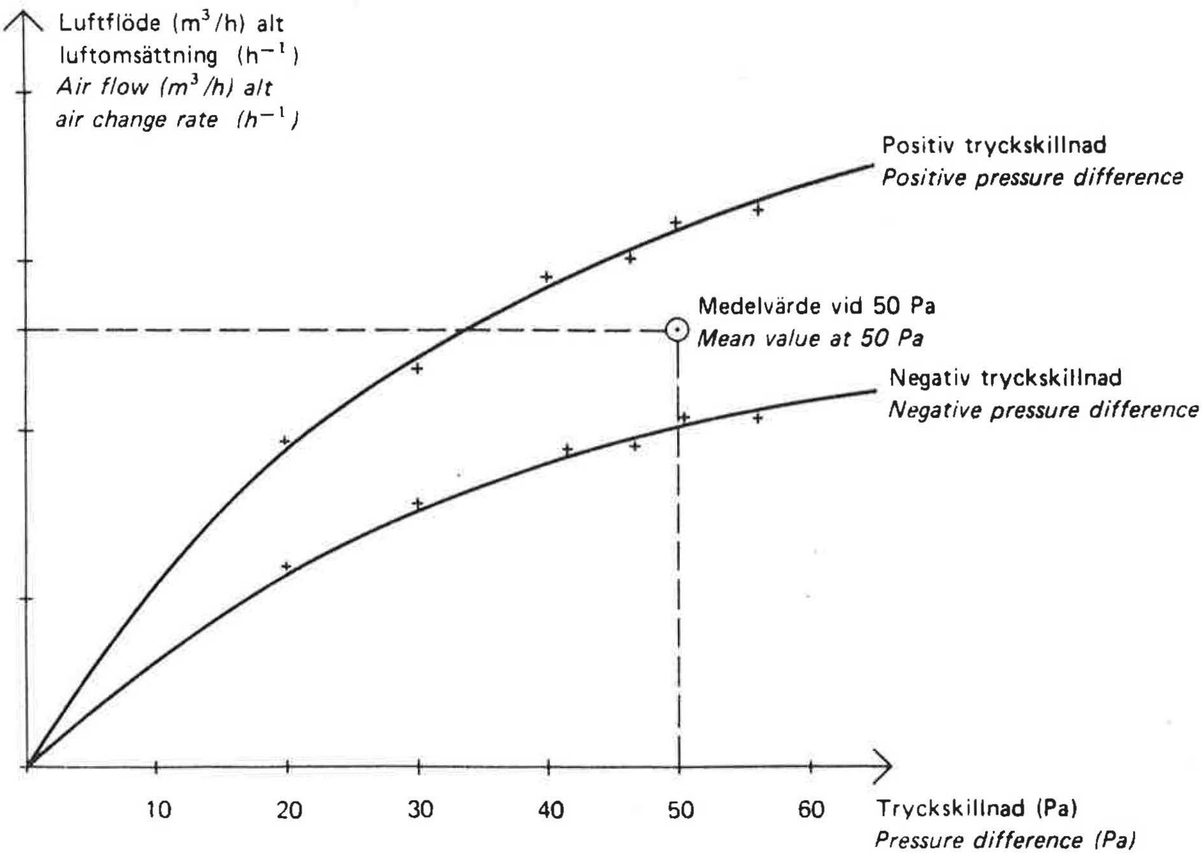
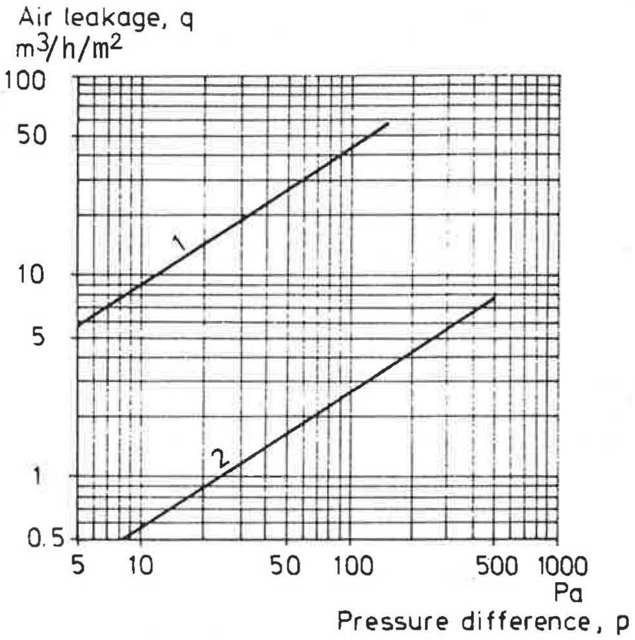


FIGURE 3: Classification of windows by highest permissible air leakage according to Swedish Standard SIS 81 81 03



Class A: air leakage shall be below curve 1 up to 150 Pa

Class B: air leakage shall be below curve 2 up to 300 Pa

Class C: air leakage shall be below curve 2 up to 500 Pa

Belgium

STANDARDS

Reference No.	Standard No.	Title
BE1	NBN B 62-001	Hygrothermal characteristics of buildings. Winter conditions. (Hygrométrie des bâtiments. Isolation thermique. Conditions hivernales). IBN 1974
BE2	NBN B 62-003	Heat loss calculations. (Calcul des déperditions calorifiques) IBN Draft 1983 (final version will be published Summer 1984)
BE3	STS 52.0	External joinery - general principles. (Menuiseries Extérieures - Géneralités) INL Draft 1983
BE4	STS 36	Metal-clad woodwork, windows, light-weight facades and window-frames. (Menuiseries metalliques, fenêtres, façade légères et huisseries). INL 1971.
BE5	STS 52	Timber cladding; windows, french-windows and light-weight facades. (Menuiseries extérieures en bois; fenêtres, portes-fenêtres et façades légères). INL 1973

BELGIUM

National standards are issued by the Belgian Standards Institute (Institut Belge de Normalisation) and are only mandatory for the public building sector, which comprises about 30% of the total building stock. NBN B 62-001 (BE1) gives parameters for individual rooms. These include a maximum ventilation rate of 1.5 ach per room and a stipulation that the air permeability of windows must be less than 6 m^3/h/metre crack length at a pressure difference of 100 Pa. This standard is likely to be withdrawn in the near future and replaced by energy conservation standards issued by the bodies responsible for the building sector in the three regions, Flanders, Wallonia and Brussels. The Wallonia region is preparing a regulation for calculating the heat demand of a building in which the air change rate is assumed to be 0.75 ach.

NBN B 62-002 (BE2) sets out a method for calculating heat loss from a building and includes an assumed ventilation rate of 1 ach or 10-20 m^3/h/ person in naturally ventilated buildings.

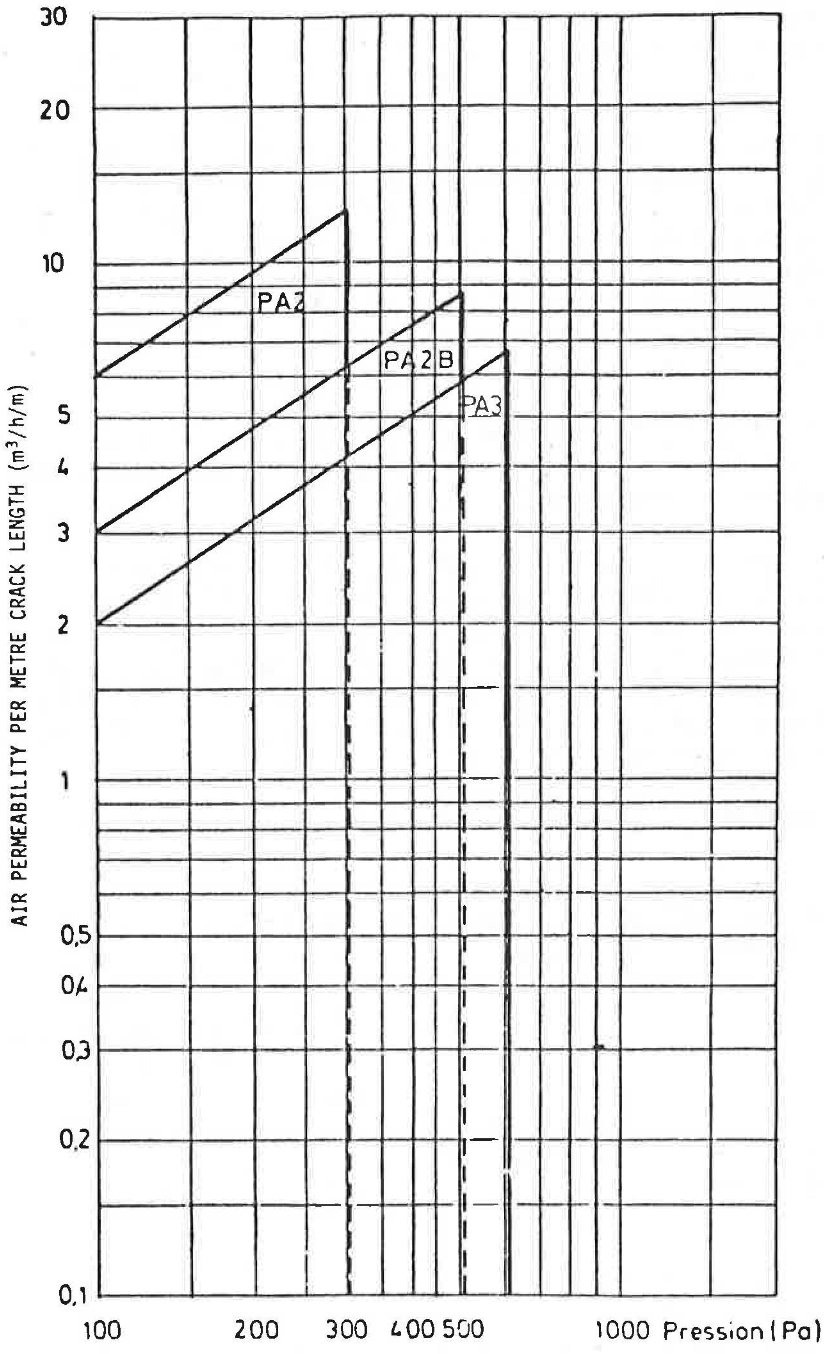
The public building sector also uses the 'Specifications Techniques Unifiées' (STS), a series of building codes issued by the National Housing Institute (Institut National du Logement). STS 52.0 (BE3) classifies windows into groups according to their air leakage performance and degree of exposure, and gives a maximum leakage value for each group at 100 Pa (see Table 1 and Figure 1). STS 36 (BE4) and STS 52 (BE5) also present these values for different types of window frame.

There are, however, no overall airtightness requirements for whole buildings.

TABLE 1: Maximum rate of leakage at 100 Pa for different grades of window according to STS 52.0

	Window classification		
	PA2	PA2B	PA3
Exposure level - height of building in which the window is situated	0-10m	10-18m	> 18m
Air permeability of joints per metre crack length (m^3/h/m)	6	3	2

FIGURE 1: Air leakage performance of different window categories according to STS 52.0



Netherlands

STANDARDS

Reference No.	Standard No.	Title
NL1	NEN 3661	Windows: Air permeability, water tightness, rigidity and strength. Requirements. (Luchtdoorlatendheid, waterdichtheid, stijfheid en sterkte). NNI 1975
NL2	NEN 1087	Ventilation in dwellings. Requirements. (Ventilatie van Woongebouwen) NNI 1979 + amendment 1981.
NL3	NPR 1088	Ventilation in dwellings: Indications and examples for constructional performance of ventilation supplies. (Ventilatie van Woongebouwen Praktijrichtlijn) NNI 1975.
NL4	Ontw NEN 1089	Ventilation in school buildings. Requirements. (Ventilatie voor schoolgebouwen). NNI 1982

NETHERLANDS

Standard NEN 3661 (NL1) covers air leakage through cracks in windows. This divides windows into classes according to exposure level and, for each class, gives a pressure difference for which air leakage must not exceed $5 dm^3/s/m^3$(see Table 1).

TABLE 1: Test pressures for different window categories for which air leakage must not exceed 5 $dm^3/s/m$ according to NEN 3661

Height of the building in which the window is situated (m)	Exposure	Pressure difference (Pa)
15	Normal	150
40	"	200
100	"	250
15	Coast	300
40	"	350
100	"	400

Ventilation requirements are documented in three standards. NEN 1087 (NL2) gives minimum ventilation requirements for dwellings as 7 dm^3/s/person. It also sets out recommended ventilation rates for individual rooms in relation to floor area. NPR 1088 (NL3) translates these flow requirements into openable window areas and size of ventilation ducts (see Table 2). Most houses in the Netherlands are naturally ventilated, except for buildings above 13m tall which are required to have mechanical extract systems. Apart from residential standards, there is now a draft standard for ventilation requirements in schools (NL4) which gives minimum air flow values, m^3/s/person or by floor area for individual rooms.

TABLE 2: Minimum ventilation requirements for dwellings according to NEN 1087 and NPR 1088

Room	Air flow per person[1] (dm^3/s)	Minimum ventilation openings[2] (m^2)
Living room	21-42	0.02-0.04
Kitchen	21-28	0.02-0.03
Bathroom and WC	14	0.01

[1] *Refers to NEN 1087*
[2] *Refers to NPR 1088*

Switzerland

STANDARDS

Reference No.	Standard No.	Title
CH1	SIA 180/1	Thermal insulation of buildings in winter (Winterlicher Wärmeschutz im Hochbau) 1979
CH2	SWK(I) Guideline 73-2	Ventilation installations in indoor swimming pools (Lüftungsanlagen im Hallenbädern) 1973
CH3	SNV 271010	Guidelines for ventilation installation in underground garages (Richtlinien für lüftungsanlagen im vollumbauten bzw. unterirdischen Fahrzeugeinstellräumen) 1977
CH4	SNV 271020	Boiler-room ventilation (Be-und Entlüftung von Heizräumen) 1975
CH5	SIA 384/2	Thermal load of buildings for the design of heating plants (Wärmeleistungsbedarf von Gebäuden) 1982

SWITZERLAND

Each canton and several towns have their own building codes which differ greatly in style and content.

There is a trend for the government to standardise building codes and the Federal Office of Energy (in co-operation with the cantons and the Swiss Association of Engineers and Architects) is in the process of working out model codes which will include heat loss due to infiltration and ventilation. These codes will, however, be voluntary with no federal power enforcing them, unless the cantons accept them as law.

Other voluntary Codes of Practice are issued by the following organisations:

(a) Schweizerische Normenvereinigung (SNV)
Swiss Standards Association

(b) Swiss Association of Engineers and Architects (SIA)

(c) Association of Swiss Heating and Cooling Firms(VSHL)

(d) Swiss Association of Heating and Cooling Engineers (SWKI)

(e) Schweizerisches Krankenhausinstitut

There is no general standard for airtightness of buildings and none of the existing recommendations include more than some air leakage values for doors and windows.

SIA 180/1 (CH1) classifies windows according to degree of exposure and gives maximum leakage rates at different pressures for each group (see Table 1 and Figure 1). These recommendations are widely used because some cantons have incorporated them into their building codes. As a consequence, there has been a move to tighter windows; in fact, new windows are usually 10-20 times tighter than the standard demands.

Standards for minimum ventilation rates exist only for specific types of building equipped with ventilation systems (restaurants, theatres, etc.) where the air change rate is prescribed. There is no general code for residential or institutional buildings which are normally ventilated through natural infiltration and window opening. There are ventilation recommendations for specialised buildings, such as swimming halls (CH2), underground garages (CH3) and boiler rooms (CH4). These are all voluntary standards and the mandatory recommendations incorporated in the cantons' building codes vary widely.

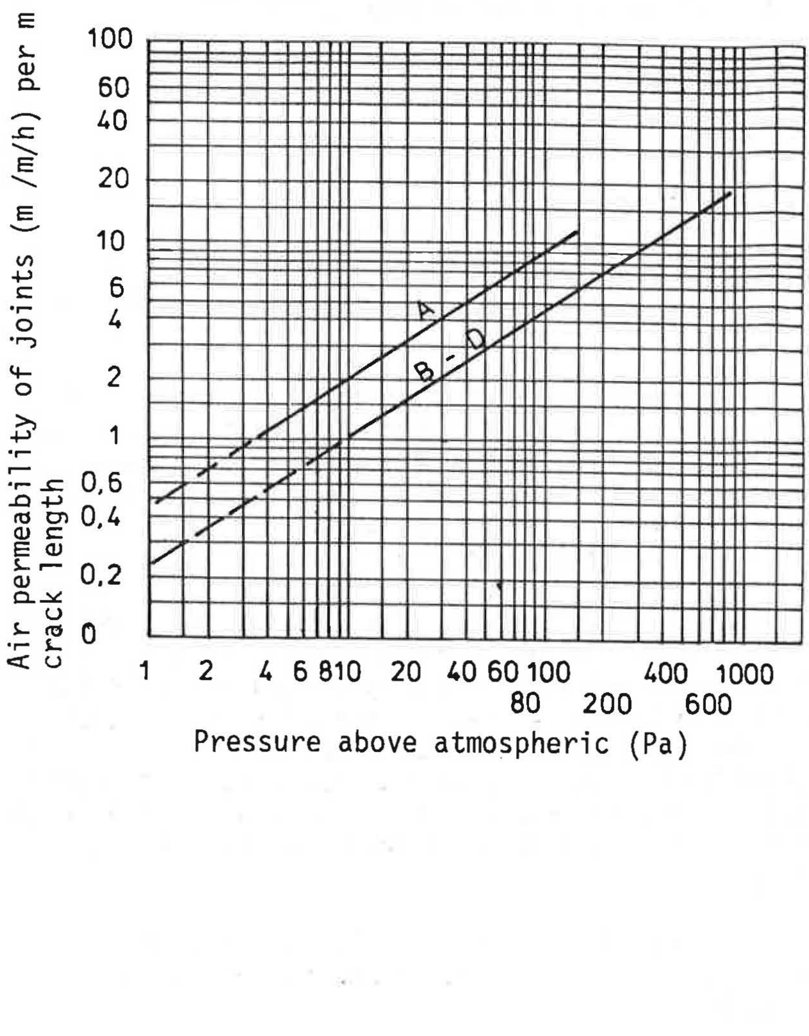
In residential buildings, recommendations exist only for bathrooms, toilets and kitchens (SIA 384/2 (CH5), building codes of cantons and local government). Typical examples are:

Kitchen		80-120 m^3/h
Bathroom with toilet	(min.)	60 m^3/h
Toilet	(min.)	30 m^3/h

TABLE: Air permeability of window joints according to SIA 180/1

	Window classification			
	A	B	C	D
Test pressure (Pa)	150	300	600	>600
Height of buildings (m) where a category is applicable.	<8	8-20	20-100	-
Allowable coefficient for air permeability of joints ($m^3/m/h\ Pa^{2/3}$)	0.44	0.22	0.22	0.22

FIGURE 1: Air permeability of window and door joints according to SIA 180/1



United Kingdom

STANDARDS

Reference No.	Standard No.	Title
UK1	BS 4315: Part 1:1968	Windows and structural gasket-glazing systems Amendment 1917, February 1976
UK2	BS 5368: Part 1:1976	Methods of testing windows. Part 1: Air permeability test. *(Equivalent to European Standard EN42)*
UK3	BS 6375:1983	Performance of windows. Part 1: Classification of weathertightness.
UK4	BS 5925:1980	Code of Practice for design of buildings: ventilation principles and designing for natural ventilation.
UK5	BS 5250:1975	Basic data for the design of buildings: the control of condensation in dwellings.
UK6	-	British Standard Draft Code of Practice on energy conservation in buildings.
UK7	-	Department of the Environment. The Building (Second Amendment) Regulations 1981. Statutory Instrument No. 1338. London HMSO 1981. Department of the Environment.
UK8	-	Department of the Environment. The Building Standards (Scotland)(Consolidation) Regulations 1971.
UK9	-	Greater London Council The London Building (Constructional) By-laws, London, GLC, 1972

UNITED KINGDOM

There are no standards in the UK covering airtightness levels for whole buildings, but there are several standards related to leakage testing of building components. Both BS 4315 (UK1) and BS 5368 (UK2) (which is equivalent to European Standard EN42) describe a pressure chamber method to test air leakage of windows in the laboratory. BS 6375 Part 1 (UK3) is a standard giving the gradings of windows in respect of resistance to air infiltration. This classifies windows into four groups according to level of exposure and, for each class, gives a pressure difference for which air leakage should not exceed 1 $m^3/h/m$ of crack length (see Table 1). It uses the test pressurization method set out in BS 5368.

TABLE 1: Maximum allowable leakage rates for different categories of window according to BS 6375 Part 1.

Class of Window	Pressure difference under test (Pa)	Maximum air leakage rate
I	150	
II	200	1 $m^3/h/metre$ length of crack
III	300	
IV	600	

BS 6375 may eventually be used in the compilation of a standard for the airtightness characteristics of complete dwellings.

The main code for ventilation rates is BS 5925 (UK4) which gives minimum and recommended ventilation rates according to type of building or room, but does not give any values for a whole residential building. The recommended outdoor air supply rate given in this standard only covers airconditioned spaces (in terms of air flow in $dm^3/s/person$ or per m^2 of floor area) and therefore does not apply to the majority of British housing. The standard also contains guidelines on the mechanisms which govern natural ventilation along with methods of calculating ventilation rates.

BS 5205 (UK5) gives some general guidelines for the provision of facilities for natural ventilation to prevent condensation, including recommended minimum air change rates in individual rooms.

There is also now a draft Code of Practice on energy conservation (UK6) which covers basic essential data for obtaining cost-effective energy conservation in buildings. It briefly discusses the role of ventilation reduction in energy conservation, describes mechanisms of air infiltration and sets out examples for calculating ventilation heat loss.

As far as the law is concerned, the Building Regulations for England and Wales (UK7) contain a requirement for mechanical ventilation rates for sanitary accommodation only. This applies to all building types, but only as an alternative to natural ventilation. The Regulations express all other ventilation requirements in terms of area of ventilation opening as a percentage of floor area.

The Scottish Building Standards (UK8) specify ventilation rates for different types of rooms; these requirements are expressed in terms of air change rate for kitchens, bathrooms and WC's, and as a volume of fresh air per person for living rooms and bedrooms (see Table 2).

TABLE 2: Minimum ventilation rates for dwellings according to the Scottish Building Standards and Building Regulations of England and Wales

Room	Air change rate (ach) or air flow per person (dm^3/s)[1]	Minimum ventilator opening as a percentage of floor area[2]
Living-rooms	3-8 dm^3/s	5%
Kitchens	6 ach	5%
Bathrooms and WCs	3 ach	5%

[1] *Refers to Scottish Building Standards*
[2] *Refers to Building Regulations of England and Wales*

Inner London differs from the rest of the UK in that it has more detailed ventilation requirements as laid down in the GLC Building (Constructional) By-laws (UK9). These state that all habitable rooms and kitchens need natural ventilation by means of openable windows. Where this is not possible, mechanical ventilation is required at a rate of 22 m^3/h per occupant or $5m^3/h$ per m^2 floor area, whichever is the greater.

West Germany

STANDARDS

Reference No.	Standard No.	Title
DE1	DIN 4701	Rules for the calculation of the heat requirements of buildings. (Regeln für die Berechnung des Wärmebedorfs von Gebäuden). 1982
DE2	DIN 18055	Windows. Air permeability of joints, water tightness and mechanical strain. Requirements and testing. (Fenster. Fugendurchlassigkeit und Schlagregensicherheit Anforderungen und Prüfung). 1981.
DE3	DIN 4108 (Part 2)	Thermal insulation in tall buildings. (Wärmeschutz im Hochbau). 1982.
DE4	DIN (EN42)	Methods of testing windows. Part 1: Air permeability.
DE5	DIN 1946 (Part 1)	Room ventilation, fundamentals (VDI ventilation rules) (Raumlufttechnik Grundlagen). 1983.
DE6	DIN 1946 (Part 2)	Room ventilation technique; technical health principles (VDI ventilation rules) (Raumlufttechnik Gesundheitstechnische) Anforderungen). 1983.
DE7	DIN 1946 (Part 4)	Ventilation plants (VDI ventilation rules). Ventilation in hospitals. (Raumlufttechnische Anlagen; Raumlufttechnische Anlagen in Krankenhäusen). 1978.
DE8	DIN 1946 (Part 5)	Ventilation in schools (VDI ventilation rules) (Lüftungstechnische Anlagen Lüftung von Schulen) 1967.
DE9	VDI 2088	Ventilation installations in dwellings (Lüftungsanlagen für Wohnungen). 1976.
DE10	DIN 18017 (Part 4)	Ventilation of bathrooms and shower rooms without outside windows with ventilators; rules for the calculation of air flow requirements (Lüftung von Bädern und Spülaborten ohne Außenfenster mit Ventilatoren; Rechnerischer Nachweis der ausreichenden Volumenströme). 1974.

WEST GERMANY

Building laws and regulations are often issued jointly by the Federal Government and the individual federal states, but it is the responsibility of the states to enforce the regulations. Most standards are produced by the German Standards Institute (DIN) with more specialised guidelines being produced by the German Institute of Engineers (VDI). Laws, regulations, standards and guidelines are closely related and details of governmental decrees concerning building are often derived from, or set out in, relevant standards.

DIN 4701 (DE1), giving rules for the calculation of heat requirements of buildings, is related to the heating design regulations issued by the Government in 1978 (updated 1982) under the Energy Conservation Law of 1976. The heating design regulations give heating requirements for different building types and these are being applied to bring existing buildings up to a stipulated level of energy efficiency. DIN 4701 gives procedures for calculating ventilation heat loss (including effects of stack and wind pressure) and applies to all heated buildings. The calculation assumes a minimum air change rate of 0.5 ach per room and gives estimates for the air permeability of the building, including a table of permeability coefficients for doors, windows and other building components in $m^3/m/h/Pa^{2/3}$.

DIN 18055 (DE2) classifies windows by exposure level and gives acceptable air permeability values for each group under pressure. DIN 4108 (DE3) is also related to the heating design regulations as it gives standards for adequate thermal insulation and includes recommendations for sealing joints and installing vapour barriers. DIN (EN42) (DE4) gives a pressure chamber method for testing the air permeability of windows, based on European Standard EN42.

There are a series of standards concerned with ventilation. The main publication is DIN 1946 which is divided into several parts. Part 1 (DE5) deals with fundamental concepts of ventilation; this includes general formulae and units for natural ventilation, and descriptions of different systems of natural ventilation. Part 2 (DE6) is concerned with indoor air quality and gives a minimum air flow rate of 20-30 m^3/h/person to maintain acceptable air quality. Parts 4 and 5 (DE7 and DE8) give minimum air change rates for hospitals and schools using mechanical ventilation. VDI 2088 (DE9) sets out ventilation rates for dwellings with mechanical ventilation; the values for internal bathrooms and WC's have been incorporated into DIN 18017 (DE10) (see Table 1).

TABLE 1: Minimum ventilation rates according to VDI 2088 and DIN 18017

Living rooms	1 - 1.5 ach
Bathrooms and toilets	6 ach
Kitchens (exhaust ventilation)	120 m^3/h
Internal bathroom (exhaust ventilation)	60 m^3/h
Internal toilet (exhaust ventilation)	30 m^3/h

Canada

STANDARDS

Reference No.	Standard No.	Title
CA1	-	Residential Standards, Canada Associate Committee on the National Building Code National Research Council of Canada, Ottawa. 1980
CA2	-	The National Building Code of Canada Associate Committee on the National Building Code National Research Council of Canada, Ottawa. 1980
CA3	-	Measures for energy conservation in new buildings Associate Committee on the National Building Code National Research Council of Canada No. 16574, Ottawa. 1978
CA4	-	Determination of airtightness of buildings by the fan pressurization method. Canadian General Standards Board Draft Standard 149-GP-10M, Ottawa. 1983.

CANADA

Residential Standards 1980 (CA1) contains requirements for dwellings derived from the National Building Code of Canada (CA2). It applies to buildings up to three storeys in height and a building area, on any storey, of not more than 600m^2. The section 'Measures to prevent condensation' gives standards for the installation of vapour barriers and other measures to prevent air leakage. The report also gives ventilation standards for both naturally and mechanically ventilated buildings. Natural ventilation is expressed in terms of minimum unobstructed area to the outside needed for various rooms; a mechanical ventilation system should be capable of producing at least one air change per hour (see Table 1). For non-residential buildings, the National Building Code gives a minimum ventilation rate of 14 m^3/h air flow per square metre of floor area.

TABLE 1: Minimum ventilation rates for dwellings according to the Residential Standards

Room	Minimum unobstructed ventilation area in m^2
Living-rooms	0.28
Kitchens	0.28
Bathrooms and WCs	0.09

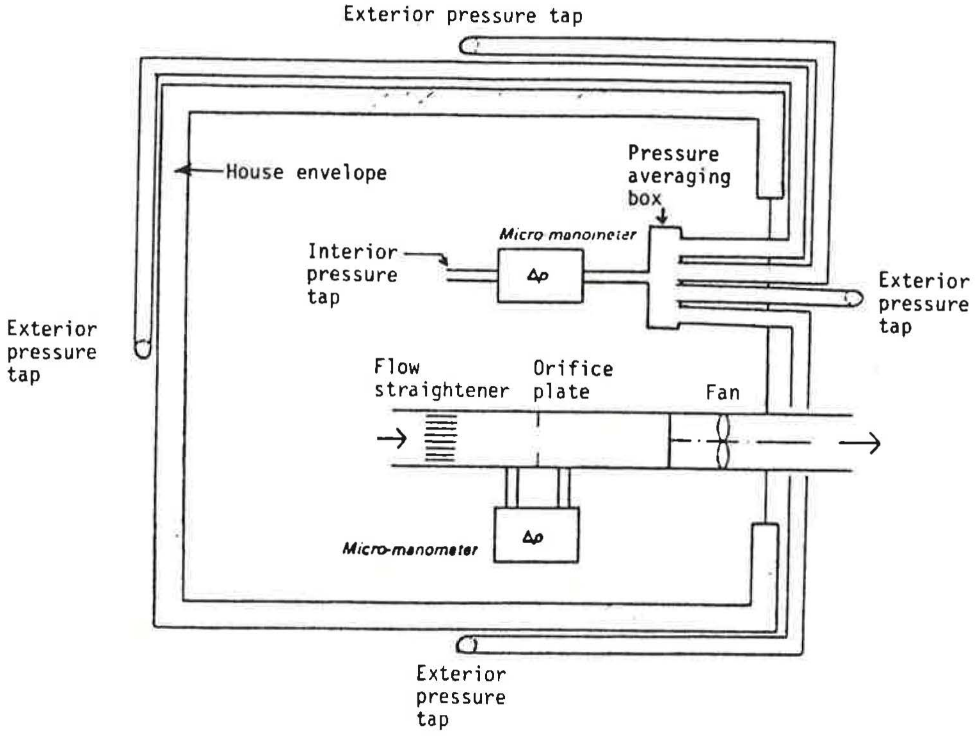
Standards for allowable infiltration for building components are documented in 'Measures for energy conservation in new buildings' (CA3) which uses ASHRAE Standard 90-75 as a guide but contains modifications to meet Canadian conditions. The section on infiltration is the same as that found in Standard 90-75.(The updated version of this standard is 90-80 - see section covering USA). Both 'Residential standards' and 'Measures for energy conservation in new buildings' are model codes only and are not mandatory requirements unless adopted by a particular province.

There is no mandatory airtightness requirement for dwellings, as exists in some countries, but a draft standard for conducting pressure tests of residences has been prepared by the Candian General Standards Board (CA4). This specifies the fan pressurization method to determine the airtightness of a building envelope; it is applicable to small detached buildings (especially houses) but, with modifications, can also be used for other buildings or parts of buildings. Testing equipment can be set up as shown in Figure 1; a pressure averaging device with connections to four exterior pressure taps is used so as to get a reliable and stable measurement of external pressure around the whole building envelope. It is suggested that the fan be set into a blower door and there are detailed appendices calibrating the fan, the air flow measuring device and the pressure measuring device. Included in the test are all rooms intended to be heated to more than 10°C, except those with separate ventilation. All external openings should be closed or sealed according to Table 2 and air flow rate is measured at several negative and positive pressures. The test should not be conducted if the wind speed is more than 5.6 m/s. The tightness of the building is expressed in terms of equivalent leakage area (ELA); this is defined as the size of an orifice opening that would pass the same air flow rate at a pressure difference of 10 Pa as would the entire building at the same pressure differential.

TABLE 2: Preparation of intentional openings according to Draft Standard 149-GP-10M

Fireplace flue	No preparation
Fireplace:	
with damper	Close
with doors	Close
without damper	Switch off all fuel combustion equipment, exhaust fans, vented dryers and air conditioners.
Doors on enclosed furnace room	Close
Fireplace combustion air intake damper	Close
Fuel-fired furnace and/or stove flues	Seal
Fuel-fired furnace and/or stove flues in enclosed furnace room	No preparation
Furnace combustion air intake	Close
Furnace fresh air intake damper	Close
Fuel-fired hot water system flues:	
with damper	Seal
Floor drains	Fill
Plumbing traps	Fill
Exhaust fans:	
with motorised damper	Close
without motorised damper	No preparation
Air-to air heat exchangers designed to operate continuously:	
intake and exhaust openings	Seal
Other air-to-air heat exchangers:	
intake and exhaust openings:	
with motorised damper	Close
without motorised damper	No preparation
Dryer vents:	
with exhaust divertor	Winter position
with motorised damper	Close
without motorised damper	No preparation
Windows and doors	Latch
Exhaust systems common to more than one unit	Seal
Window air conditioners	Seal
Attic hatch	Close

FIGURE 1: The general arrangement of the equipment during the test showing one possible air flow metering system according to Draft Standard 149-GP-10M



United States of America

STANDARDS

Reference No.	Standard No.	Title
US1	ASHRAE Standard 90-80	Energy conservation in new building design. 1980
US2	ASTM Standard E 283-73	Standard test method for rate of air leakage through exterior windows, curtain walls and doors. 1973. *1982 Annual Book of ASTM Standards, Part 18, p1026-1030*
US3	ASTM Standard E 783-81	Standard method for field measurement of air leakage through installed exterior windows and doors. 1981. *1982 Annual Book of ASTM Standards, Part 18, p1494-1499*
US4	ASTM Standard E 779-81	Standard practice for measuring air leakage by the fan pressurization method. 1981. *1982 Annual Book of ASTM Standards, Part 18, p1484-1493*
US5	ASTM Standard E 741-80	Standard practice for measuring air leakage rate by the tracer dilution method. 1980. *1982 Annual Book of ASTM Standards, Part 18, p1426-1435*
US6	-	Model Energy Code 1983. Council of American Building Officials.
US7	ASHRAE Standard 62-1981	Ventilation for acceptable indoor air quality. 1981.
US8	-	Minimum Property Standards US Department of Housing and Urban Development. 1979

UNITED STATES OF AMERICA

The ASHRAE[1] Standard 90-80 (US1) gives recommended levels of airtightness for exterior windows and doors in all buildings. Limiting values of air leakage, as determined by ASTM[2] Standard E 283-73 (US2) are specified for a pressure difference of 75 Pa (see Table 1).

TABLE 1: Maximum leakage rates for components at 75 Pa according to ASHRAE 90-80

Component	Maximum leakage rate
Windows	0.77 dm^3/s per metre of sash crack
Sliding glass doors (residential)	2.5 dm^3/s per m^2 of door area
Entrance swinging doors (residential)	6.35 dm^3/s per m^2 of door area
Swinging, revolving, sliding doors for other than residential use	17.0 dm^3/s per linear metre of door crack

Methods of assessing air infiltration and component leakage are given in a series of standards produced by ASTM. The ASTM test method quoted in ASHRAE Standard 90 consists of sealing the test specimen into the face of an air chamber and measuring the air flow through it under a specified pressure difference. A similar Standard E 783-81 (US3) uses this method in the field by sealing a test chamber to the component. This is intended for measuring air leakage through the component alone, and not leakage through cracks around the component.

ASTM Standard E 779-81 (US4) sets out a fan pressurization method for measuring air leakage rates through the whole building envelope. This is intended primarily for one-storey buildings but an appendix is provided for estimating stack effect when testing taller buildings. A blower door assembly is suggested for use and details of this are illustrated. In ideal test conditions, the wind speed should be 2.2 m/s or less and the indoor and outdoor temperature difference 11°C or less; tests should not be carried out at wind speeds over 4.5 m/s. Air flow rate is measured and air leakage results are presented in the same way as indicated by the Swedish and Norwegian pressurization standards. However, unlike these standards, no indication is given of how the building envelope should be sealed when under test.

ASTM have also produced a standard on measuring air infiltration rates by the tracer dilution method (US5). This describes different methods of sampling the tracer gas ('grab' and 'multi-point' sampling) and gives

[1] *The American Society of Heating, Refrigerating and Air-conditioning Engineers.*
[2] *American Society for Testing and Materials.*

four calculation methods for estimating air change rates - finite difference, decay time, graphical and least sqaure method. An appendix is also provided giving a compilation of gases used to perform infiltration measurements. This includes details for each gas on maximum allowable concentration, minimum detectable concentration, toxicology, chemical inertness and suitable measuring apparatus.

These are all voluntary standards but some 46 states have adopted requirements based on Standard 90 into their building codes. Each state is responsible for regulating its own code, adapted from one of four model codes according to local building regulations. The Southern Building Code is used mainly in the South-East, the Uniform Building Code in the West and Midwest, the National Building Code in the East and the BOCA Code in the Midwest and North-East. The recommendations found in ASHRAE Standard 90 are also now being incorporated into the model codes so their application may become more widespread in the future. The Model Energy Code (US6) is a consensus of the groups issuing the major building codes and is based on Standard 90. There is no standard on airtightness requirements for a whole building, but ASHRAE are in the process of drafting a standard covering air leakage performance for residential buildings.

Ventilation requirements are covered in ASHRAE Standard 62-1981 (US7). This gives minimum ventilation requirements in terms of volumetric airflow rate per person for a wide range of industrial and commercial buildings. For residential buildings, outdoor air requirements are given in terms of $dm^3/s/room$ (see Table 2).

TABLE 2: Minimum ventilation requirements for dwellings according to ASHRAE 62-1981

Room	Outdoor air requirements in $dm^3/s/room$	
Living rooms	5	capacity requirements for ventilation installations for intermittent use
Kitchens	50	
Bathrooms and WCs	25	

In addition, the US Department of Housing and Urban Development periodically issues a set of Minimum Property Standards (HUD-MPS) that cover ventilation requirements and apply to federally financed home construction and to homes purchased with federally granted loans. The 1979 version sets intermittent exhaust rates in kitchens and bathrooms at 15 and 8 ach respectively, and natural ventilation rates at 0.5 ach.

New Zealand

STANDARDS

Reference No.	Standard No.	Title
NZ1	NZS 4211:1979	Specification for performance of windows. Standards Association of New Zealand.
NZ2	NZS 1900	Model building by-law Standards Association of New Zealand
NZ3	-	The Draining and Plumbing Regulations 1978 Department of Health, Wellington.
NZ4	-	Factories and Commercial Premises Act 1981 Department of Labour, Wellington

NEW ZEALAND

There are few standards in New Zealand concerned with building airtightness and ventilation rates. For domestic buildings there are no overall airtightness requirements, though windows must pass an air leakage test as set out in NZS 4211 (NZ1). This classifies windows into three grades according to air leakage performance and gives maximum rate of leakage at 150 Pa for each grade (see Table 1).

TABLE 1: Maximum rate of leakage at 150 Pa for different grades of window according to NZS 4211

	Rate of air leakage dm^3/s		
	Grade A	Grade B	Grade C
Per m. of opening joint length	0.6	2.0	4.0
Per m^2 of total window area	2.0	8.0	17.0

As far as commercial buildings are concerned, there is no standard which details fabric tightness.

Ventilation requirements for domestic buildings are mentioned in Chapter 4 of NZS 1900 (NZ2). This does not specify ventilation rates directly but gives minimum area of openable window as 5% of the floor area in each room. Most local authorities in New Zealand have adopted NZS 1900.

'The Drainage and Plumbing Regulations (NZ3) is government legislation specifying ventilation requirements in bathrooms, toilets and laundries in domestic and commercial buildings. This gives minimum openable window areas rather than minimum ventilation rates. There is no standard specifying minimum ventilation rates for commercial buildings, the closest approximation being found in 'Factories and Commercial Premises Act 1981 (NZ4) which makes broad statements about the need for adequate control of the indoor environment with adequate fresh air.

SECTION 2

Subject Analysis

TABLE 2:1 Subject analysis of standards covering airtightness requirements

	Airtightness requirements	Techniques for measuring air leakage	Rules for the calculation of ventilation heat loss
Whole buildings	NO1, SE1	CA4, SE2, US4, US5	DE1, DK2, NO4, UK6
Components	BE1, BE2, BE3, CA3, CH1, DE1, DE2, DE3, DK3, NL1, NO3, NZ1, SE1, SE3, UK3, US1	EC1, IS1, IS2, NO2, UK1, UK2, US2, US3	

TABLE 2.2 Subject analysis of standards covering minimum ventilation requirements

Requirements for minimum ventilation rates in terms of :	Natural ventilation		Mechanical ventilation	
	Dwellings	Other (Commercial/ Industrial)	Dwellings	Other (Commercial/ Industrial)
Air changes/hour	BE1, DE5, UK5, US8		CA1, CH2[1], DE9, DE10, NO4, UK7[1], US8[1]	CH2[2], CH3[3], DE7[4], DE8[5], UK7[1]
Air flow rate per person or per unit floor area.	US7		DE5, DE9, DE10, NL2, SE1, UK4, US7	CA2, DE6, NL4[5], NO4, SE1[6], UK4, US7
Area of ventilation opening	CA1, DK1, NL3, NO4, NZ2, NZ3[1], UK7	CH4[7], DK1, NZ3[1], UK7,		

[1] Sanitary accommodation only
[2] Underground garages
[3] Swimming pools
[4] Hospitals
[5] Schools
[6] Recreational Centres and Hospitals
[7] Boiler rooms

Key:

BE *Belgium*
CA *Canada*
CH *Switzerland*
DE *West Germany*
DK *Denmark*
EC *European Standard*
IS *International Standard*
NL *Netherlands*
NO *Norway*
NZ *New Zealand*
SE *Sweden*
UK *United Kingdom*
US *United States of America*

APPENDIX 1

Details of Issuing Organisations

COUNTRY	ISSUING BODY	PUBLICATIONS PRODUCED
International	International Standards Organisation (ISO) 1 rue de Varembé Case Postale 56 CH 1211 Geneva 20 Switzerland	International standards
	European Standardization Committee (CEN) 5 Boulevard de l'Empereur B 1000 Brussels Belgium	European standards (EN)

COUNTRY	ISSUING BODY	PUBLICATIONS PRODUCED
Belgium	The Belgian Standards Institute (IBN) Boulevard Saint-Lazare, 10 B-1030 Brussels	Belgian standards
	The National Housing Institute (INL) *(address as above)*	Unified technical specifications (STS)
Canada	Associate Committee on the National Building Code National Research Council of Canada Ottawa Ontario KlA OR6	National Building Code
	Canadian General Standards Board (CGSB) c/o Dept of Supply and Services 11 Laurier Street Hull Quebec KlA OS5	Canadian standards
Denmark	The Danish Standards Association (DS) Aurehøjvej 12 DK 2900 Hellerup	Danish standards
	Danish Society of Engineers (DIF) Organisation for Norms and Standards Vester Farimagsgade 31 DK 1606 Copenhagen V	DIF norms, some being published as Danish standards
	The Danish Ministry of Housing National Building Agency Stormgade 10 DK 1470 Copenhagen K	Danish Building Regulations

COUNTRY	ISSUING BODY	PUBLICATIONS PRODUCED
Netherlands	The Netherlands Standards Institute (NNI) Kalfjeslaan 2 PO 5059 2600 GB Delft	Dutch standards
New Zealand	Standards Association of New Zealand (SANZ) Private Bag Wellington	New Zealand standards
	Department of Health PO Box 5013 Wellington	The Drainage and Plumbing Regulations, 1978
	Department of Labour Private Bag Wellington	The Factories and Commercial Premises Act, 1981
Norway	Norwegian Standards Association (NSF) Haakon VII's gate 2 Oslo 1	Norwegian standards
	The Norwegian Council for Building Standardisation Københavngt 10 Oslo 5	Construction standards
	The Royal Ministry of Local Government and Labour PO Box 8112 Dep. Oslo 1	Norwegian Building Code (BF)

COUNTRY	ISSUING BODY	PUBLICATIONS PRODUCED
Sweden	Swedish Standards Institute (SS) Box 3295 S-103 66 Stockholm	Swedish standards
	The National Board of Physical Planning and Building Box 12512 S-102 29 Stockholm	Swedish Building Code (SBN)
Switzerland	Swiss Standards Association (SNV) Kirchenweg 4 8032 Zurich	Swiss standards
	Swiss Association of Engineers and Architects (SIA) Postfach 8039 Zurich	Swiss standards on thermal protection and heating, ventilating and airconditioning problems.
	Swiss Association of Heating & Cooling Engineers (SWKI) Postfach 2327 3001 Berne	Recommendations for heating installations, ventilation, etc.
United Kingdom	British Standards Institute Linford Wood Milton Keynes MK14 6LE	British standards
	HMSO Books PO Box 569 London, SE1 9NH	Building regulations for England, Wales and Scotland
	Greater London Council The County Hall London, SE1 7PB	London building by-laws

COUNTRY	ISSUING BODY	PUBLICATIONS PRODUCED
United States of America	The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 1791 Tullie Circle NE Atlanta GA 30329	HVAC standards
	American Society for Testing and Materials (ASTM) 1916 Race St Philadelphia PA 19103	Standards on materials, products, systems and services
	US Dept of Housing and Urban Development (HUD) 451 Seventh St SW Washington DC 20410	Minimum property standards
West Germany	The German Standards Institute (DIN) Burggrafenstraße 4-10 Postfach 1107 1000 Berlin 30	German standards
	The German Institute of Engineers (VDI) Postfach 1139 4000 Düsseldorf 1	Technical guidelines

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The Air Infiltration Centre provides technical support to those engaged in the study and prediction of air leakage and the consequential losses of energy in buildings. The aim is to promote the understanding of the complex air infiltration processes and to advance the effective application of energy saving measures in both the design of new buildings and the improvement of existing building stock.

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