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# VIP SERIES – AIVC
# BUILDING AND DUCTWORK AIRTIGHTNESS

AIVC Webinar – Nolwenn Hurel (Cerema)

May 12, 2025

## VIP series on Building & Ductwork Airtightness

- Series of Ventilation Information Papers (VIP) published by the AIVC
  - **“Building and ductwork airtightness - National trends and requirements”**
  - Template prepared: **similar structure** for all papers
  - Authors found in various countries via the TightVent Airtightness Associations Committee (**TAAC**) and the **AIVC** board members
  - Available on the AIVC website: https://www.aivc.org/collection-keys/vip

# VIP series on Building & Ductwork Airtightness

- For both BUILDING and DUCTWORK airtightness, it details :
  - **national requirements and drivers**: airtightness indicator, requirements in the regulation, energy programs, airtightness justifications, sanctions, etc.;
  - if it is included in the **energy calculations** and how;
  - the **airtightness test protocol:** qualification for the testers, guidelines, requirements on measuring devices;
  - **tests performed:** tested buildings/ductworks, database, evolution with time;
  - **guidelines** to build airtight buildings/ductworks.

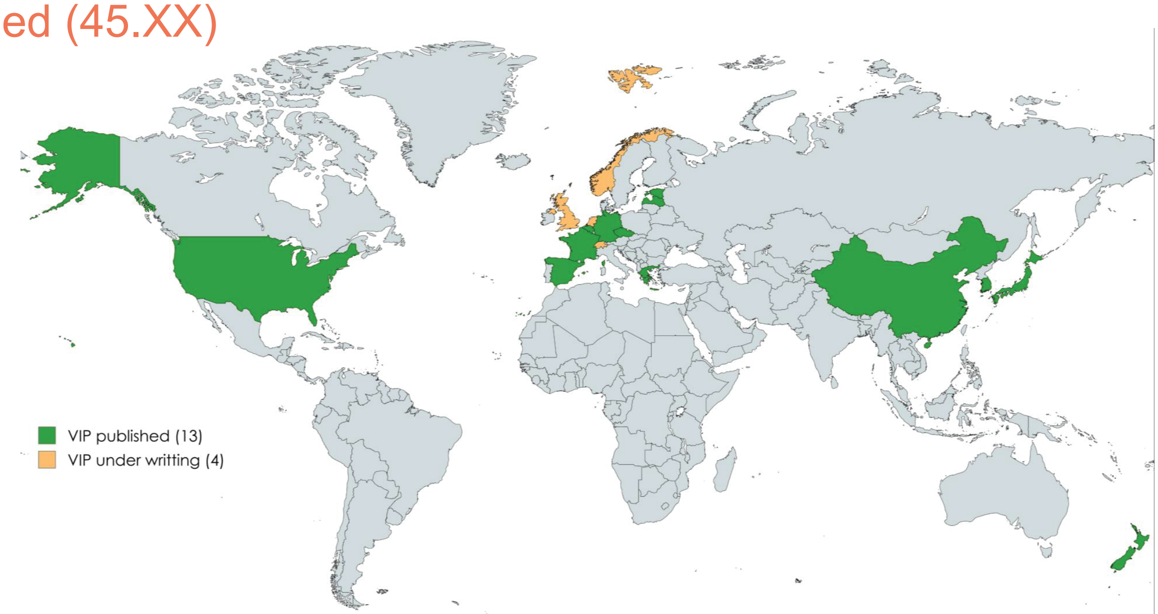

Ventilation Information Paper
n° 45.1
July 2022
AIVC
Trends in building and ductwork airtightness in Estonia
1 Introduction on the building market in Estonia



# VIP series on Building & Ductwork Airtightness

## 13 VIPs published (45.XX)

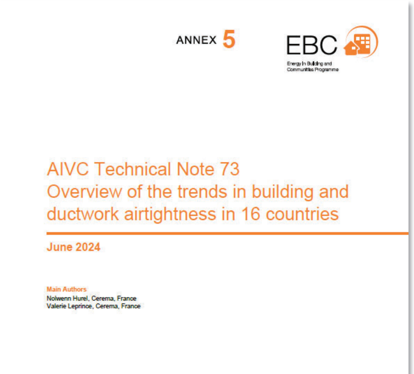
**1** Estonia
**2** Spain
**3** Czech Republic
**4** Belgium
**5** Latvia
**6** France
**7** Greece
**8** China
**9** Japan
**10** Republic of Korea
**11** New Zealand
**12** USA
**13** Germany

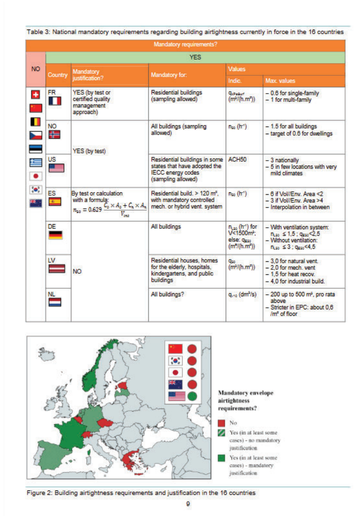


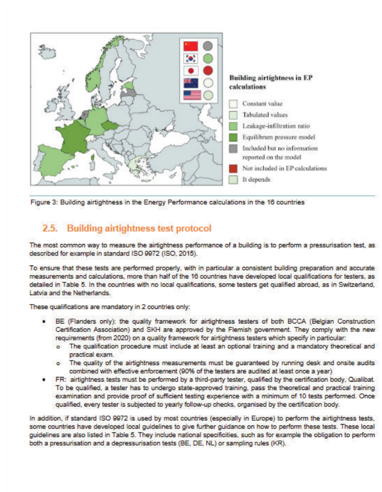
# TN 73: Overview of the trends in building and ductwork airtightness in 16 countries

Nolwenn Hurel, Valérie Leprince (June 2024)

Available on the **AIVC website**:
https://www.aivc.org/sites/default/files/TN73.pdf



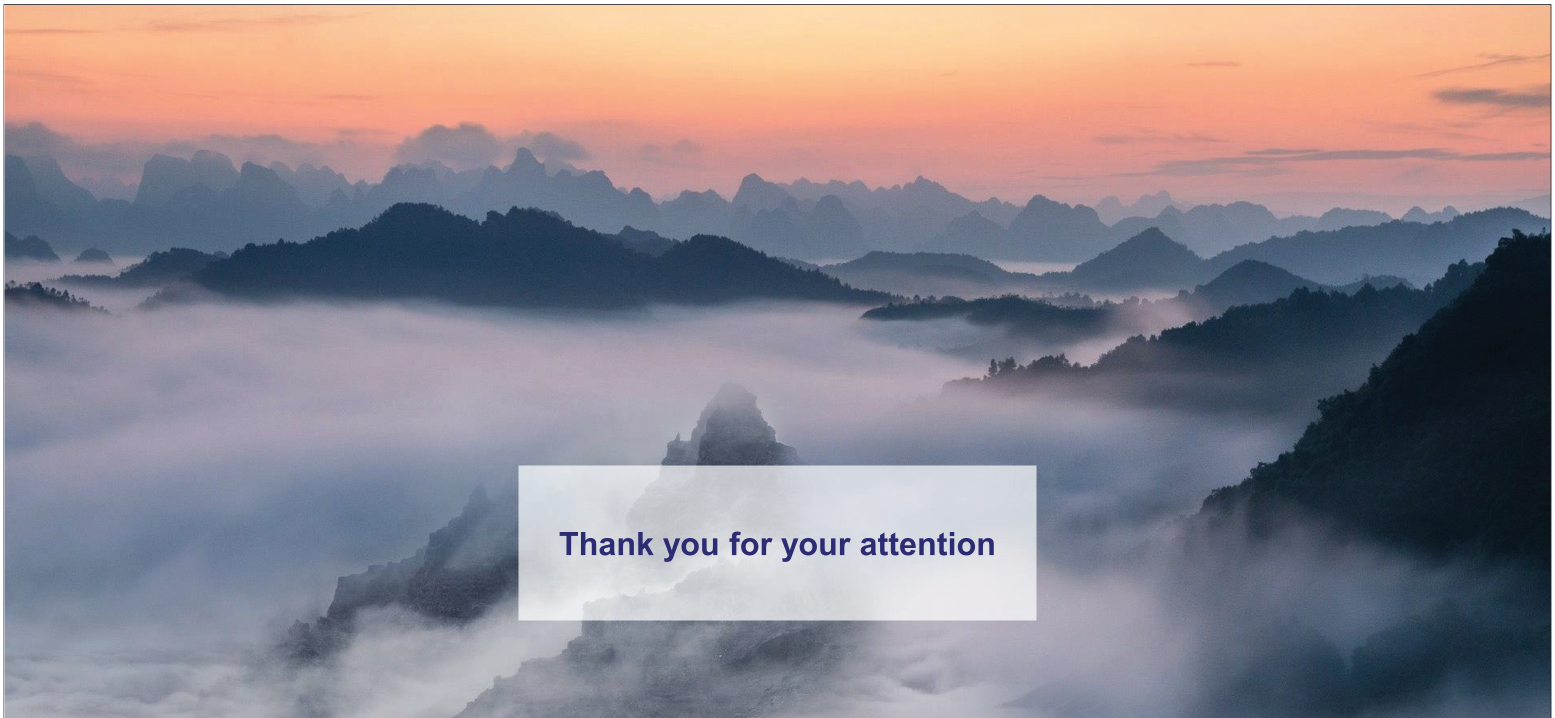






# Webinar program:

- Building and ductwork airtightness - National trends and requirements in:
  - **Estonia** - Jaanus Hallik (Tallinn University of Technology, Estonia) **15' (+10' for questions)**
  - **Germany** - Oliver Solcher (FLiB, Germany) **15' (+10')**
  - **USA** - Andrew K. Persily (NIST, USA) **15' ' (+20')**

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# Trends in building and ductwork airtightness in Estonia

Jaanus Hallik, Targo Kalamees, Alo Mikola
Tallinn University of Technology

12.05.2025 AIVC/TightVent Webinar | Building and ductwork airtightness trends and regulations in Estonia, Germany and the U.S.

1

## General background in Estonia

- First requirements set in 1995 for overall airtightness of building envelope: $q_{E50} < 3\ m^3/(h \cdot m^2)$
- When EP calculation and certification scheme emerged (2008) a general suggestion of targeted $q_{E50}$ was lowered to $1.0\ m^3/(h \cdot m^2)$
- Several studies related to building envelope airtightness and its development in current building stock (mainly residential buildings).
- No detailed studies on airtightness of ductwork related to energy consumption or indoor air quality.
- Studies related to ventilation renovation in old apartement buildings point to systematic problems with old shafts and ductwork.

2

build EST

# Building airtightness



build EST

## Airtightness indicator (building envelope)

Building envelope air leakage rate $\boldsymbol{q}_{\mathbf{E50}}$ [$m^3/(h \cdot m^2)$] measured according to EVS EN-ISO 9972 (blowerdoor testing)

Current target requirements during EPC procedure:

- Tabulated base values (no testing) OR
- Good target value $\boldsymbol{q}_{\mathbf{E50}}$ **= 1.5** $m^3/(h \cdot m^2)$ (testing mandatory!) OR
- ~~Specific declared air leakage rate $q_{E50,decl}$ in the case of systematic quality assurance scheme in a single construction or prefabrication company (testing mandatory!)~~ Ineffective from 01.06.2025

| | Base value of air leaga rate, $q_{E50}$ | |
|---|---|---|
| | new building or major renovation | minor or no renovation |
| detached houses | 4.0 | 6.0 |
| other buildings | 2.5 | 4.0 |

# Declared air leakage rate

$$q_{E50,decl} = \overline{q_{50}} + k \cdot \sigma_{q50}, \quad m^3/(h \cdot m^2)$$

where

$$k = 0.675 + 1/\sqrt{n}$$

$\overline{q_{50}}$ – air leakage rate of building type

$\sigma_{q50}$ – standard deviation of air leakage rate

n – number of measured buildings

$q_{E50,decl}$ is calculated based on measurements (5 or more) and includes 75 % of the distribution with a confidence interval of 84 % in the case of normal distribution of the means.

- The company must have a description of systematic airtight solution (description of specific tasks and materials used, order of works, etc)
- Testing mandatory after completion of works.

5



# Blowerdoor testing in Estonia

- No national guidelines (strictly acc. to ISO 9972)
- No qualification scheme for airtightness testers
- Calibration is needed according to measurement device requirements
- Rough estimation that 30% - 35% of new buildings and major renovations are tested
- No national database of testing results (however University maintains partial database and studies airtightness development of Estonian building stock)

# Development of airtightness in Estonia

Average airtightness ($q_{E50}$) of newer buildings are significantly better.



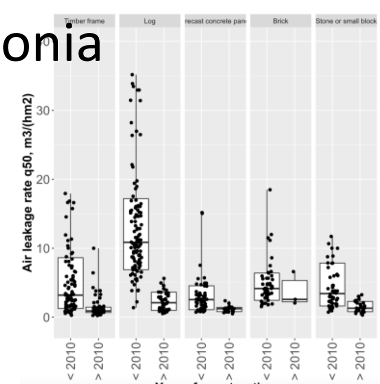


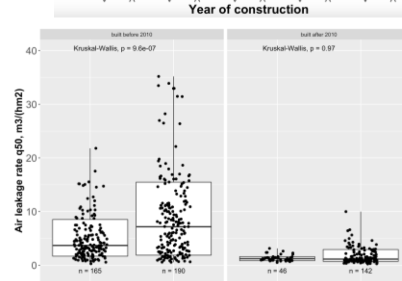


# Development of airtightness in Estonia

The average airtightness of buildings in almost all structure types has significantly reduced since the minimum energy performance classification was forced in Estonia (2008):

- Log-wood: 13.0 → 2.3 m$^3$/(h·m$^2$)
- Lightweight timber frame: 5.1 → 1.2 m$^3$/(h·m$^2$)
- Prefab concrete panel: 6.2 → 1.2 m$^3$/(h·m$^2$)
- Small blocks: 4.3 → 1.5 m$^3$/(h·m$^2$)
- Brick wall: 4.8 → 3.8 m$^3$/(h·m$^2$)
- Significant reduction in variability!
- Old apartment buildings significantly more airtight compared to old detached houses.

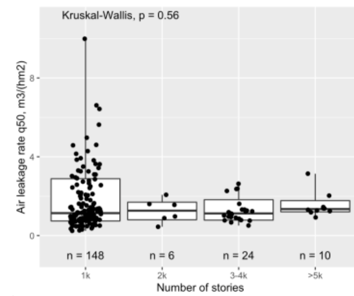


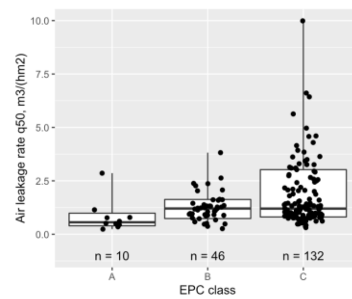



# Development of airtightness in Estonia

**In new buildings:**

- No difference between apartment buildings and detached houses.
- Number of floors / compactness: no signif. effect.
- EPC class A buildings are more airtight: 1.2 → 0.6 $m^3/(h \cdot m^2)$ compared to class B and C
- Small concrete block wall has 2x lower air leakage compared to lightweight ceramsite block wall on average: 1.7 $m^3/(h \cdot m^2)$.
- Building/prefab companies with systematic measurement routine have significantly lower variability of air leakage rate, but airtightness is significantly improved only with timber structure.








**Airtightness of Estonian dwellings – median and base-values for heat loss estimation**

Hallik *et al* 2023 *J. Phys.: Conf. Ser.* **2654** 012063 (https://doi.org/10.1088/1742-6596/2654/1/012063)

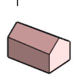


**Table 1.** Effect of construction type and age group on air leakage rate and its distribution for detached houses.

| | | Air leakage rate $q_{E50}$, $m^3/(h \cdot m^2)$ | | | | | |
|---|---|---|---|---|---|---|---|
| Wall contruction | Built | n | Mean | σ | Base value range | Median | Interquartile range |
| Timber frame | ≤1920 | 0 | - | - | - | - | - |
| Timber frame | 1921-1945 | 3 | 9.9 | - | - | - | - |
| Timber frame | 1946-1970 | 2 | 13.4 | - | - | - | - |
| Timber frame | 1971-1990 | 1 | 16.8 | - | - | - | - |
| Timber frame | 1991-2010 | 68 | 4.1 | 3.8 | 1.1 - 7.1 | 2.7 | 1.6 - 5.4 |
| Timber frame | >2010 | 76 | 1.3 | 1.4 | 0.2 - 2.4 | 0.9 | 0.8 - 1.3 |
| Log | ≤1920 | 38 | 15.7 | 8.6 | 8.5 - 22.9 | 13.6 | 9.7 - 16.7 |
| Log | 1921-1945 | 19 | 13.1 | 5.3 | 8.3 - 17.9 | 12.8 | 9.8 - 15.8 |
| Log | 1946-1970 | 4 | 21.2 | - | | - | |
| Log | 1971-1990 | 0 | - | - | | - | |
| Log | 1991-2010 | 13 | 10.5 | 8.4 | 2.5 - 18.5 | 8.1 | 4.7 - 11.9 |
| Log | >2010 | 42 | 2.3 | 1.3 | 1.2 - 3.4 | 2.1 | 1.1 - 3.1 |
| Lightweight concrete block | all years* | 0 | - | - | - | - | - |
| Precast concrete panel | ≤1990* | 0 | - | - | - | - | - |
| Precast concrete panel | 1991-2010 | 3 | 2.4 | - | - | - | - |
| Precast concrete panel | >2010 | 0 | - | - | - | - | - |
| Cast concrete | ≤2011* | 0 | - | - | - | - | - |
| Cast concrete | >2010 | 1 | 0.6 | - | - | - | - |
| Brick | ≤1945* | 0 | - | - | - | - | - |
| Brick | 1946-1970 | 5 | 11.9 | - | - | 11.5 | 11.2 - 12.0 |
| Brick | 1971-1990 | 1 | 8.6 | - | - | - | - |
| Brick | 1991-2010 | 2 | 4.9 | - | - | - | - |
| Brick | >2010 | 3 | 3.8 | - | - | - | - |
| Stone or small block | ≤1970* | 0 | - | - | - | - | - |
| Stone or small block | 1971-1990 | 2 | 4.9 | - | - | - | - |
| Stone or small block | 1991-2010 | 29 | 4.9 | 3.3 | 2.1 - 7.7 | 3.8 | 2.4 - 7.8 |
| Stone or small block | >2010 | 20 | 1.4 | 0.8 | 0.7 - 2.1 | 1.3 | 0.8 - 1.7 |

** multiple age groups combined*

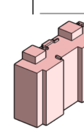


**Table 2.** Effect of construction type and age group on air leakage rate and its distribution for apartment buildings.

| | | Air leakage rate $q_{E50}$, $m^3/(h \cdot m^2)$ | | | | | |
|---|---|---|---|---|---|---|---|
| Wall construction | Built | n | Mean | σ | Base value range | Median | Interquartile range |
| Timber frame | ≤1920 | 1 | 14,6 | - | - | - | - |
| Timber frame | 1921-1945 | 2 | 9,0 | - | - | - | - |
| Timber frame | 1946-1990* | 0 | - | - | - | - | - |
| Timber frame | 1991-2010 | 8 | 1,8 | - | - | 1,6 | 1,1 - 2,1 |
| Timber frame | >2010 | 6 | 1,0 | - | - | 0,9 | 0,8 - 1,1 |
| Log | ≤1920 | 21 | 10,5 | 4,8 | 6,2 - 14,8 | 9,6 | 6,7 - 14,7 |
| Log | 1921-1945 | 16 | 8,8 | 1,9 | 7,0 - 10,6 | 8,8 | 7,1 - 10,3 |
| Log | >1945* | 0 | - | - | - | - | - |
| Lightweight concrete block | ≤1945* | 0 | - | - | - | - | - |
| Lightweight concrete block | 1946-1970 | 1 | 3,1 | - | - | - | - |
| Lightweight concrete block | 1971-1990 | 3 | 4,4 | - | - | - | - |
| Lightweight concrete block | >1990* | 0 | - | - | - | - | - |
| Precast concrete panel | ≤1920 | 0 | - | - | - | - | - |
| Precast concrete panel | 1921-1945 | 0 | - | - | - | - | - |
| Precast concrete panel | 1946-1970 | 10 | 6,1 | 5,0 | 1,2 - 11 | 4 | 2,7 - 6,9 |
| Precast concrete panel | 1971-1990 | 19 | 3,2 | 1,3 | 2,0 - 4,4 | 3 | 2,5 - 3,6 |
| Precast concrete panel | 1991-2010 | 25 | 1,8 | 1,1 | 0,8 - 2,8 | 1,6 | 1,0 - 2,1 |
| Precast concrete panel | >2010 | 28 | 1,2 | 0,4 | 0,9 - 1,5 | 1,2 | 0,9 - 1,3 |
| Cast concrete | ≤1990* | 0 | - | - | - | - | - |
| Cast concrete | 1991-2010 | 1 | 2,2 | - | - | - | - |
| Cast concrete | >2010 | 1 | 3,1 | - | - | - | - |
| Brick | ≤1920 | 0 | - | - | - | - | - |
| Brick | 1921-1945 | 1 | 4,8 | - | - | - | - |
| Brick | 1946-1970 | 11 | 4,7 | 1,2 | 3,5 - 5,9 | 4,2 | 3,6 - 5,5 |
| Brick | 1971-1990 | 29 | 3,7 | 1,4 | 2,5 - 4,9 | 3,6 | 2,5 - 4,5 |
| Brick | 1991-2010 | 2 | 3,2 | - | - | - | - |
| Brick | >2010 | 0 | - | - | - | - | - |
| Stone or small block | ≤1970* | 0 | - | - | - | - | - |
| Stone or small block | 1971-1990 | 1 | 7,9 | - | - | - | - |
| Stone or small block | 1991-2010 | 14 | 2,7 | 1,5 | 1,3 - 4,1 | 2,5 | 1,7 - 3,4 |
| Stone or small block | >2010 | 11 | 1,6 | 0,7 | 1,0 - 2,2 | 1,3 | 1,0 - 2,2 |

** multiple age groups combined*

# Ductwork airtightness



## Airtightness indicator (ductwork)

Maximum permissible leakage air flow per casing surface area $\boldsymbol{f}_{max}$ [$m^3/(s \cdot m^2)$] measured according to EVS-EN 12599:2012.

Current target requirements:

- The airtightness class (ATC) of ventilation ductwork should be at least 4 (previous name B): $f_{max} < 0.009 \cdot p_t^{0.65} \cdot 10^{-3}$
- Recommended ducts and components of Class C or better

Ductwork airtightness testing is not mandatory and depends on client's requirements defined in contract and project (10 – 15% of new houses).

The airtightness of the ventilation ductwork is not directly an input for the building energy calculations.



12

# Thank you for your attention!

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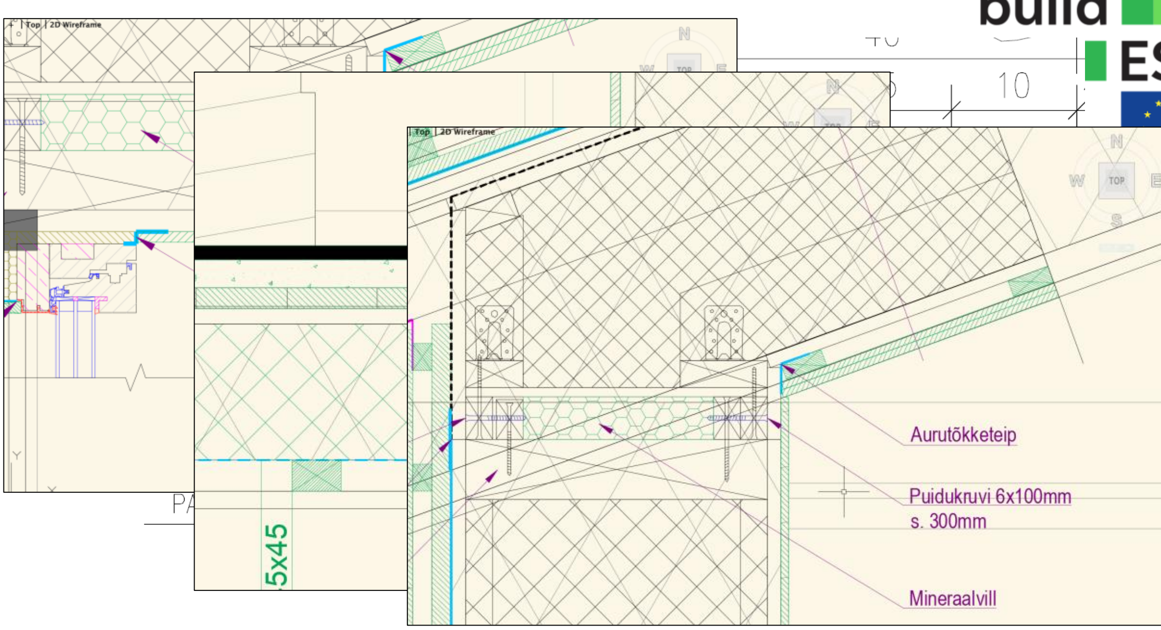


14

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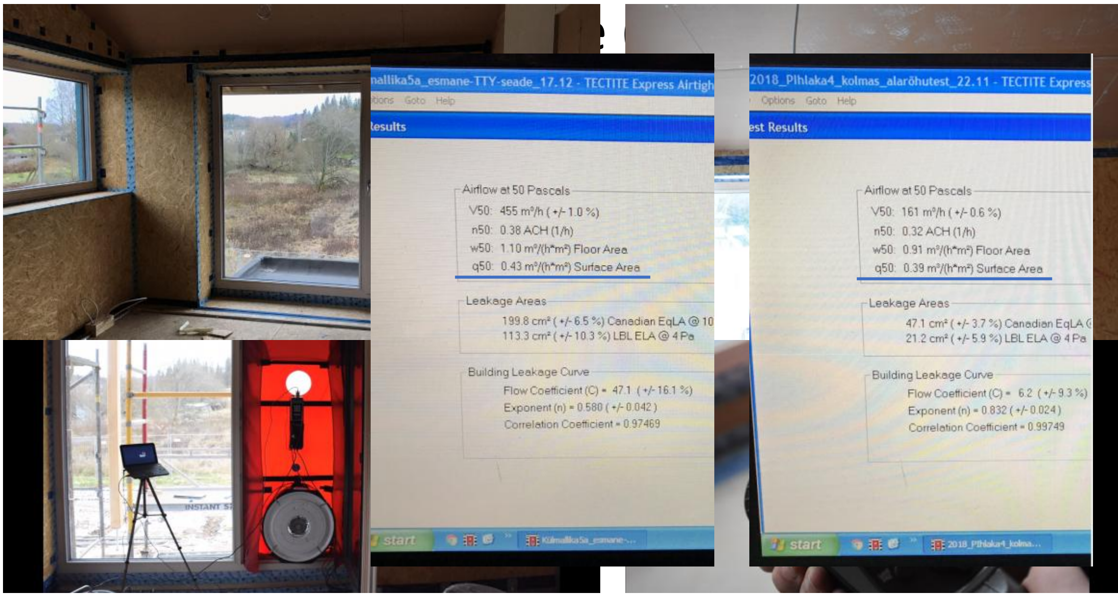
15



build EST

16



nallika5a_esmane-TTY-seade_17.12 - TECTITE Express Airtigh
Results
Airflow at 50 Pascals
V50: 455 m³/h ( +/- 1.0 %)
n50: 0.38 ACH (1/h)
w50: 1.10 m³/(h*m²) Floor Area
q50: 0.43 m³/(h*m²) Surface Area
Leakage Areas
199.8 cm² ( +/- 6.5 %) Canadian EqLA @ 10
113.3 cm² ( +/- 10.3 %) LBL ELA @ 4 Pa
Building Leakage Curve
Flow Coefficient (C) = 47.1 ( +/- 16.1 %)
Exponent (n) = 0.580 ( +/- 0.042 )
Correlation Coefficient = 0.97469
start
2018_Pihlaka4_kolmas_alarõhutest_22.11 - TECTITE Express
Options Goto Help
est Results
Airflow at 50 Pascals
V50: 161 m³/h ( +/- 0.6 %)
n50: 0.32 ACH (1/h)
w50: 0.91 m³/(h*m²) Floor Area
q50: 0.39 m³/(h*m²) Surface Area
Leakage Areas
47.1 cm² ( +/- 3.7 %) Canadian EqLA @
21.2 cm² ( +/- 5.9 %) LBL ELA @ 4 Pa
Building Leakage Curve
Flow Coefficient (C) = 6.2 ( +/- 9.3 %)
Exponent (n) = 0.832 ( +/- 0.024 )
Correlation Coefficient = 0.99749
start

Fachverband Luftdichtheit im Bauwesen e.V.


V entilation
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n° 45.13
November 2024
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airtightness in
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Stefanie Rolfsmeier, BlowerDoor GmbH, Germany

Wolf Rienhardt, Germany

(Oliver Solcher, Fachverband Luftdichtheit im Bauwesen e.V.)



1

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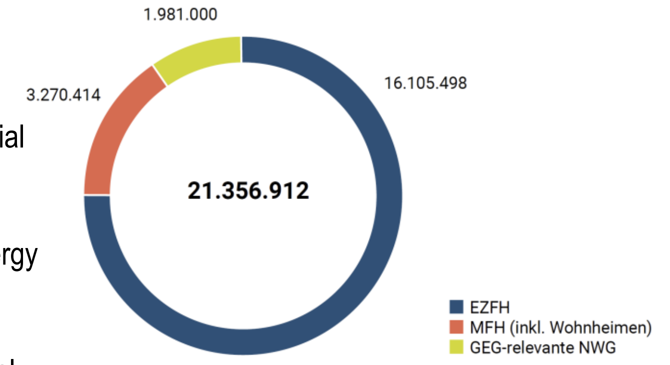
**Residential and non-residential building stock in 2021** (source: dena Building report 2023)

There were around **19.4 million residential buildings** in Germany. Of these, 12.9 million were single-family homes, 3.2 million were two-family homes and 3.3 million were multifamily homes.

From 2011 to 2021, about 100,000 residential buildings were built per year.

There are approximately **2 million non-residential buildings** that are Building Energy Act -relevant. This figure is based on a statistical evaluation from 2019.

The past years, about 11,000 non-residential (heated) buildings were built per year.




2

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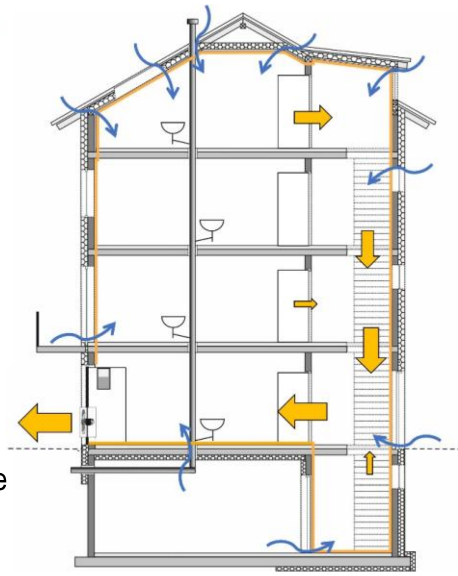
## Building airtightness requirements in the regulation

The **Building Energy Act (GEG)** set requirements for the quality of the air barrier and honors compliance with limit values if an air permeability test is performed:

**New buildings must be** constructed in such a way that the heat-transferring building envelope, including the joints, is **sealed in accordance with the recognized rules of technology**.

**If the airtightness of a new building is checked** according to DIN EN ISO 9972:2018-12 Annex NA, the measured **net air change rate may be considered in the annual primary energy demand**. When checking the airtightness, the measurements shall be carried out with both pressurization and depressurization. The maximum values specified shall be complied with for both cases.



**Acc. GEG air tightness test is not mandatory BUT building air tight is!**

3

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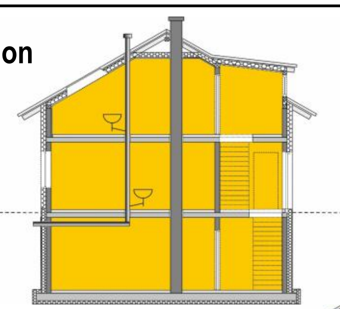
## Building airtightness requirements in the regulation

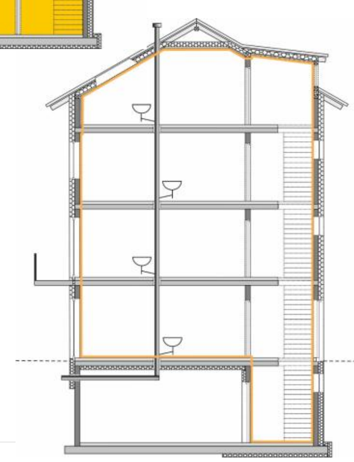


### Buildings with an internal volume ≤ 1500 m³

The **net air change rate** measured at a reference pressure difference of 50 Pascals shall not exceed:

**$n_{L50}$ ≤ 1.5 h$^{-1}$** for buildings with ventilation system

**$n_{L50}$ ≤ 3.0 h$^{-1}$** for buildings without ventilation system



### Buildings with an internal volume > 1500 m³

The **air permeability** at a reference pressure difference of 50 Pascals shall not exceed:

**$q_{E50}$ ≤ 2.5 m³/hm²** for buildings with ventilation system

**$q_{E50}$ ≤ 4.5 m³/hm²** for buildings without ventilation system

4

Fachverband Luftdichtheit im Bauwesen e.V.

## Incentive for Building airtightness

Programs that provide or require a good building airtightness are:

**BEG and KFW (federal funding for energy efficient buildings)**

BEG and KfW support new buildings and renovations with various programs. All of these measures are linked to certain boundary conditions.

Certain efficiency house programs **require airtightness testing**.

**For all measures** funded by BEG and KfW regarding the building envelope **an airtightness concept is required**.

**Passive Houses requirements**

Air tightness shall not exceed **0.6 air changes per hour** at a reference pressure of **50 Pascal ($n_{50}$)** and shall be verified by on-site air permeability measurement (depressurization and pressurization).

**DGNB (German Sustainable Building Council)**

The aim of the DGNB is, among other things, to minimize the energy required for the room conditioning of buildings, while at the same time ensuring a high thermal comfort and to avoid structural damage. The **DGNB prescribes various limit values depending on the building type and its use**.



Fachverband Luftdichtheit im Bauwesen e.V.

## Building airtightness in the energy performance calculation

Determination of the infiltration air change in the EP calculation is done **according to DIN V 18599**:

| Categories for the general estimation of the building tightness | Design values $n_{50}$ 1/h | Design values $q_{50}$ (m³/m²h) |
|---|---|---|
| I | a) 3; b) 1.5 | a) 3; b) 2 |
| II | 4 | 6 |
| III | 6 | 9 |
| IV | 10 | 15 |

**Cat. I:** Compliance with the building airtightness requirement according to DIN 4108-7:2001-08 (i.e. **airtightness test is performed after completion**)
a) Buildings without ventilation and air-conditioning system,
b) Buildings with ventilation and air-conditioning systems (also residential ventilation);

**Cat. II:** buildings or parts of buildings to be constructed, for which **no airtightness test is provided**

**Cat. III:** cases not corresponding to Categories I, II or IV;

**Cat. IV:** **presence of obvious leaks**, such as open joints in the air barrier of the heat-transferring building envelope.

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## Building airtightness in the energy performance calculation for natural ventilation

| $n_{50}$ no or not sealed ATD $[h^{-1}]$ | $n_{inf}$ $[h^{-1}]$ | $\Delta n_{win}$ $[h^{-1}]$ | $n_{win}$ $[h^{-1}]$ | $n_{EP\text{-}calc}$ $[h^{-1}]$ |
|---|---|---|---|---|
| 0.5 | **0.035** | 0.3895 | 0.4895 | **0.5245** |
| 1 | **0.07** | 0.379 | 0.479 | **0.549** |
| 1.5 | **0.105** | 0.3685 | 0.4685 | **0.5735** |
| 2 | **0.14** | 0.358 | 0.458 | **0.598** |
| 3 | **0.21** | 0.337 | 0.437 | **0.647** |
| 4 | **0.28** | 0.316 | 0.416 | **0.696** |
| 6 | **0.42** | 0.274 | 0.374 | **0.794** |
| 10 | **0.7** | 0.19 | 0.29 | **0.99** |



Fachverband Luftdichtheit im Bauwesen e.V.

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## National guidelines for building airtightness

Germany has a national guideline for performing airtightness tests: the **DIN EN ISO 9972:2018-12** with the **German national annex**:

Internal volume $V_L$ and the net air change rate $n_{L50}$

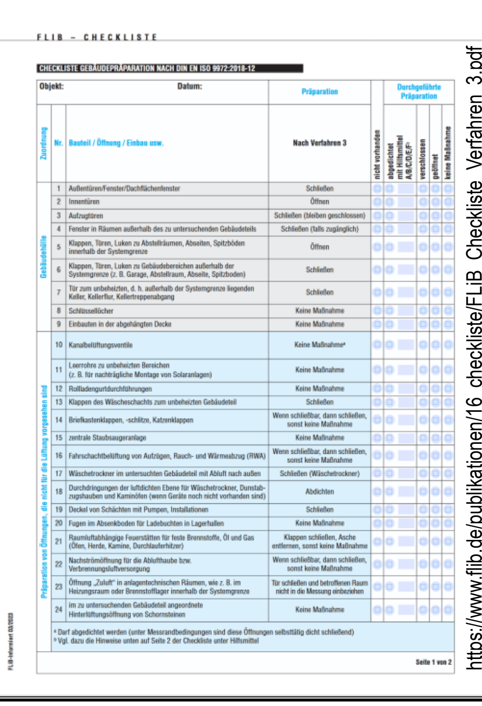
**Detailed checklist** for building preparation (method 3)

**Depressurisation and pressurization** test, building pressure of 50 Pa must be achieved, pressure drop within the building max 10%

**Weighted calculation** of the air leakage flow

Calculation of the **uncertainties** of the measurement

Instructions for **sample testing** of arcade apartments, **section-by-section measurement** as well as **guard-zone measurements**



FLIB – CHECKLISTE

CHECKLISTE GEBÄUDEPRÄPARATION NACH DIN EN ISO 9972:2018-12

Objekt: Datum:

| Zuordnung | Nr. | Bauteil / Öffnung / Einbau usw. | Präparation: Nach Verfahren 3 | nicht vorhanden | Durchgeführte Präparation: abgedichtet | mit Hilfsmittel A/B/C/D/E/F[b] | verschlossen | geöffnet | keine Maßnahme |
|---|---|---|---|---|---|---|---|---|---|
| Gebäudehülle | 1 | Außentüren/Fenster/Dachflächenfenster | Schließen | | | | | | |
| | 2 | Innentüren | Öffnen | | | | | | |
| | 3 | Aufzugtüren | Schließen (bleiben geschlossen) | | | | | | |
| | 4 | Fenster in Räumen außerhalb des zu untersuchenden Gebäudeteils | Schließen (falls zugänglich) | | | | | | |
| | 5 | Klappen, Türen, Luken zu Abstellräumen, Abseiten, Spitzböden innerhalb der Systemgrenze | Öffnen | | | | | | |
| | 6 | Klappen, Türen, Luken zu Gebäudebereichen außerhalb der Systemgrenze (z. B. Garage, Abstellraum, Abseite, Spitzboden) | Schließen | | | | | | |
| | 7 | Tür zum unbeheizten, d. h. außerhalb der Systemgrenze liegenden Keller, Kellerflur, Kellertreppenabgang | Schließen | | | | | | |
| | 8 | Schlüssellöcher | Keine Maßnahme | | | | | | |
| | 9 | Einbauten in der abgehängten Decke | Keine Maßnahme | | | | | | |
| Präparation von Öffnungen, die nicht für die Lüftung vorgesehen sind | 10 | Kanalbelüftungsventile | Keine Maßnahme[a] | | | | | | |
| | 11 | Leerrohre zu unbeheizten Bereichen (z. B. für nachträgliche Montage von Solaranlagen) | Keine Maßnahme | | | | | | |
| | 12 | Rollladengurtdurchführungen | Keine Maßnahme | | | | | | |
| | 13 | Klappen des Wäscheschachts zum unbeheizten Gebäudeteil | Schließen | | | | | | |
| | 14 | Briefkastenklappen, -schlitze, Katzenklappen | Wenn schließbar, dann schließen, sonst keine Maßnahme | | | | | | |
| | 15 | zentrale Staubsaugeranlage | Keine Maßnahme | | | | | | |
| | 16 | Fahrschachtbelüftung von Aufzügen, Rauch- und Wärmeabzug (RWA) | Wenn schließbar, dann schließen, sonst keine Maßnahme | | | | | | |
| | 17 | Wäschetrockner im untersuchten Gebäudeteil mit Abluft nach außen | Schließen (Wäschetrockner) | | | | | | |
| | 18 | Durchdringungen der luftdichten Ebene für Wäschetrockner, Dunstabzugshauben und Kaminöfen (wenn Geräte noch nicht vorhanden sind) | Abdichten | | | | | | |
| | 19 | Deckel von Schächten mit Pumpen, Installationen | Schließen | | | | | | |
| | 20 | Fugen im Absenkboden für Ladebuchten in Lagerhallen | Keine Maßnahme | | | | | | |
| | 21 | Raumluftabhängige Feuerstätten für feste Brennstoffe, Öl und Gas (Öfen, Herde, Kamine, Durchlauferhitzer) | Klappen schließen, Asche entfernen, sonst keine Maßnahme | | | | | | |
| | 22 | Nachströmöffnung für die Ablufthaube bzw. Verbrennungsluftversorgung | Wenn schließbar, dann schließen, sonst keine Maßnahme | | | | | | |
| | 23 | Öffnung „Zuluft" in anlagentechnischen Räumen, wie z. B. im Heizungsraum oder Brennstofflager innerhalb der Systemgrenze | Tür schließen und betroffenen Raum nicht in die Messung einbeziehen | | | | | | |
| | 24 | im zu untersuchenden Gebäudeteil angeordnete Hinterlüftungsöffnung von Schornsteinen | Keine Maßnahme | | | | | | |

[a] Darf abgedichtet werden (unter Messrandbedingungen sind diese Öffnungen selbsttätig dicht schließend)
[b] Vgl. dazu die Hinweise unten auf Seite 2 der Checkliste unter Hilfsmittel

FLiB-informiert 03/2023

Seite 1 von 2

https://www.flib.de/publikationen/16_checkliste/FLiB_Checkliste_Verfahren_3.pdf

## Ductwork airtightness indicator

With EnEV 2007 [4], **requirements for energy efficiency of cooling and air-conditioning systems were set for the case of construction or renewal**. This regulation, as well as the amended versions, **does not contain a classification for the tightness of air ducts**. However, it does require for air conditioning systems with more than 12 kW nominal cooling capacity for cooling demand and for air handling units (AHU) with a design air flow rate of ≥ 4,000 m³/h that the **electrical power for the fan systems does not exceed the limit value of category SFP 4** (SFP: Specific Fan Power) according to DIN EN 13779 (May 2005).

The GEG, which came into force on 01 November 2020, replaced the last applicable EnEV 2016. The GEG has now come into force in the amended version of 16 October 2023 on 01 January 2024. **In the GEG, DIN EN 16798-3 (November 2017) is referenced for the energy efficiency requirements of ventilation and air conditioning systems**. In this set of regulations, at least tightness class B (ATC 4) is required and C (ATC 3) is recommended.



Fachverband Luftdichtheit im Bauwesen e.V.

## Incentive for Ductwork airtightness

The guideline for **federal funding for efficient buildings – non-residential buildings (BEG NWG)** [20] **requires** pneumatic balancing and **proof of the tightness of the air duct system**.

For non-residential buildings, **proof must be provided that the tightness classes in accordance with DIN EN 1507 and DIN EN 12237 are met** as a prerequisite for the energy efficiency of the systems. The tightness of the duct system is tested in accordance with EN 12599 D.8. For systems with complex air duct systems, the test can be carried out in sections and limited to themain ducts.

Quelle: Lindab/Wöhler

Fachverband Luftdichtheit im Bauwesen e.V.

FLiB

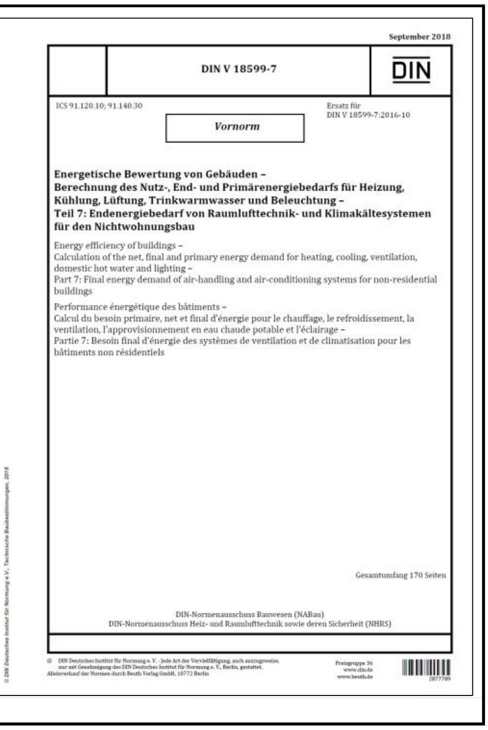
## Ductwork airtightness in the EP calculation

Calculations of the energy consumption of air handling systems are often made for nominal operation, which is based on a utilization profile. **The design of the air handling unit for nominal operation includes the** legally binding owed or contractually agreed **leakage air flow rate**, which is a function of the leakage class. Thus, the **calculation of energy consumption also includes** the proportional **energy consumption caused by the leakage air volume flow**.

***5.5.3 Heat input of the air distribution (heat losses due to air transport)***

*If the supply air temperature is only slightly below the room temperature setpoint (< -10 K), **the heat loss due to leaks in the ductwork can be neglected.***

*The planning specification of the air volume flows for the central ventilation unit is the sum of the required air volume flows for the zones/utilisation units. There is no surcharge for possible leakages.*



September 2018

DIN V 18599-7

DIN

ICS 91.120.10; 91.140.30

Ersatz für DIN V 18599-7:2016-10

*Vornorm*

**Energetische Bewertung von Gebäuden –**
**Berechnung des Nutz-, End- und Primärenergiebedarfs für Heizung, Kühlung, Lüftung, Trinkwarmwasser und Beleuchtung –**
**Teil 7: Endenergiebedarf von Raumlufttechnik- und Klimakältesystemen für den Nichtwohnungsbau**

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Part 7: Final energy demand of air-handling and air-conditioning systems for non-residential buildings

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AIVC & TightVent Webinar
Building and ductwork airtightness trends and regulations in Estonia, Germany and the U.S.A
12 May 2025

# Building and ductwork airtightness in the U.S.: national trends and requirements


Andrew K. Persily (NIST, USA)
Steven Emmerich (NIST)
Iain Walker (LBNL)


1

## BASED ON VIP 45.12

Published in May 2024; USA can and does change


Ventilation Information Paper
n° 45.12
May 2024

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Operating Agent and Management
Sint-Pietersnieuwstraat 41,
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www.inive.org

International Energy Agency's Energy in Buildings and Communities Programme

AIVC
Air Infiltration and Ventilation Centre

Trends in building and ductwork airtightness in USA

Iain Walker, LBNL, USA
Steve Emmerich, NIST, USA
Andrew Persily, NIST, USA

2

## AIRTIGHTNESS MOTIVATIONS

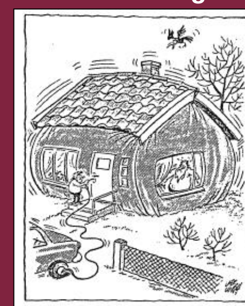
Historically, many in USA didn't care much about airtightness
Or assumed it was not an issue
Or thought it was a bad thing

But the situation has gotten better

We keep telling them it's important because....
Energy consumption for heating & cooling
Indoor air quality
Moisture management
Noise

And it might even be required

**Build Tight, Ventilate Right**



**Arne Elmroth**
**Air Infiltration Review, 1980**



## USA AIRTIGHTNESS REQUIREMENTS

Standards (e.g., ASHRAE)
  Voluntary, consensus

Model codes (e.g., International Energy Conservation Code)
  Local adoption makes them law, adoption often partial

State and local codes
  Force of law
  Focus on new buildings and renovations
  Enforcement varies

Other: Federal agencies, states, various programs, etc.

## AIRTIGHTNESS METRICS (2.2) from Fan Pressurization Tests

**ACH50**

(Personally, I don't like goofy, made-up symbols)

Air changes per hour ($h^{-1}$) at 50 Pa or $Q_{50}$ is better

**Effective or specific leakage area at 4 Pa, ELA or SLA**

Normalized leakage area, ELA/floor area

**Airflow divided by surface area**

$L/s \bullet m^2$ at 50 Pa (often 75 Pa in non-residential)

Envelope area for normalization, include below grade?



## TEST PROCEDURES (2.5)

**Residential**

ASTM E779-19 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

- U.S. standard for multipoint measurements; First approved in 1981

ASTM E1827-11 (2017) Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

- Standard for single point measurements - almost always at 50 Pa.

Most testing uses ANSI/RESNET 380 or blower door manufacturer's instructions.

**Non-residential**

ASTM E779

ASTM E3158-18 Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building

# USA RESIDENTIAL AIR TIGHTNESS LIMITS (2.3.1)

IECC energy airtightness requirement is 3 ACH50 (set in 1998)
Except in mild climates where the requirement is 5 ACH50

U.S. EPA Energy Star requirement for reference design home is 3 ACH50
Also includes checklists for air sealing individual building components.
Checklists used in U.S. Department of Energy Weatherization program
DOE Zero Energy Ready Home program requirements vary with climate

| 2009 IECC Climate Zone | 1-2 | 3-4 | 5-7 | 8 |
|---|---|---|---|---|
| Air Leakage Limit (ACH50) | ≤3.0 | ≤2.5 | ≤2.0 | ≤1.5 |

Interzone airtightness requirements in multifamily residential buildings, e.g., Standard 62.2 and LEED; most around 1 to 1.5 L/s•$m^2$ at 50 Pa



# VIP TABLE 2. NON-RESIDENTIAL AIR TIGHTNESS LIMITS

| | Air Leakage at 75 Pa (L/s·$m^2$) | | |
|---|---|---|---|
| Standard or code | Material | Assembly | Whole building |
| ASHRAE 90.1-2022 | 0.02 | 0.2 | 2.0 |
| ASHRAE/ICC/USGBC/IES 189.1-2023 | References ASHRAE 90.1 | References ASHRAE 90.1 | 1.0 |
| IECC | 0.02 | 0.2 | 2.0 |
| IgCC-2021 | Same as 189.1 | Same as 189.1 | 1.25 |
| USACE ECB 2009-29 | 0.02 | - | 1.25 |
| GSA P100-2021* | 0.02 | 0.2 | 1.25 |

Whole building limits based on 6-sided enclosure including slab and below-grade walls.
GSA P100-2021 recently replaced but still available
https://www.gsa.gov/system/files/P100%202022%20Addendum%20Final_.pdf

**DATABASES**

LBNL Residential Diagnostics Database (ResDB): nearly 150,000 homes through about 2010 (resdb.lbl.gov).

NIST, Commercial Building Airtightness Database (CBAD): over 1000 buildings (> 400 military, > 600 commercial/institutional) online soon

**GUIDELINES TO BUILD AIRTIGHT**

Checklists under many programs, for example:

ENERGY STAR Qualified Homes, Version 3 (Rev. 04), Inspection Checklists for National Program Requirements

IECC Air Barrier and Insulation Inspection Checklist

BPI Technical Standards for Certified Shell Specialists.

National Institute of Building Sciences Whole Building Design Guide

Air Barrier Association of America Air Barrier System Specification



## DUCT LEAKAGE

### Residential

Little change in recent years in requirements.

Testing has led to better sealing and redesign to bring ducts inside conditioned space.

Construction practice adapts to leakage requirements.

State requirements have national impacts since most equipment targets national markets.

### Non-residential

Increased awareness of energy impacts has led to changes in regulations and reduced leakage for ducts and HVAC components.

## CONCLUSIONS

**USA has long lagged Europe and elsewhere on airtightness and testing requirements.**

**But the situation has been improving for both residential and non-residential.**

**Requirements in standards, codes and other programs have stimulated change.**

**US Army Corps of Engineers has played key role in improving non-residential airtightness.**

**Standardized test methods are crucial to improving airtightness.**