PLEIAQ

Trends in building and ductwork airtightness in different countries

WORKSHOP "TOWARDS HIGH QUALITY, LOW-CARBON VENTILATION IN AIRTIGHT BUILDINGS"

MAY 19TH 2023

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Context : AIVC VIPs

Building airtightness

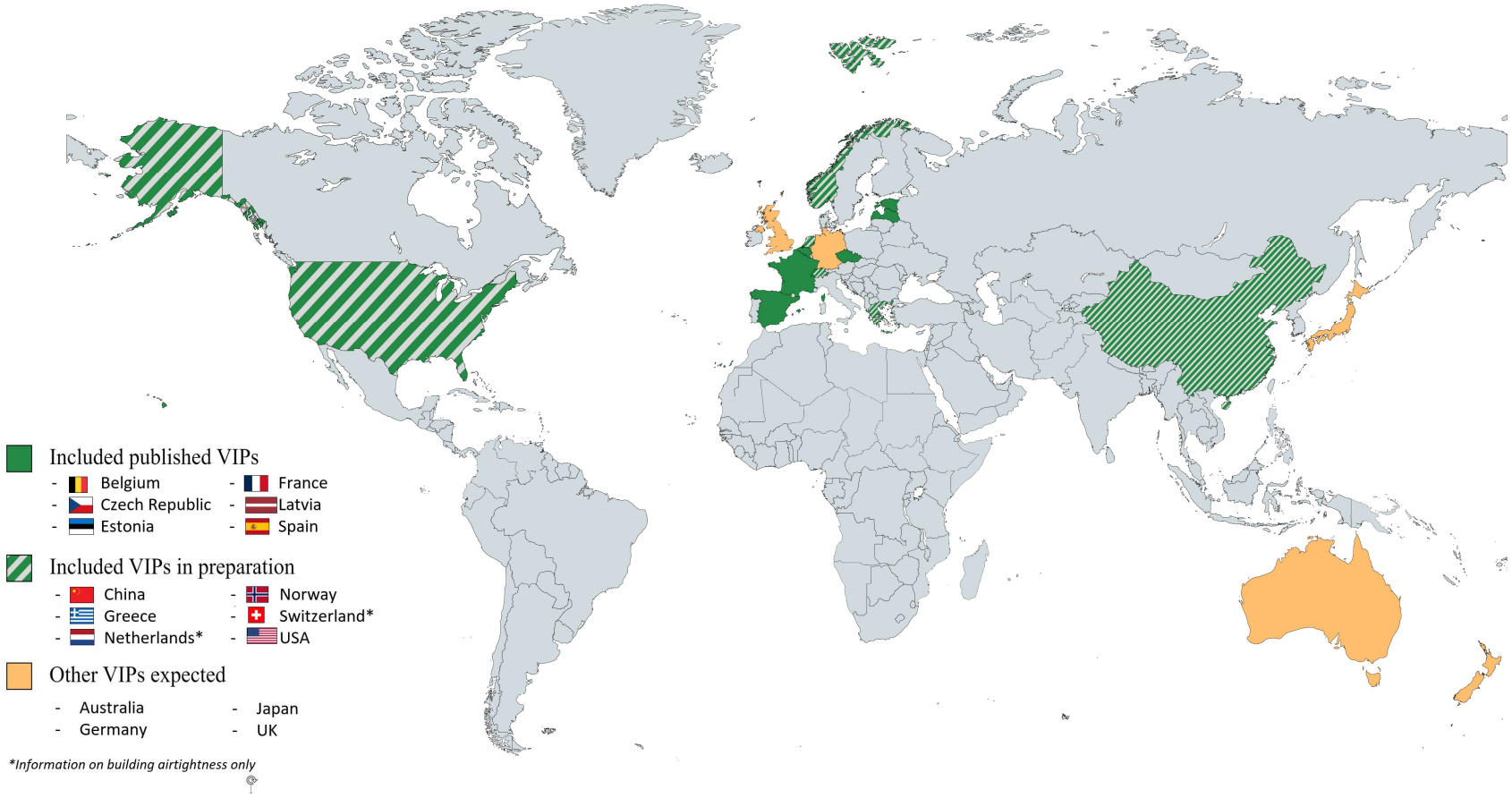
Ductwork airtightness

VIP series on Building & Ductwork Airtightness

Series of Ventilation Information Papers (VIP) published by the AIVC

- Title: *"Building and ductwork airtightness - National trends and requirements"*
- Authors found in various countries via the TightVent Airtightness Associations Committee (**TAAC**) and the **AIVC** board members
- Template prepared: **similar structure** for all papers
- Already **7 published papers**:
  - Estonia (VIP 45.1)
  - Spain (VIP 45.2)
  - Czech Republic (VIP 45.3)
  - Belgium (VIP 45.4)
  - Latvia (VIP 45.5)
  - France (VIP 45.6)
  - Greece (VIP 45.7)
- Available on the **AIVC website**: https://www.aivc.org/collection-keys/vip
- Overview summary in preparation

Countries included in this overview (12)

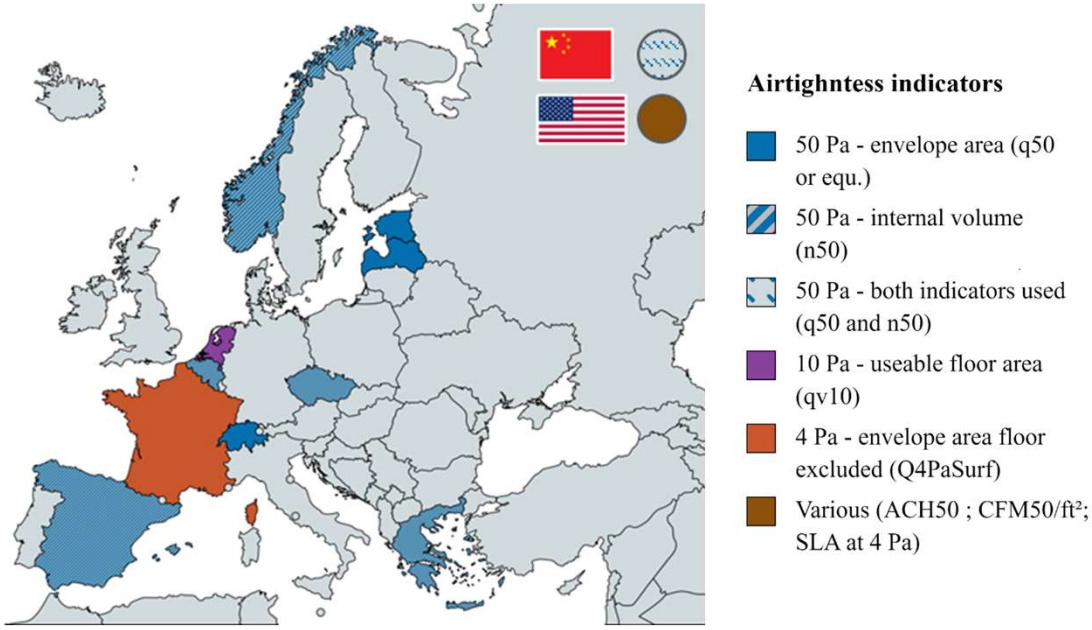



Context : AIVC VIPs
Building airtightness
Ductwork airtightness

Envelope airtightness indicators

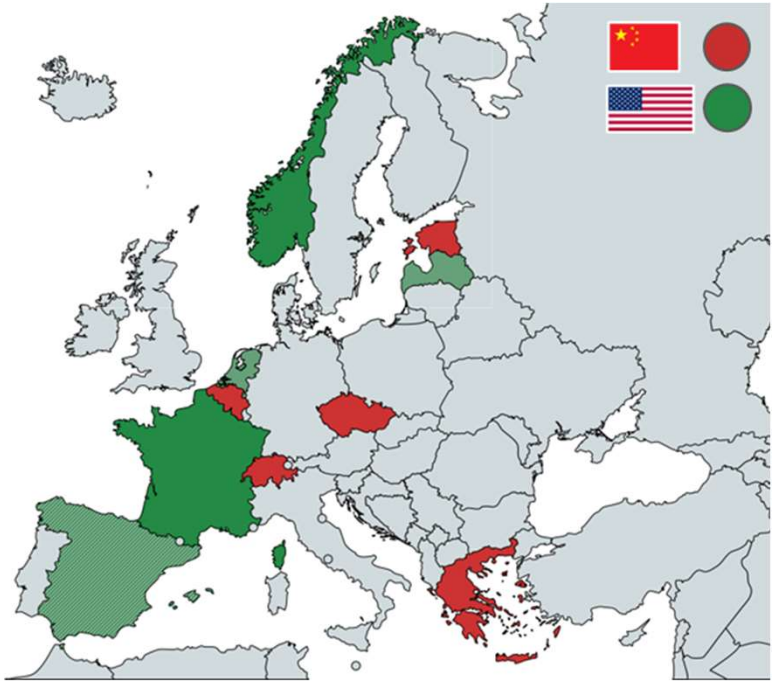
Flowrate at pressure :	Devided by :		
	Envelope area	Building volume	-
50 Pa	q_{50} ($m^3/(h.m^2)$)	n_{50} (h^{-1})	
10 Pa			q_{v10} (m^3/h)
4 Pa	$q_{4PaSurf}$ ($m^3/(h.m^2)$)		

- BE: Average of p^+ and p^- ; external dim.
- FR: Floor excluded from the envelope area
- LV: n_{50} also sometimes used
- NL: q_{v10} sometimes divided by the floor area
  n_{50} and ACH50 also used
- USA: various indicators: ACH50 ; CFM50/ft²;
  Specific Leakage Area (-) at 4 Pa



Mandatory envelope airtightness requirements

Mandatory requirements?					
NO	YES				
	Country	Mandatory for:	Values		Mandatory justification ?
			Indic. (unit)	Max. values	
	FR	Residential buildings	$q_{4PaSurf}$ ($m^3/(h.m^2)$)	• 0.6 for single-family • 1 for multi-family	YES, by test or certified quality management approach
	LV	Residential houses, homes for the elderly, hospitals, kindergartens, and public buildings	q_{50} ($m^3/(h.m^2)$)	• 3,0 for natural vent. • 2,0 for mech. vent • 1,5 for heat recov. • 4,0 for industrial build.	NO
	NL	All buildings ?	q_{v10} (L/s)	• 200 up to 500 m^3, pro rata above • Stricter in EPC: about 0,6 /m^2 of floor	NO
	NO	All buildings	n_{50} (h^{-1})	• 1.5 for all buildings • target of 0.6 for dwellings	YES
	ES	Residential build. > 120 m^2, with mandatory controlled mech. or hybrid vent. system	n_{50} (h^{-1})	• 6 if Vol//Env. Area <2 • 3 if Vol//Env. Area >4 • Interpolation in between	YES, by test or calculation with a formula: $n_{50} = 0.629 \frac{C_0 \times A_0 + C_h \times A_h}{V_{int}}$
	US	Residential buildings in some states that have adopted the IECC energy codes	ACH50	• 3 nationally • 5 in few locations with very mild climates	YES, by test (sampling allowed for muti-family)



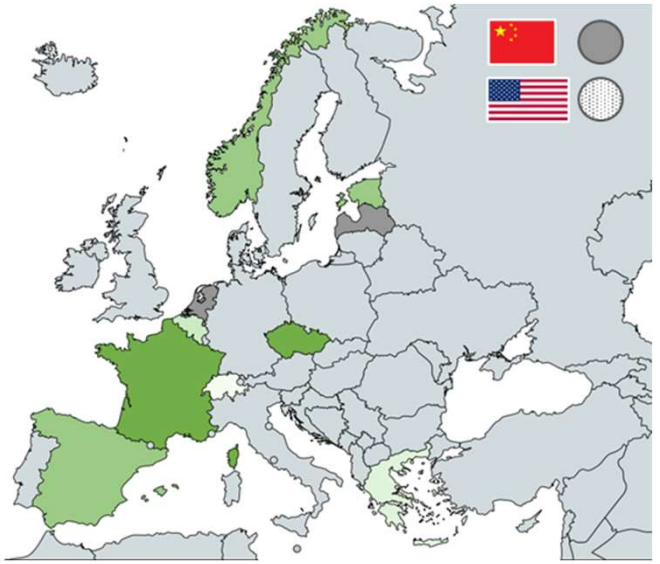
Building airtightness in Energy Performance Calculations

Level of accuracy and complexity

Type of model	Country	Details	Default values		
			Used?	Values	Comments
Constant value (per building surface)	CH	Not a variable: fixed additional outside air volume flow of 0.15 m³/(h.m²) (net floor area reference) regardless of the quality of the envelope (not possible to use test values)			
Tabulated values	GR	Fixed tabulated air infiltration rates (m³/h) given for different types of windows and doors; for chimneys and ventilation boxes (not possible to use test values)			
Leakage-infiltration ratio	BE	$v_{inf} = 0.04 * v_{50} * A_T$	YES	**VERY penalizing** v_{50}: 12 m³/(h·m²) for heating; 0 for cooling	**Test** not officially mandatory but **necessary** for the EP calculation
Simple infiltration model (SIM)	EE	$q_{inf} = q_{50}.A/X$ A: area of the building envelope (m²) X: factor depending on the **number of storeys** (ranging from 15 to 35)	YES	Penalizing q_{50} (m³/(h.m²)): - detached house: 4 (6 for minor renovation) - other buildings : 2,5 (4)	Other possibilites: - Use 1.5 m³/(h·m²) to be justified by test later - Use of a calculated "declared air leakage rate"
	NO	Common case: $n_{inf} = n_{50}.0{,}07$ but depends **on number of facade exposed** and **degree of exposure to wind**	NO	-	Requirements can be used prior to the test
	ES	Fixed infiltration rate estimated from n_{50} with hypotheses (wind speed of 2,8 m/s, Cp values per façade, n=0,67; etc.)	YES	Calculation of n_{50} by a formula: $n_{50} = 0.629 \frac{C_0.A_0 + C_h.A_h}{V_{int}}$	-
Equilibrum pressure model	CZ	Method 1 of the standard EN 16798-7, with an hourly time step (pressure calculated by a mass balance equation)	NO	-	Common practice: use recommended n_{50} values at level I according to ČSN 73 0540-2
	FR		YES	Non-residential: $Q_{4PaSurf}$: 1.7 or 3 m³/(h·m²) depend. on the building use	No default values for residential buildings: minimum requirements to be justified

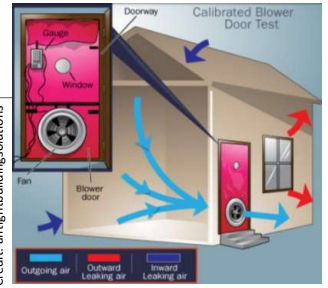
US: it depends on the states, most jurisdictions use a prescriptive approach and do not model energy use (IECC: SIM; dynamic infiltration rat; California: SIM; fixed infiltration rate)

LV,NL, CN: no information reported on the model



Building airtightness test protocol

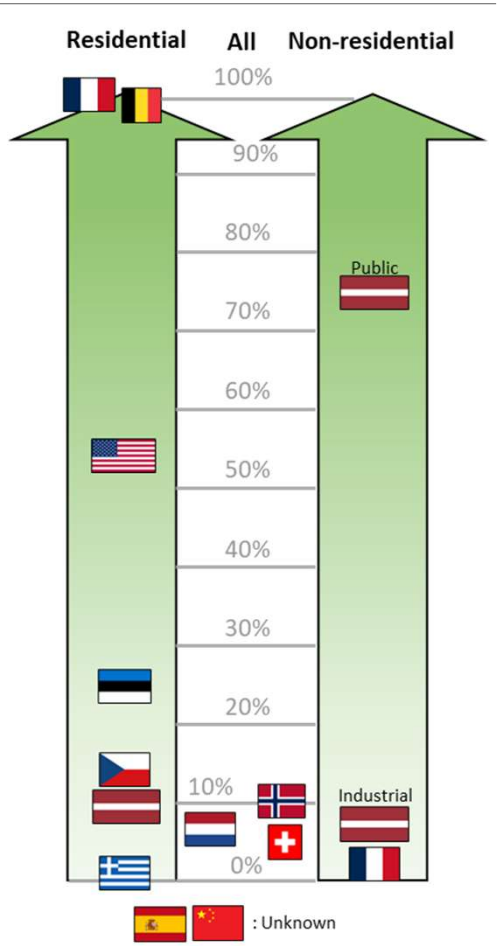
Country	National qualification for testers				National guidelines		
	Existing?	Mandatory?	Name	Number or %	Existing?	Name (year)	Specificities
BE	YES (Fl.)	YES ?	By BCCA and SKH	150 – 190 (Fl.)	YES	STS-P 71-3 (2014), mandatory only in Fl.	Tests in p^+ and p^- (or correction if not possible)
CN	NO	-	-	-	YES	T/CECS 704 (2020)	Tracer gaz method allowed
CZ	YES	NO	A.BD_CZ (mandatory for members)	15 (30-35%)	YES	annex of TNI 73 0330	Method for testing multi-family build.
						New Green Savings (NGS) guidelines	For buildings in this energy performance programme
EE	NO	NO	-	-	NO	-	-
FR	YES	YES	Qualibat	842	YES	FD P50-784	Application guide of EN ISO 9972
GR	YES	NO	Seminars by Aerosteganotita	10	NO	-	-
LV	NO	NO	Some qualified with Retrotec, FliB, ATTMA	11	NO	In accordance with LVS EN 9972:2016	
NL	NO	NO	Some qualified by SKH	10-15%	YES	NEN 2686	Tests in p^+ and p^-
NO	NO	NO	-	-	YES	There are simplified methods in use not complying entirely with ISO 9972	
ES	NO	NO	Trainings by manufacturers	?	NO	In accordance with UNE-EN ISO 9972:2019	
CH	NO	NO	qualified with FLIB	2 (~2%)	YES	Minergie airtightness guideline (RiLuMi)	for building and test preparation (test in accordance with EN ISO 9972)
US	YES	NO ?	energy auditor certification (ABNSI/BPI-1100-T-2014) by BPI	?	YES	Standard ASTM E779	for multipoint measurements
						Standard ASTM E1827	for single point measurements (50 Pa)
						More commonly used: ANSI/RESNET 380 or blower door manufacturer's instructions (more simple than ASTM standards)	



Credit: airtightbuildingsolutions

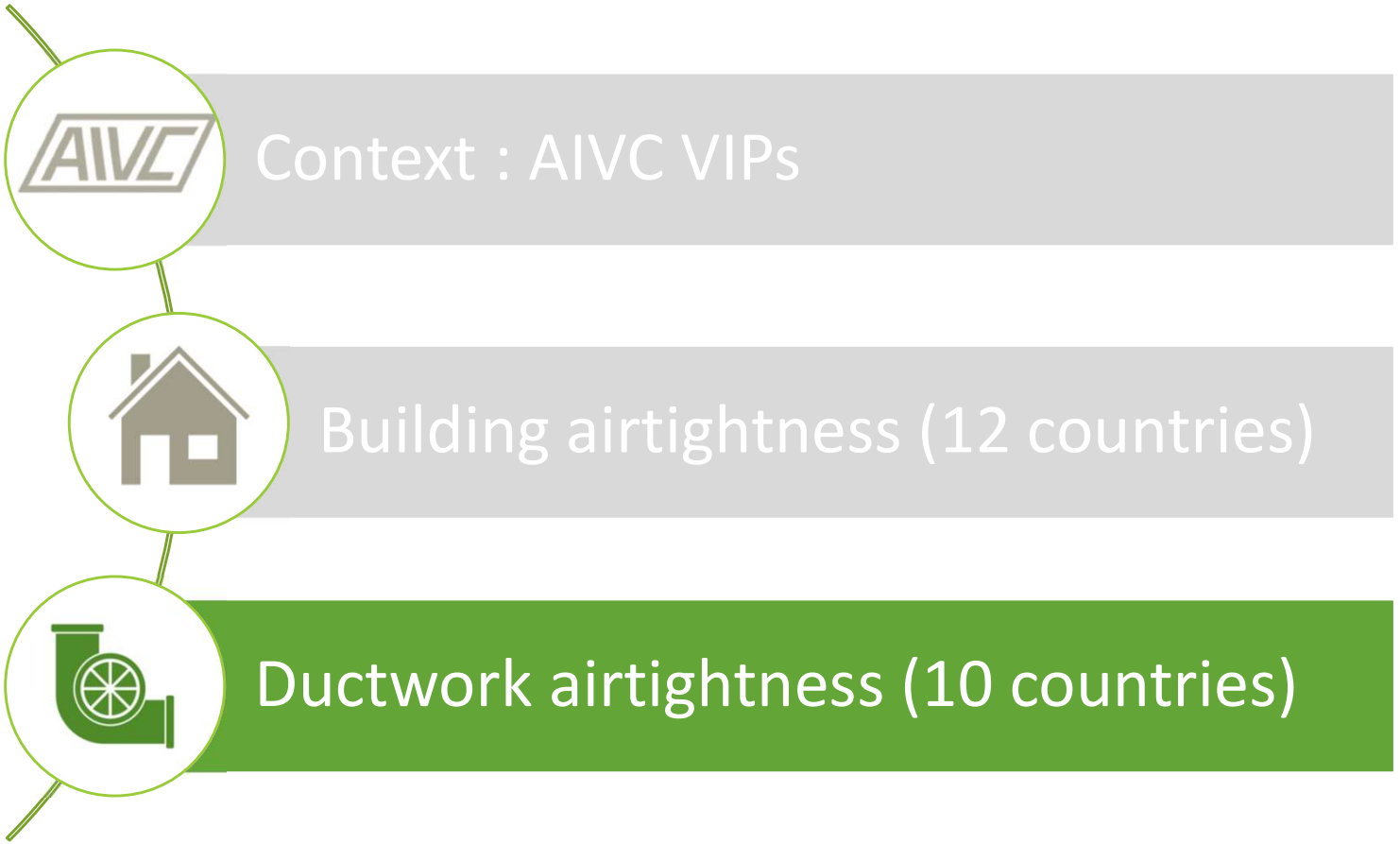
Building airtightness tests performed

Country	Residential buildings	Non-residential buildings	Public database		
			Existing?	In charge:	% of tests
BE	New: alm. 100%	-	YES	Flanders: VEKA	100%
	deep retrofit: ~ 25%			quality frameworks like BCCA	All from this QF
CN	unknown	-	NO	-	-
CZ	<15%	-	YES	A.BD_CZ	~ 3%
EE	~ 25%	-	NO	-	-
FR	100%	very few	YES	Qualibat (since 2007)	100%
GR	very very few	-	YES	Aerosteganotita	?
LV	5-15%	public: 70-80%	NO	-	-
		industrial: 5-10%			
NL	5-10%		NO	Some data gathered (Retrotec's rCloud, SKH scheme, Uni. of Twente)	
NO	~ 10%		NO	-	-
ES	Unknown		NO	One-time effort: 400 cases (INFILES Project)	
CH	~ 5%		NO	survey of Minergie	
US	>50% (depends on the states)	-	NO	Old one from LBNL (150 000 entries)	

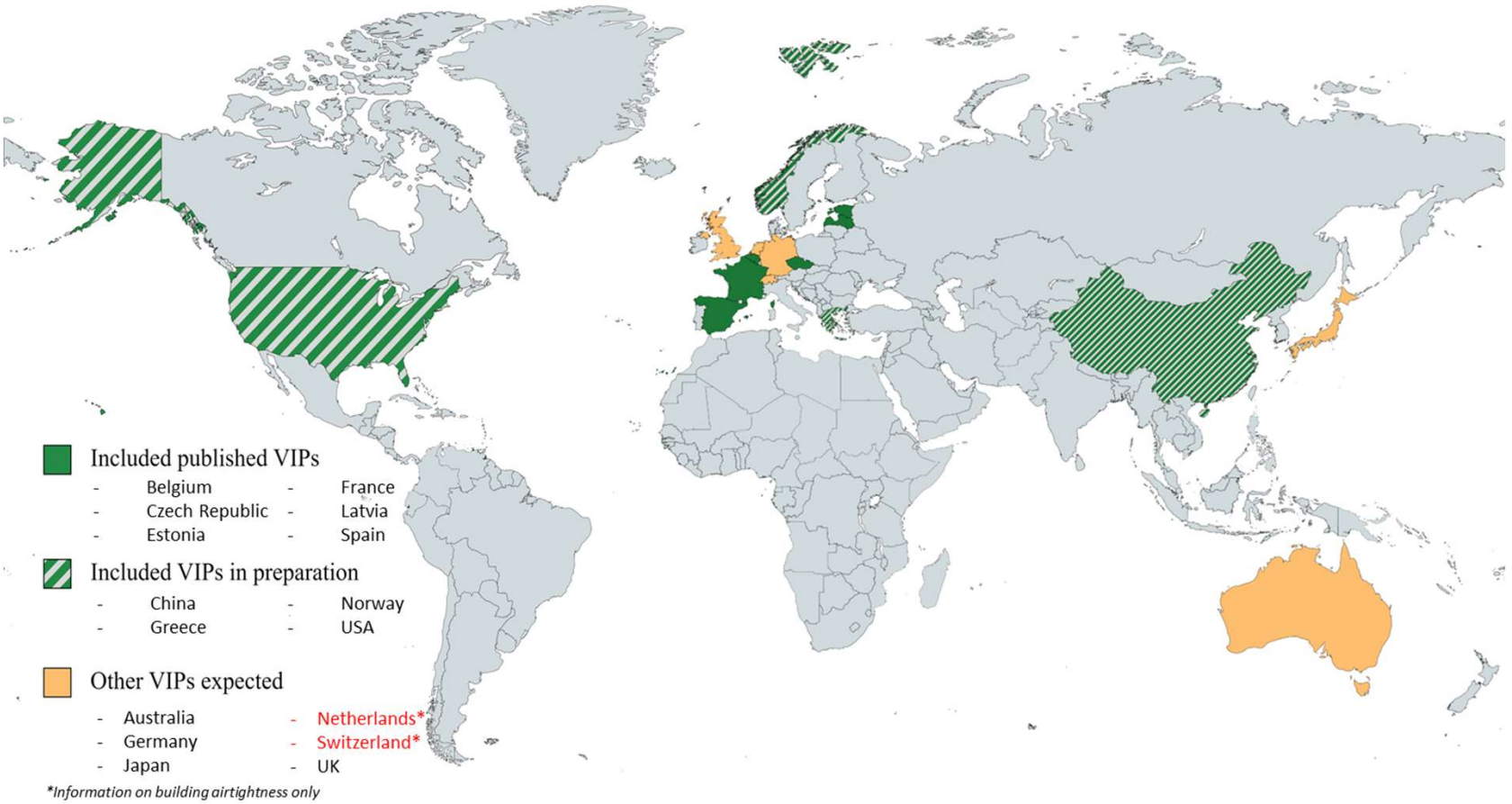


Guidelines to build airtight

Country	Guidelines to build airtight		
	Existing?	Name	Details/Comments
BE	YES	Technical Guidance on building airtightness (by Buildwise)	Technical Information Note : recommended principles for constructing airtight buildings
CN	YES	Guideline T/CECS 826 (2021)	applies to the design, construction, and acceptance of airtight materials for building construction
CZ	YES	Standard ČSN 74 6077	recommends several technical solutions for an airtight design of the window-to-wall interface
EE	In prep.		Estonian national standard under development
FR	YES	Carnets Mininfil (2010)	Design and implementation guide for designers, craftsmen and construction companies
GR	NO	-	-
LV	NO	-	-
NL	NO	-	Some manufacturers of building provide guideline
NO	NO	-	Airtightness issues are important in the Norwegian building research details database
ES	YES	Basic Document for the Energy Saving in Buildings (DB HE1)	Construction solutions and workmanship of the building envelope for good airtightness
		UNE 8529:2016	Joints and discontinuities on the thermal envelope
CH	YES	SIA 180, SIA 4001,...	Standards that relate to specific components (roof, wall, window....)
		RiLuMi for Minergie	
US	YES	Guidelines in many individual programs , usually in the form of checklists. Examples : 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.	


Context : AIVC VIPs
Building airtightness (12 countries)
Ductwork airtightness (10 countries)

10 countries included (not NL and CH)



Ductwork airtightness indicators

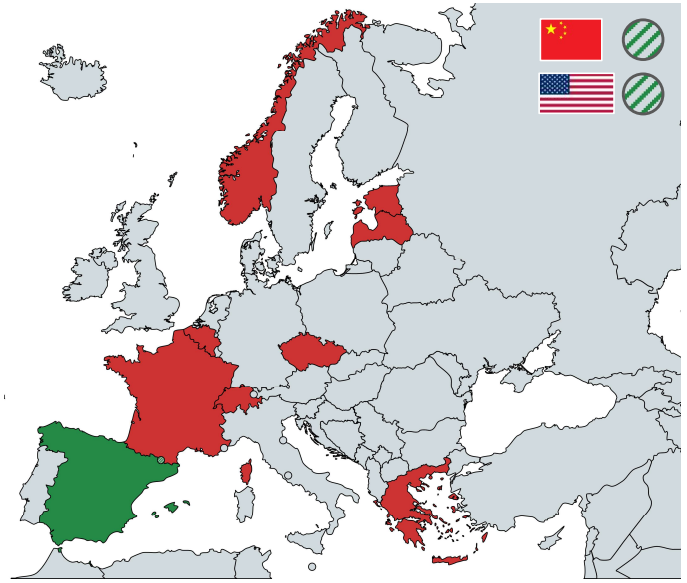
- **European countries**: f ($m^3/(s.m^2)$)
  Flowrate divided by the ductwork area
  Use of airtightness classes →
- **USA**: $CFM25/ft^2$
  Flowrate at 25 Pa divided by the floor area
- **China:** Q ($m^3/(h.m^2)$)
  Flowrate divided by the ductwork area (pressure not defined)

Airtightness classes		Air leakage limit (fmax) according to the test pressure (p_t) [$m^3.s^{-1}.m^{-2}$]
Previous name	**New name**	
	ATC 7	Not classified
	ATC 6	$0,0675 \times p_t^{0,65} \times 10^{-3}$
A	ATC 5	$0,027 \times p_t^{0,65} \times 10^{-3}$
B	ATC 4	$0,009 \times p_t^{0,65} \times 10^{-3}$
C	ATC 3	$0,003 \times p_t^{0,65} \times 10^{-3}$
D	ATC 2	$0,001 \times p_t^{0,65} \times 10^{-3}$
	ATC 1	$0,00033 \times p_t^{0,65} \times 10^{-3}$

Mandatory ductwork airtightness requirements

Mandatory requirements?					
NO	YES				
	Country	Mandatory for:	Values: Indic. (unit)	Values: Max. values	Mandatory justification ?
	ES	New and retrofitted buildings		Class B	YES (by test since 2007 - UNE-EN 12599) but in practice: not always tested)
	CN	All buildings	Q (m^3/h)	See Table	NO
	US	Some cases / States	CFM25 (CFM)	ENERGY STAR & IECC: Max (8 /100 ft^2; 80) California & ASHRAE 62.2: 6% of total system airflow North Carolina: 6 /100 ft^2 Kentucky: 12 /100 ft^2 ; ...	NO

Design pressure	Permitted air leakage rate $m^3/(m^2 \cdot h)$	
	Rect. metal duct	Round metal duct
≤ 500 Pa	$\leq 0.1056P^{0.65}$	$\leq 0.0528P^{0.65}$
500 -1500 Pa	$\leq 0.0352P^{0.65}$	$\leq 0.0176P^{0.65}$
≥ 1500 Pa	$\leq 0.0117P^{0.65}$	$\leq 0.0117P^{0.65}$

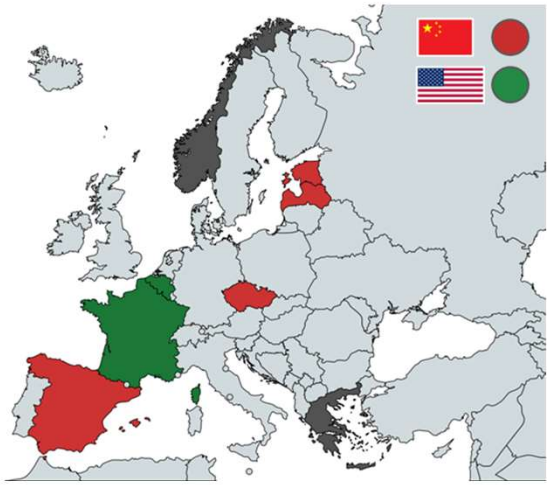


Ductwork airtightness in Energy Performance Calculations

Country	Details	Default values		
		Used?	Values	Comments
BE	non-residential: NO residential: can be valorised through a reduction in the factor m (valorising the execution quality of the vent. system)	-		
FR	The ductwork airtightness influences the total air change rate of the internal volume (included in the calculation of the ventilation flow rate)	YES	2.5 Class A	Any other class used in the EP calculation has to be justified
USA (Califo.)	A multizone air flow and thermal model is used to calculate the impacts of duct leakage as a reference that other compliance software must match	YES (CA)	15% prior to 2013; 5% since 2013 (introduction of duct perf. Requirements in 2013)	No information on other states

CN, CZ, EE, ES, LV: Not included in the EP calculation

GR, NO: No information provided



Ductwork airtightness in EP calculation ?

- Yes (in at least some cases)
- No
- No information provided

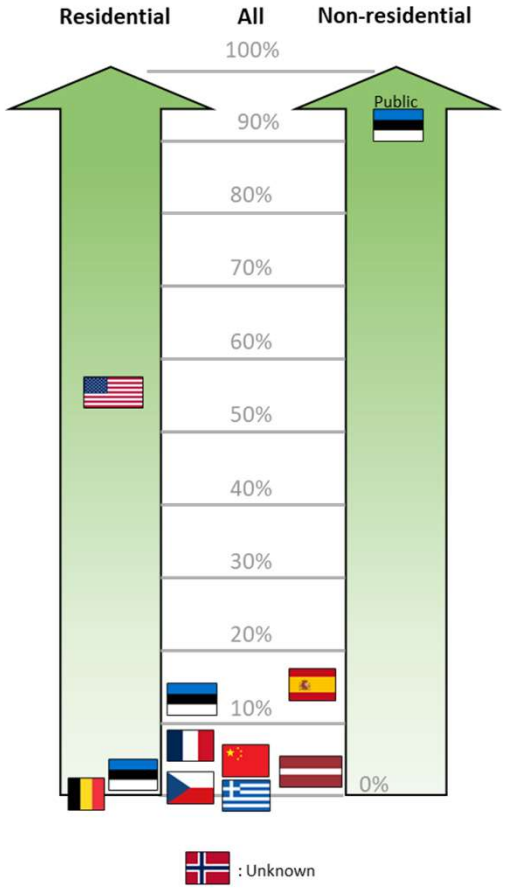
Ductwork airtightness test protocol


Credit: Wikipedia

Country	National qualification for testers			National guidelines		
	Existing?	Mandatory?	Name	Existing?	Name (year)	Specificities
BE	NO	NO	-	NO	-	-
CN	NO	NO	-	N/A	-	-
CZ	NO	NO	(2 accredited laboratories to test products)	NO	-	-
EE	NO	NO	-	NO	-	-
FR	YES		Qualibat (133 testers)	YES	FD E 51-767 (Tests have to comply with EN 12237, EN 1507, EN 13403 and EN 12599)	- sampling rules for multi-family dwellings - rules to select a sample of houses among a group of houses, and a sample of ductworks for buildings than include more than 5 fans. - requirements regarding the preparation of the ductwork - reference pressure difference of the test depending of the type on building - corrections that shall be applied for particular situations
GR	N/A	N/A	-	N/A	-	-
LV	NO	NO	-	NO	-	-
NO	NO	NO	-	NO	-	-
ES	NO	NO	Usually: technicians who install the system also test it	NO	-	-
US	YES	NO	BPI (BPI 2017 ANSI/BPI-1200-S-2017) and RESNET	YES	For residential: - More commonly used for residential: ANSI/RESNET 380 - More advanced test methods in ASTM Standard (ASTM E1554) - In California (and ref. in ASHRAE 62.2): California Building Energy Efficiency Standards, Residential Appendix RA3.1 (CEC 2019) For non-residential: also fixed-pressure duct testing methods	

Ductwork airtightness tests performed

Country	Residential buildings	Non-residential buildings	Public database		
			Existing?	In charge:	% of tests
BE	< 1%	-	No	(not public: VEKA in Flanders)	limited
CN	Very few		NO	-	-
CZ	Very limited for special installations		NO		
EE	Few (usually no test)	Public: almost 100%	YES	Estonian building registry	100% ?
	10-15%				
FR	Few (1323 tests in 2020)		YES	Cerema	100%
GR	Close to 0%		NO		
LV	Very few		NO	-	-
NO	N/A		NO	-	-
ES	Rather low		NO	-	
US	>50% (depends on the states)	-	NO	Old one from LBNL (150 000 entries)	



Guidelines to build airtight ductwork

Country	Guidelines to build airtight ductwork		
	Existing?	Name	Details/Comments
BE	NO	-	-
CN	YES	Standard GB 50738-2011 and JGJ 141-2017	Stipulated: material selection, production, installation and inspection, etc.
CZ	NO	-	Every producer provides his product with installation description
EE	YES	RKAS guideline	
FR	YES	DTU 68.3 (national standard)	Rules for design and installation of ventilation systems in buildings. Widely required by building owner for insurance purposes
GR	N/A	-	-
LV	N/A	-	-
NO	N/A	-	-
ES	NO	-	-
US	YES	California: California building standards include thorough instructions for duct and envelope sealing Many organizations provide training for testing and sealing ductwork: - US DOE Building America: BSC information on duct sealing for all climates - Energy Star duct sealing guidance for homeowners - SMACNA HVAC Duct Construction Standards - Metal and Flexible - ACCA Quality Installation Specification	

Thank you for your attention

And thank you to the VIP authors:

BE: Liesje Van Gelder (BCCA), Maarten De Strycker (BCCA), Christophe Delmotte (Buildwise), Arnold Janssens (Ugent)
CH: Michael Wehrli (TheCH)
CN: Jie Hu, Guoqiang Zhang, Zhengtao Ai (Hunan University)
CZ: Jiří Novák (CTU), Daniel Adamovský (CTU, UCEEB), Jan Vitouš (CTU, UCEEB)
ES: Timo Hoek (airtest), Irene Poza-Casado (UVA), Sergio Melgosa (eBuilding)
ET: Targo Kalamees, Jaanus Hallik, Alo Mikola (Tallinn University of Technology)
FR: Bassam Moujalled, Adeline Mélois (Cerema, LOCIE)
GR: Theodoros Sotirios Tountas (F.U.V.)
LV: Andrejs Nitijevskis (IRBEST Ltd), Latvia Vladislavs Keviss (IRBEST Ltd), Nolwenn Hurel (PLEIAQ)
NL: Frans Dam, Rob Dam (Retrotec EU)
NO: Tormod Aurlien (NMBU)
US: Iain Walker (LBNL), Steve Emmerich (NIST)