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Trends in building and ductwork airtightness in Belgium

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1 General introduction

This paper provides an overview of requirements and guidelines for building and ductwork airtightness in Belgium and observed trends in this airtightness. Although standards and guidelines are generally published on the national level in Belgium, building energy performance regulation is a regional matter. This means that each of the three regions – Flemish, Brussels Capital and Walloon Region – can have a different approach. However, the building regulation and requirements in relation to building and ductwork airtightness are very similar. Therefore, when there are differences between the three regions, the developments are discussed separately. First, the building market in each of the regions is illustrated in Table 1 with some statistics.

Statistics for the **Flemish building market** are taken from "Statistiek Vlaanderen" of the Vlaamse Statistische Autoriteit[1], "Energiekaart" of the Vlaams Energie- en Klimaatagentschap (VEKA)[2] and "StatBel" of the Belgian Federal Government[3]. Statistics for the **Brussels building market** are taken from "bisa.brussels" of BISA[4] and "StatBel" of the Belgian Federal Government[5]. Statistics for the **Walloon building market** are taken from "Stratégie wallonne de rénovation" of Wallonie énergie SPW[6] and "StatBel" of the Belgian Federal Government[7] and provided by Wallonie énergie SPW.

Table 1: Building market statistics for Belgium

	Flemish Region	Brussels Capital Region	Walloon Region
Area (km²)	13 522	162	16 901
Inhabitants (2021)	6 653 062	1 219 970	3 648 206
Residential building stock (2021)	3 288 816	592 942	1 749 879
Residential building stock increase 2001-2021	20%	16%	19%
New building permits 2020 (both residential and non-residential)	26 744	155	14 705
Renovation permits 2020 (both residential and non-residential)	21 300	1 846	4 200
New dwelling permits 2020	43 327	796	27 221

[1] https://www.vlaanderen.be/statistiek-vlaanderen/bouwen-en-wonen
[2] https://apps.energiesparen.be/energiekaart/vlaanderen
[3] https://statbel.fgov.be/en/themes
[4] https://ibsa.brussels/le-saviez-vous
[5] https://statbel.fgov.be/en/themes
[6] https://energie.wallonie.be/fr/strategie-de-renovation.html?IDC=9580
[7] https://statbel.fgov.be/en/themes

The housing stock increase in the Flemish and Walloon region is similar, with an increase of 20% and 19% between 2001 and 2021, respectively. That corresponds to an average increase of 1% per year. The increase in the Brussels Capital Region is slightly smaller. In the most recent years, there has been an acceleration in housing construction in all regions.

In 2020, the majority of the new building permits in the different regions relate to residential buildings. Compared to 2019, residential new construction has strongly increased (+5%) in the Flemish Region, slightly increased (+2%) in the Walloon Region, and temporarily decreased (-4%) in the Brussels Region.

Non-residential new construction has fallen in the Flemish (-5%) and Walloon Region (-2%), and remained at a status quo in the Brussels Capital Region. Nevertheless, the number of non-residential new buildings remains at a high level compared to previous decades, with about 5 100 and 2000 new buildings in the Flemish and Walloon Region respectively.

A residential building may contain several dwellings (housing units). Therefore, the number of permitted new dwellings is higher than the number of permitted new buildings. The share of multifamily buildings varies in the different regions: 90% of the dwellings permitted in 2020 in the Brussels Capital Region were flats, while in the Flemish and Walloon Region this is lower with 57% and 56% of the dwellings permitted in 2020 being flats.

Also, in terms of renovation permits there are differences between the regions: in Brussels, the number of renovation permits is much higher than the number of new building permits, in Flanders renovation and new building permits are in the same order of magnitude, while in the Walloon Region the number of renovation permits is a factor 3 lower compared to new building permits. A large majority of the renovation permits was related to the renovation of residential buildings (respectively 89%, 94% and 88% in the Flemish, Brussels and Walloon Region).

2 Building airtightness

2.1 Introduction

The regional regulations have been promoting airtightness testing since the introduction of the regional Energy Performance of Buildings Directive by using a very disadvantageous default value in the Energy Performance Calculation for all building types when no airtightness testing is performed. The calculation of the energy performance of buildings taking into account the airtightness of buildings was introduced in 2006 in the Flemish Region (replacing an earlier thermal regulation dating from 1992[8]), in 2009 in the Brussels Capital Region (replacing an earlier thermal regulation dating from 2000), and in 2010 in the Walloon Region (replacing an earlier thermal regulation dating from 1995[9]). In none of the regions there is a minimum requirement for airtightness. However, the strengthening energy performance requirements towards Nearly Zero Energy Buildings became more and more difficult to meet without the result of an airtightness test to replace the disadvantageous default value in the Energy Performance Calculation.

The regional building Energy Performance Regulations are available at:

- For Flemish Region: Energy Decree in Dutch at https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen
- For Brussels Capital Region: Execution Decree in French at https://environnement.brussels/thematiques/batiment-et-energie/obligations/la-performance-energetique-des-batiments-peb/travaux-p-5
- For Walloon Region: EPB Decree in French at https://energie.wallonie.be/fr/reglemen

[8] https://codexti.vlaanderen.be/Zoeken/Document.aspx?DID=1001772&param=informatie
[9] https://energie.wallonie.be/fr/reglementation-thermique-du-1er-decembre-1996-au-31-aout-2008.html?IDD=113398&IDC=7224

tation-wallonne-sur-la-peb.html?IDC=7224

2.2 Airtightness Indicator

In the context of Energy Performance Regulation, the airtightness indicator used in the regulations of the three regions is v_{50} [m³/(h·m²)], the leakage flow per heat loss area. This is the average of the measured flow at 50 Pa for pressurization and depressurization, divided by the heat loss area, which sums the areas of the building envelope directly in contact with the exterior environment, in contact with adjacent unheated spaces, or in contact with the ground. Areas of partition walls between protected volumes are not included (e.g., terraced houses). This heat loss area should be calculated based on the exterior dimensions and according to the regulation, referred to in section 2.1. This v_{50} is hence slightly different from the q_{E50} of ISO 9972:2015[10], which is calculated based on the full building envelope (including partition walls).

When only the pressurization or depressurization test is in accordance with the regulation (e.g., baseline higher than 5 Pa, r^2 too low, …), in the Flemish Region v_{50} can be calculated based on the compliant test including a correction factor and the report needs a motivation.

Specifications for the measurements are available at:

- For Flemish Region in Dutch (Ministerial Decision of 28 December 2018 Annex 6): https://www.vlaanderen.be/epb-pedia/epb-regelgeving/ministeriele-besluiten-energieprestatieregelgeving/bijlagen-van-het-mb-van-28-december-2018#sb-bijlage-6-d0ad9099-0e54-44d2-b46f-929db7e98cf8
- For Brussels Capital Region in French (Ministerial Decision of 9 November 2017 Annex 1): https://environnement.brussels/sites/default/files/annexe1_fr.pdf.pdf
- For Walloon Region in French (Government Decision of 12 December 2013 – version 3 of 28/05/2013): https://energie.wallonie.be/fr/etancheite-a-l-air.html?IDC=7224&IDD=112019

2.3 Requirements and drivers

2.3.1 Building airtightness requirements in the regulation

In Belgium, there is no minimum requirement for building envelope airtightness. If no airtightness test is performed, a default value of v_{50} = 12 m³/(h·m²) for heating (and v_{50} = 0 m³/(h·m²) for cooling and overheating) shall be used in the Energy Performance Calculation for all building types. Since the beginning of Energy Performance Regulations, Belgium is promoting airtightness testing by using this very disadvantageous default value in the calculation of the energy performance of the building (E-level) when the test is not performed.

Furthermore, since January 1st, 2018, the Flemish Region has a minimum requirement for the global performance of the building envelope for residential buildings (S-level, taking into account thermal insulation, airtightness, solar gains, etc.), and poor airtightness would jeopardize the chance to comply with required S-level. Using the default values by lack of an airtightness test, makes the mandatory S-level almost impossible to achieve. Therefore, airtightness testing has become implicitly mandatory for every new residential building in Flanders. The target value for v_{50} should be 3 m³/(h·m²) or lower[11].

2.3.2 Incentive for building airtightness

In line with the Energy Performance Regulation in Belgium, there is no direct incentive for good building airtightness. However, this is one of the main components in the calculation of the heating energy use and total primary energy use

[10] https://www.iso.org/standard/55718.html
[11] https://www.energiesparen.be/bouwen-en-verbouwen/epb-pedia/epb-plichtig-toepassing-en-eisen/e-peil-s-peil-hernieuwbare-energie-en-andere-eisen/s-peil/ontwerptips-voor-een-laag-s-peil

of buildings. In Belgium, the total primary energy use is expressed in a dimensionless indicator E-level, for which requirements are in force.

Furthermore, a Passive label (or Plus or Premium) can be obtained from Pixii (Passive House Platform)[12] for buildings with, amongst other requirements, a measured n_{50}-value lower than 0.6 h^{-1}.

In the Flemish Region, there are subsidies and tax benefits for buildings with an ambitious value of the E-level in comparison with regulatory requirements.

2.3.3 Building airtightness justifications

In the context of the Belgian Regulation, one has to use the default value as stated above when no conform pressurization test of the particular building is available. For multifamily buildings, the test can be performed on the building as a whole or on each individual dwelling separately. Sampling testing is not allowed. The presence of a measurement report in the Energy Performance Calculation is systematically checked by the administration.

In Flanders, each test has to be performed by a qualified tester of a recognised company, to be registered in a database and to be declared conform to the STS-P 71-3 and legal requirements (see §2.5.2). This conformity declaration is needed for the test result to be used in the Energy Performance Calculation.

In the Walloon Region, there is no specific quality framework for measurement reports or for the people who carry out the measurements.

In Brussels Capital Region, there is also no specific quality framework, however, testers have to be independent (have no right on the building and have no link with the design or construction of it or with the people involved).

2.3.4 Sanctions

Since there are no explicit requirements for building airtightness in the Belgian Energy Performance Regulations, there are no sanctions related to this. It is always allowed to use the default values when no conform airtightness test is available. However, there are requirements on the performance of the building envelope and total primary energy use, and poor building airtightness may result in non-compliance with these requirements. This might be resulting in a fine or loss of the subsidy or tax benefit. For example, in Flanders, the fine for not meeting the S-level requirement is 1.5 EUR per 1 kWh deviation. Fines are only imposed when the amount is at least 250 EUR. The maximum fine is 25 EUR per m^3 of protected volume for new buildings and 10 EUR per m^3 of protected volume for renovated buildings. There is, however, no requirement to make the building compliant if the required S-level is not met.

Furthermore, in Flanders, when no conformity declaration of the performed test can be submitted or this document is found to be fraudulent, fines and other sanctions are possible as well.

2.4 Building airtightness in the energy performance calculation

2.4.1 Calculation

As part of the Energy Performance Calculation, the monthly heat losses through ventilation in an energy sector are obtained by multiplying the heat transfer coefficient through ventilation by the length of the relevant month and by the difference between the monthly average indoor temperature and the monthly average outdoor temperature. One part of this heat transfer coefficient through ventilation is related to in- and exfiltration. The in- and exfiltration flow [m³/h] is calculated as:

$$V_{in/exfiltration} = 0.04 * v_{50} * A_T$$

with v_{50} the measured airtightness indicator [m³/(h·m²)] and A_T the heat loss area (based on exterior dimensions) [m²], which sums the areas of the building envelope directly in contact with the exterior environment, in contact with adjacent unheated spaces, or in contact with the ground. Areas of partition walls between protected volumes are not included (e.g., terraced houses). If no conform measurement is available, the below-mentioned default values

[12] https://pixii.be/ontdek/kennis/nieuwe-kwaliteitslabels-energieneutraal-bouwen

should be used. According to research[13,14,15], this 0.04 depends on the wind exposure, but was chosen as an average, conservative value for the built environment in Belgium.

The heat transfer coefficient [W/K] through in- and exfiltration is then calculated as:

$$H_{V,in/exfiltration} = 0.34 * V_{in/exfiltration}$$

Details are available at:

- For Flemish Region in Dutch:
  - For residential building units (Energy Decree Annex V): https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen/energiebesluit-bijlage-v
  - For non-residential building units (Energy Decree Annex VI): https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen/energiebesluit-bijlage-vi
- For Brussels Capital Region in French:
  - For residential building units (Government Decree Annex XXI): https://document.environnement.brussels/opac_css/elecfile/AGBR_202011_AE28-MC2021-Anx1FR.pdf
  - For non-residential building units (Government Decree Annex XXII): https://document.environnement.brussels/opac_css/elecfile/AGBR_202011_AE28-MC2021-Anx2FR.pdf
- For Walloon Region in French:
  - For residential building units (EPB Decree Annex A1): https://energie.wallonie.be/servlet/Repository/annexe-a1-per-2021-fr.pdf?ID=66859
  - For non-residential building units (EPB Decree Annex A3): https://energie.wallonie.be/servlet/Repository/annexe-a3-pen-2021-fr-version-coordonnee.pdf?ID=66860

2.4.2 Default values

When no measured building airtightness is declared, a default value of v_{50} = 12 m³/(h·m²) for heating and v_{50} = 0 m³/(h·m²) for cooling and overheating shall be used in the Energy Performance Calculation. This value was based on the average v_{50} value of dwellings in the nineties according to the SENVIVV research[16].

2.5 Building airtightness test protocol

2.5.1 Qualification of Airtightness testers

In Belgium, measurements should be performed regarding the regional measurement specifications mentioned in §2.2. There are however no overarching requirements for qualification.

In the Brussels Region, testers have to be independent (have no right on the building and have no link with the design or construction of it or with the people involved) since January 1st, 2018. Because of the lack of a qualification procedure in Brussels and Wallonia, there is no information on the number of testers.

Since January 1st, 2015, all airtightness tests in the Flemish Region used in the Energy Performance Calculation should be done within a quality framework. There is no distinction in building type. In October 2020, the Flemish government has tightened the requirements on a quality framework for airtightness testers:

- The organizer of a quality framework must have a qualification procedure for airtightness testers, which includes at least:
  - an optional training,

[13] Dubrul C., 1988. Technical Note AIVC 23 Inhabitant behaviour with respect to ventilation – a summary report of IEA Annex VIII https://www.aivc.org/resource/tn-23-inhabitant-behaviour-respect-ventilation-summary-report-iea-annex-viii
[14] Jones, B., Persily, A., Sherman, M. H., 2016. The Origin and Application of Leakage-Infiltration Ratios. Conference: ASHRAE AIVC IAQ 2016. Defining Indoor Air Quality: Policy, Standards and Best Practices. USA, 2016.
[15] Delmotte, C., 2021. Airtightness of buildings – Assessment of leakage-infiltration ratio and systematic measurement error due to steady wind and stack effect. Energy & Buildings 241 (2021).
[16] Wouters et al., AIVC VIP 18: Trends in the Belgian building ventilation market and drivers for change, 2008, https://www.aivc.org/resource/vip-18-trends-belgian-building-ventilation-market-and-drivers-change

- a mandatory theoretical and practical exam.
- The organizer of a quality framework must guarantee the quality of the airtightness measurements by running desk and onsite audits combined with effective enforcement.
    - Minimal random annual desk and onsite audits are 10% each.
    - Random audits are supplemented by targeted audits so that 90% of the active airtightness testers are audited at least once a year.
    - At least half of the onsite audits concern the correctness of the reported leakage flows for airtightness. The organizer of a quality framework guarantees that an airtightness tester cannot know at the time when they send the result of the measurement whether that result will be checked or not.
- The organizer of a quality framework shall develop a database gathering all measurement data that can be consulted by the government.
- The organizer of a quality framework is impartial: he/she should not have any members or directors who also carry out airtightness measurements in the context of the regulation.

Since the new requirements on qualification bodies, the quality framework for airtightness testers of both BCCA (Belgian Construction Certification Association) and SKH are approved by the Flemish government.

All testers shall be qualified and their company recognised by one of the approved qualification bodies to perform a test in this context.

Since the beginning of this quality framework, the number of recognised companies for airtightness testers has been fluctuating between 150 and 190 in Flanders. Most theoretical and practical exams are taken by BCCA and for the past few years, they notice a refresh rate of around 10%. Airtightness testing is generally only part of the activity of the recognised companies.

2.5.2 National guidelines

The technical specifications STS-P 71-3 are a national guideline published in 2014. The STS are "Unified technical specifications". They are edited by the Belgian Federal Public Service for Economy to optimise and standardise quality in the construction sector. Various STS exist on the construction field, STS-P 71-3 are for airtightness testing[17].

The STS-P 71-3 include:

- Possible objectives of the airtightness test: e.g., standard test compliant to EPB-Regulation, leakage detection, indicative test or partial test (e.g., only negative pressure inside the buildings) and requirements according to the objective
- Steps of an airtightness test and "who does what"
- Details, in addition to NBN EN 13829:2011[18], on
    - Definitions
    - Building preparation
    - Pressure steps, etc.
    - Leakage detections
    - Measurement devices and calibration
    - Calculation process
    - Report
    - A general description of a quality framework (Annex 6)

These STS-P 71-3 require an airtightness test to be performed in both pressurization and depressurization (or if not possible, to have a correction on the measured value). There are also some exceptions described for buildings with a volume greater than 4000 m^3. Since these STS-P 71-3 only describe pressurisation tests with fans, other tests (such as Pulse technique or using the installed ventilation system) are not allowed in Belgium to be used in Energy Performance Calculation.
These STS-P 71-3 are in revision to update towards the revised standard NBN EN ISO 9972:2015[19].

[17] https://economie.fgov.be/nl/themas/ondernemingen/specifieke-sectoren/bouw/technische-specificaties-sts
[18] https://www.nbn.be/shop/en/standard/nbn-en-13829-nl-2011_12896/
[19] https://www.nbn.be/shop/en/standard/nbn-en-iso-9972-2015_7471/

Only in Flanders, tests must be declared conform to the technical specifications STS-P 71-3 requirements to guarantee the reliability of airtightness tests. In the other regions, the STS-P 71-3 are not mandatory by the government in Energy Performance Calculation.

Its Annex 6 on a quality framework for the airtightness tests is informative but its application is imposed by the Flemish Regulation, therefore in this context, there should be a collective monitoring system, the tester must be qualified, its company recognised and the tests registered in a database.

Furthermore, Buildwise has published Technical Guidance on building airtightness[20]. This Technical Information Note describes the recommended principles for constructing airtight buildings, covering the following aspects in detail:

- The basic data for determining airtightness;
- The expression of airtightness and building requirements;
- The design of an airtight building and the coordination of the execution;
- Airtightness products and materials;
- The treatment of construction details;
- The assessment of the airtightness performance of a building;
- The maintenance of the building and the potential impact of the occupants.

2.5.3 Requirements on measuring devices

The STS-P 71-3 include requirements for the measuring devices. All devices should comply with the NBN EN 13829:2011 and furthermore, the pressure gauge should measure with an accuracy of ± 1 Pa in the interval between 0 Pa and 100 Pa.

Pressure gauges, thermometers and anemometers shall be calibrated (or have a calibration check) every 2 years according to the STS-P 71-3. Calibration of fans is not required. The calibration check of the measuring instruments shall contain at least 6 points distributed approximately between the positive and negative parts of the measuring interval in the following way: 10%, 20%, 40%, 60%, 80% and 100% (or a minimum of 12 points if the measuring interval contains negative and positive values). The verification shall include also the checking and adjustment (if necessary) of the zero point of the pressure gauge. The calibrations and the calibration checks of the measuring devices must be carried out by either an accredited lab, an ISO 9001 certified laboratory, or the manufacturer or the importer of these measuring instruments.

These requirements of STS-P 71-3 are in revision.

2.6 Building airtightness tests performed

2.6.1 Tested buildings

Because of the unfavourable default value, almost all newly built residential buildings in Belgium are tested. Since only in Flanders some statistics on the building airtightness tests performed are publicly available (Figure 1), this chapter mainly focuses on tests performed in this region. A steep increase can be noticed from only 1% in 2006 to 80% in 2014 and 97% in 2019. For deep energy retrofit of residential buildings, this varies by around 25% between 2015 and 2019[21].

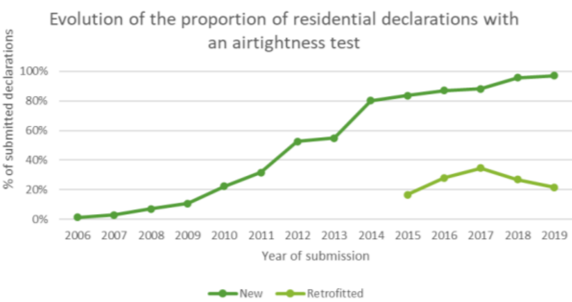

Figure 1: Evolution of the proportion of residential declarations with an airtightness test in Flanders

2.6.2 Database

There are several databases including information on building airtightness of both residential and non-residential buildings, mainly for Flanders Region. First of all, there is the database managed by VEKA with all

[20] https://www.buildwise.be/fr/publications/notes-d-information-technique/255/

[21] https://apps.energiesparen.be/energiekaart/vlaanderen/epb-luchtdichtheid

Energy Performance Declarations. Some statistics can be consulted online[22]. This database contains all airtightness measurement results used in Energy Performance Calculation in Flanders. Only tests declared compliant with the EPB-Regulations and the STS-P 71-3 are included and all tests should have been performed by qualified testers within the Quality Framework.

The Brussels Capital and Walloon Region both have a similar database, however, these are not publicly available.

Besides that, each quality framework organization should have its own database with all performed tests. The database of BCCA contains only the tests within the quality framework of BCCA and thus only data uploaded in the database of BCCA. All data is provided by qualified testers and contains all building types. Multiple tests for the same building are possible, however, preliminary tests are usually not registered. Information in the database includes: administrative data, main destination (residential, school, ...), time and location of the test, leakage rate (m³/h), heat loss area (m²) or internal volume (m³) and the full test report. Since the quality framework is only mandatory in Flanders, most airtightness tests in this database were performed in this region.

2.6.3 Evolution of the airtightness level

The residential buildings that were tested turned out to be much more airtight than the value in the absence of a test. VEKA reports that the leakage rate in the tests carried out in Flanders is on average, across all residential buildings, 3.2 m³/(h·m²) for building permits in 2019. This was 3.8 m³/(h·m²) in 2006.
Although the number of tests has risen sharply, the average v_{50} value has only fallen very slightly[23].

The mean value in the Walloon Region is also between 3 m³/(h·m²) and 4 m³/(h·m²) since the beginning of the Energy Performance Calculation.

The statistics of the BCCA database show a skew-normal distribution of measurement results with an average of v_{50}= 3.36 m³/(h·m²) in 2021. The evolution is shown in the following graphs (Figure 2, Figure 3), based on datasets varying between 2 665 and 7 383 tests, mainly performed in Flanders.

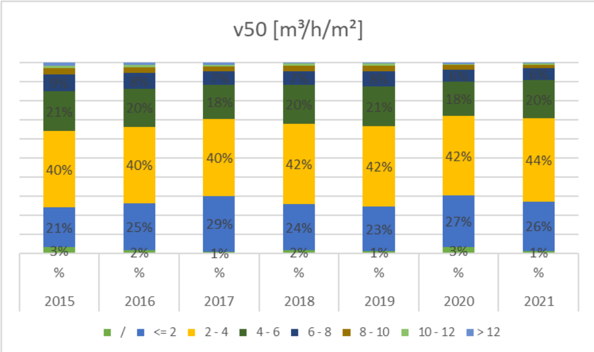

Figure 2: Evolution of distribution of v50 values of building airtightness measurements in BCCA database

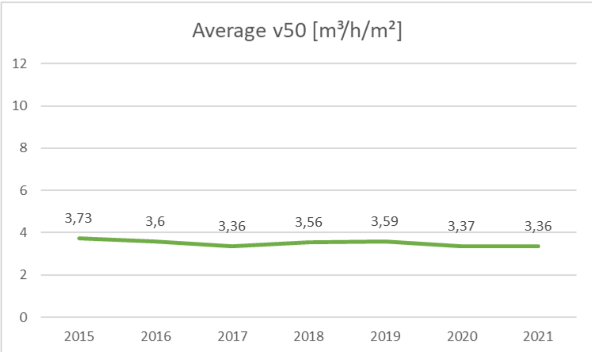

Figure 3: Evolution of average v50 value of building airtightness measurements in BCCA database

Please note that based on the SENVIVV research, a conservative estimate of the v_{50} value of dwellings in the nineties was derived as 12 m³/(h·m²)[24].

2.7 Conclusion

The major change regarding airtightness in Belgium was the implementation of the quality framework in Flanders in 2015 including the qualification of airtightness testers and registration of all tests to facilitate random on site and desktop audits by the quality

[22] https://apps.energiesparen.be/energiekaart/vlaanderen/epb-luchtdichtheid
[23] https://apps.energiesparen.be/energiekaart/vlaanderen/epb-luchtdichtheid
[24] Wouters et al., AIVC VIP 18: Trends in the Belgian building ventilation market and drivers for change, 2008, https://www.aivc.org/resource/vip-18-trends-belgian-building-ventilation-market-and-drivers-change

framework organization. Since 2018, requirements on the performance of the building envelope (S-level, taking into account thermal insulation, airtightness, solar gains, etc.) were set, which made airtightness testing implicitly mandatory for every new residential building in Flanders. Because of the high default value for airtightness by lack of a test, testing is also strongly recommended for non-residential buildings (in Flanders and for all types of buildings in Brussels and Wallonia). Since 2018, testers in Brussels Capital Region should be independent.

Since 2015, the airtightness of buildings seems quite steady and a further improvement in terms of v_{50}-value and number of tests seems unrealistic. There are no major changes planned regarding regulation in the short term.

2.8 Key documents

- STS-P 71-3 Luchtdichtheid van gebouwen - Luchtdichtheidstest https://economie.fgov.be/nl/themas/ondernemingen/specifieke-sectoren/bouw/technische-specificaties-sts
- STS-P 71-3 Etanchéité à l'air des bâtiments - Essai de pressurisation https://economie.fgov.be/fr/themes/entreprises/secteurs-specifiques/construction/specifications-techniques-sts
- TV255 Technische Voorlichting 255 Luchtdichtheid van gebouwen https://www.buildwise.be/nl/publicaties/technische-voorlichtingen/255/
- NIT 255 Note d'information technique 255 L'étanchéité à l'air des bâtiments https://www.buildwise.be/fr/publications/notes-d-information-technique/255/
- Energy Performance Regulation in Flanders https://www.vlaanderen.be/epb-pedia/gebouw/luchtdichtheid
- Energy Performance Regulation in Brussels https://environnement.brussels/thematiques/batiment-et-energie/obligations/la-performance-energetique-des-batiments-peb/travaux-p-5
- Energy Performance Regulation in Wallonia https://energie.wallonie.be/fr/etancheite-a-l-air.html?IDC=7224&IDD=112019 and https://energie.wallonie.be/fr/l-etancheite-a-l-air.html?IDC=9475&IDD=97700
- Quality Framework of BCCA https://www.ikbouwluchtdicht.be/ or https://www.jeconstruisetanchealair.be
- FAQ on airtightness testing according to STS-P 71-3 and quality framework https://www.ikbouwluchtdicht.be/faq/ or https://www.jeconstruisetanchealair.be/faq-question-frequemment-posees/

3 Ductwork airtightness

3.1 Introduction

In contrast to building airtightness, ductwork airtightness is much less promoted in Belgium and its regions. Despite its importance for well-working ventilation systems at low power, the impact of this ductwork airtightness is only limited in the Energy Performance Regulations. If (although only in rare cases) a ductwork airtightness measurement is carried out in residential buildings, it can be valorised through a reduction in the factor *m*, which is a multiplication factor valorising the execution quality of the installed ventilation system[25]. Ductwork airtightness measurements in non-residential buildings however cannot be valorised in Energy Performance Calculations.

3.2 Airtightness indicator

For natural exhaust ducts, the total leakage flow for all ducts is expressed as $V_{leak,stack,zone}$ [m³/h] at a reference pressure of 2 Pa (in accordance with NBN EN 14134:2019[26]). For mechanical supply ducts, the total leakage flow for all ducts is expressed as $V_{leak,supplyduct,zone}$ [m³/h] at the

[25] https://www.vlaanderen.be/epb-pedia/technieken/ventilatie/impact-van-ventilatie-op-het-e-peil/m-factor
[26] https://www.nbn.be/shop/en/standard/nbn-en-14134-2019_23563/

operational pressure of the ventilation system (in accordance with NBN EN 14134:2019). For mechanical exhaust ducts, the total leakage flow for all ducts is expressed as $V_{leak,extr.duct,zone}$ [m³/h] at the operational pressure of the ventilation system (in accordance with NBN EN 14134). More information can be found in Annex B of:

- For Flanders: https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen/energiebesluit-bijlage-v
- For Brussels: https://document.environnement.brussels/opac_css/elecfile/AGBR_202011_AE28-MC2021-Anx1FR.pdf
- For Wallonia: https://energie.wallonie.be/servlet/Repository/annexe-a1-per-2021-fr.pdf?ID=66859

3.3 Requirements and drivers

3.3.1 Ductwork airtightness requirements in the regulation

There are no requirements for ductwork airtightness in the Energy Performance Regulations of Belgium.

3.3.2 Incentive for Ductwork airtightness

There are only very little incentives for ductwork airtightness in Belgium. Due to the implementation of a quality framework for residential ventilation in Flanders in 2016, there is an indirect incentive for ductwork airtightness since ventilation flows are required to be measured.

3.3.3 Ductwork airtightness justifications

When a ductwork airtightness measurement is performed in residential applications, the results can be valorised in the Energy Performance Regulation based on a measurement report in accordance with NBN EN 14134:2019.

3.3.4 Sanctions

Since there are no requirements for ductwork airtightness in the Energy Performance Regulation, there are no sanctions related to this. However, if test results are used in the Energy Performance Calculation and no measurement report can be submitted, fines and other sanctions are possible as well.

3.4 Ductwork airtightness in the energy performance calculation

3.4.1 Calculation

Ductwork airtightness is not taken into account in the Energy Performance Calculation for non-residential buildings. As part of the Energy Performance Calculation for residential buildings, the monthly heat losses through ventilation in an energy sector are obtained by multiplying the heat transfer coefficient through ventilation by the length of the relevant month and by the difference between the monthly average indoor temperature and the monthly average outdoor temperature. One part of this heat transfer coefficient through ventilation is related to the hygienic ventilation.

The heat transfer coefficient through hygienic ventilation for heating is calculated as:

$$H_{V,hyg} = 0.34 * r_{preh} * V_{hyg}$$

with r_{preh} the reduction factor for preheating of ventilation air flow and V_{hyg} the hygienic ventilation flow [m³/h] calculated as:

$$V_{hyg} = \left[0.2 + 0.5 * e^{\left(\frac{-V_{EPR}}{500}\right)}\right] * f_{reduc,vent} * m * V$$

with V_{EPR} [m³] the total volume of the calculated unit, $f_{reduc,vent}$ [-] the reduction factor for ventilation, taking into account the lower air flows due to demand-controlled ventilation, *m* the multiplication factor [-] related to the type of ventilation system and its installation quality and V the volume of the considered energy zone [m³].

The factor *m* is defined depending on the type of ventilation system:

- **Natural ventilation**

  The factor *m* can be improved by taking into account the degree of self-regulation of the natural inlets and outlets and the airtightness of the natural ducts as:

$$m = 1.0 + 0.5$$

$$* \left(\frac{r_{nat\ supply} + r_{nat\ exh} + r_{leak,stack}}{r_{nat\ supply,def} + r_{nat\ exh,def} + r_{leak,stack,def}} \right)$$

with $r_{nat\ supply}$ the correction factor for the degree of self-regulation of the natural inlets, $r_{nat\ exh}$ the correction factor for the degree of self-regulation of the natural outlets, $r_{leak,\ stack}$ the correction factor for the airtightness of the natural ducts and $r_{nat\ supply,def}$, $r_{nat\ exh,def}$ and $r_{leak,\ stack,def}$ default values for these correction factors.

The correction factor for the airtightness of the natural ducts is calculated as:

$$r_{leak,stack} = \frac{\sum_k V_{leak,stack,zone,k}}{V_{req,exh,zone}}$$

with $V_{leak,stack,zone,k}$ the leakage flow of the natural duct *k* in the ventilation zone (at 2 Pa) and $V_{req,exh,zone}$ the required exhaust flow for all individual rooms in the ventilation zone. The default value $r_{leak,\ stack,def}$ is 0.025.

- **Mechanical supply ventilation**

The factor *m* can be improved by taking into account the adjustment of valves, the degree of self-regulation of the natural outlets and the airtightness of the mechanical supply and natural exhaust ducts as

$$m = 1.0 + 0.5 * \left(\frac{r_{mech\ supply} + r_{nat\ exh} + r_{leak,stack}}{r_{mech\ supply,def} + r_{nat\ exh,def} + r_{leak,stack,def}} \right)$$

with $r_{mech\ supply}$ the correction factor for the adjustment of valves and airtightness of mechanical supply ducts, $r_{nat\ exh}$ the correction factor for the degree of self-regulation of the natural outlets, $r_{leak,\ stack}$ the correction factor for the airtightness of the natural ducts and $r_{mech\ supply,def}$, $r_{nat\ exh,def}$ and $r_{leak,\ stack,def}$ default values for these correction factors.

The correction factor for the airtightness of the natural ducts is calculated in the same way as for natural ventilation. The correction factor for the mechanical supply ducts is calculated as:

$$r_{mech\ supply} = r_{adj,mech\ supply} \frac{\sum_l V_{leak,supply\ duct,zone,l}}{V_{req,mech\ supply,zone}}$$

with $r_{adj,,mech\ supply}$ the correction factor for the adjustment of valves, $V_{leak,supply\ duct,zone,l}$ the leakage flow of the mechanical supply duct *l* (at nominal position) in the ventilation zone and $V_{req,mech\ supply,zone}$ the required supply flow for all individual rooms in the ventilation zone. The default value for $\frac{\sum_l V_{leak,supply\ duct,zone,l}}{V_{req,mech\ supply,zone}}$ is 0.18.

- **Mechanical exhaust ventilation**

The factor *m* can be improved by taking into account the adjustment of valves, the degree of self-regulation of the natural inlets and the airtightness of the mechanical exhaust ducts as:

$$m = 1.0 + 0.5 * \left(\frac{r_{nat\ supply} + r_{mech\ extr}}{r_{nat\ supply,def} + r_{mech\ extr,def}} \right)$$

with $r_{nat\ supply}$ the correction factor for the degree of self-regulation of the natural inlets, $r_{mech\ extr}$ the correction factor for the adjustment of valves and airtightness of the mechanical exhaust ducts and $r_{nat\ supply,def}$ and $r_{mech\ extr,def}$ default values for these correction factors.
The correction factor for the mechanical exhaust ducts is calculated as:

$$r_{mech\ extr} = r_{adj,mech\ extr} \frac{\sum_m V_{leak,extr\ duct,zone,m}}{V_{req,mech\ extr,zone}}$$

With $r_{adj,mech\ extr}$ the correction factor for the adjustment of valves, $V_{leak,extr\ duct,zone,m}$ the leakage flow of the mechanical exhaust duct *m* (at nominal position) in the ventilation zone and $V_{req,mech\ extr,zone}$ the required exhaust flow for all individual rooms in the ventilation zone. The default value for $\frac{\sum_l V_{leak,extr\ duct,zone,l}}{V_{req,mech\ extr,zone}}$ is 0.18.

- **Mechanical supply and exhaust ventilation**

The factor *m* can be improved by taking into account the adjustment of valves and the airtightness of the mechanical ducts as

$$m = 1.0 + 0.5 * \left(\frac{r_{all\ mech}}{r_{all\ mech,def}} \right)$$

with $r_{all\ mech}$ the correction factor for the adjustment of valves and airtightness of the mechanical ducts and $r_{all\ mech,def}$ the default value for this correction factor.
The correction factor for the mechanical ducts is calculated as

$$r_{all\ mech} = \frac{max(V_{cal,mech\ supply,zone}\ ;\ V_{cal,mech\ extr,zone})}{max(V_{req,mech\ supply,zone}\ ;\ V_{req,mech\ extr,zone})}$$

with

$$V_{cal,mech\ supply,zone} = r_{adj,mech\ supply} * V_{req,mech\ supply,zone} + \sum_{l} V_{leak,supply\ duct,zone,l}$$

and

$$V_{cal,mech\ extr,zone} = r_{adj,mech\ extr} * V_{req,mech\ extr,zone} + \sum_{m} V_{leak,extr\ duct,zone,m}$$

with $r_{adj,,mech\ supply}$ the correction factor for the adjustment of inlet valves, $V_{leak,supply\ duct,zone,l}$ the leakage flow of the mechanical inlet duct *l* (at nominal position) in the ventilation zone, $V_{req,mech\ supply,zone}$ the required supply flow for all individual rooms in the ventilation zone, $r_{adj,,mech\ extr}$ the correction factor for the adjustment of outlet valves, $V_{leak,extr\ duct,zone,m}$ the leakage flow of the mechanical exhaust duct m (at nominal position) in the ventilation zone and $V_{req,mech\ extr,zone}$ the required exhaust flow for all individual rooms in the ventilation zone.

Note that there is a similar heat transfer coefficient through ventilation for cooling and overheating calculations. For simplicity, we do not explain the differences in this paper.
Details are available in Dutch at https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen/energiebesluit-bijlage-v
and in French at
https://energie.wallonie.be/servlet/Repository/annexe-a1-per-2021-fr.pdf?ID=66859 and https://document.environnement.brussels/opac_css/elecfile/AGBR_202011_AE28-MC2021-Anx1FR.pdf.

3.4.2 Default values

When no information is available on the adjustment of valves, the degree of self-regulation of the natural inlets and/or outlets and the airtightness of the ducts, a default value for factor *m* of 1.5 for heating calculations and 1 for cooling calculations has to be considered (in Dutch at https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen/energiebesluit-bijlage-v
and in French at
https://energie.wallonie.be/servlet/Repository/annexe-a1-per-2021-fr.pdf?ID=66859 and https://document.environnement.brussels/opac_css/elecfile/AGBR_202011_AE28-MC2021-Anx1FR.pdf)

3.5 Ductwork airtightness test protocol

3.5.1 Qualification of ductwork Airtightness testers

There is no qualification scheme for ductwork airtightness testers in Belgium. There are only few people performing such tests.

3.5.2 National guidelines

There are no guidelines to perform ductwork airtightness in Belgium.

3.5.3 Requirements on measuring devices

There are no specifications regarding the equipment in Belgium.

3.6 Ductwork airtightness Tests performed

3.6.1 Tested Ductwork

Only few ductwork systems have been tested in Belgium. There is no evolution noticed.

3.6.2 Database

The VEKA database contains limited field data on ductwork airtightness levels achieved in Flanders. This data is however not publicly available. Also in the other regions, there is no public data.

3.6.3 Evolution of the ductwork airtightness level

There are too few tests performed to examine the evolution. Less than 1% of residential ductwork is tested.

3.7 Guidelines to build airtight ductwork

Buildwise has published a Technical Guidance on ventilation systems for residential buildings (https://www.buildwise.be/nl/publicaties/technische-voorlichtingen/258/ or https://www.buildwise.be/fr/publications/notes-d-information-technique/258/). Airtightness of the ductwork is discussed to a limited extent.

STS-P 73-1 are technical specifications for residential ventilation (https://economie.fgov.be/nl/themas/ondernemingen/specifieke-sectoren/bouw/technische-specificaties-sts or https://economie.fgov.be/fr/themes/entreprises/secteurs-specifiques/construction/specifications-techniques-sts). They also make only a notice of airtightness measurements for ductwork.

3.8 Conclusion

Ductwork airtightness is much less promoted in Belgium. There are no requirements and only very few incentives for better airtightness. Therefore, only few ductwork systems are tested and no relevant statistics are available.

There is no evolution to be expected regarding ductwork airtightness. In the revision of STS-P 73-1, there might be some more attention to ductwork airtightness measurements.

3.9 Key documents

- STS-P 73-1 Systemen voor basisventilatie in residentiële toepassingen https://economie.fgov.be/nl/themas/ondernemingen/specifieke-sectoren/bouw/technische-specificaties-sts
- STS-P 73-1 Systèmes pour la ventilation de base dans les applications résidentielles https://economie.fgov.be/fr/themes/entreprises/secteurs-specifiques/construction/specifications-techniques-sts
- TV258 Technische Voorlichting 258 Praktische gids voor de basisventilatiesystemen voor woongebouwen https://www.buildwise.be/nl/publicaties/technische-voorlichtingen/258
- NIT258 Note d'information technique 258 Guide pratique des systèmes de ventilation de base des logements https://www.buildwise.be/fr/publications/notes-d-information-technique/258
- Energy Performance Regulation in Flanders https://www.vlaanderen.be/epb-pedia/technieken/ventilatie
- Energy Performance Regulation in Brussels https://environnement.brussels/thematiques/batiment-et-energie/obligations/la-performance-energetique-des-batiments-peb/travaux-p-5
- Energy Performance Regulation in Wallonia https://energie.wallonie.be/fr/reglementation-wallonne-sur-la-peb.html?IDC=7224
- NBN EN 14134:2019 Ventilatie van gebouwen - Prestatiemeting en controles voor residentiële ventilatiesystemen
- NBN EN 14134:2019 Ventilation des bâtiments - Mesure de la performance et vérifications des systèmes de ventilation résidentiels

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