Airtightness of window-wall interfaces in masonry brick walls and wood-frame construction

Nathan Van Den Bossche

Overview

• Introduction
• Experimental setup
• Masonry construction
• Wood-frame construction
• Conclusions
Introduction

An ‘average’ dwelling:
Exterior volume $V_e$: 617 m³
Interior volume $V_i$: 453 m³
Area building shell $A_b$: 426 m²
Area windows $A_w$: 43.4 m²

$n_{50} = \frac{V_{50}}{V_s} \ [h^{-1}]$

$v_{50} = \frac{V_{50}}{A_s} \ [m^3/h/m^2]$

<table>
<thead>
<tr>
<th></th>
<th>$V_{50}$ [m³/h]</th>
<th>$n_{50}$ [h⁻¹]</th>
<th>$v_{50}$ [m³/h/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard (EPBD)</td>
<td>5112.0</td>
<td>11.28</td>
<td>12.00</td>
</tr>
<tr>
<td>Low energy</td>
<td>906.0</td>
<td>2.00</td>
<td>2.13</td>
</tr>
<tr>
<td>Passive house</td>
<td>271.8</td>
<td>0.60</td>
<td>0.64</td>
</tr>
</tbody>
</table>
Introduction

Typical distribution of air leakage paths

- Wall, roof, floor: 42%
- Interfaces: 31%
- Windows & WWI: 24%
- Other (elec. sockets...): 3%

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Experimental setup
Experimental setup

AIVC – TIGHTVENT webinar - Department of Architecture – nathan.vandenbossche@ugent.be
Overview

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• Wood-frame construction
• Conclusions
Masonry construction

• Air leakage per meter @ 50Pa (including corners)
• 14 details tested for standard configuration
• 1 detail tested in a passive house wall
• collaboration with manufacturers and contractors
• results: 0.00 to 33.07 m³/h/m

3 Classes:
• **Poor**: \( v_{50} > 3.3 \) m³/h/m
• **Average**: 0.33 m³/h/m < \( v_{50} < 3.3 \) m³/h/m
• **Good**: \( v_{50} < 0.33 \) m³/h/m
12mm plaster
140mm perforated clay bricks
80mm insulation
30mm cavity
90mm masonry veneer

0.13m³/h/m

0.19m³/h/m

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0.10m³/h/m

0.03m³/h/m
Results

- Poor
- Average
- Good
Overview

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Foil continuous – exterior corner

Basic setup:

0.3 m³/h/m

Silicone at corners:

0.09 m³/h/m
Foil continuous – exterior corner

Impact 10 screws Ø 4mm:
0.09 m³/h/m extra

Screws removed:
0.16 m³/h/m extra

Foil discontinuous – exterior corner

Basic setup:
0.23 m³/h/m
Foil continuous – interior corner

Basic setup:
1.68 m³/h/m

Silicone at corners:
1.19 m³/h/m
Foil discontinuous – interior corner

Basic setup:
1.13 m³/h/m

Spray-in-place polyurethane foam (SPF)

SPF without moistening:
0.09 m³/h/m

SPF with moistening:
0.03 m³/h/m
Foil – window in plywood frame

Basic setup:
0.25 m³/h/m
SPF – window in plywood frame

**SPF with moistening:**

0.00 m³/h/m

---

**Other type of plywood:**

Air currents at plywood edge

Additional 0.11 m³/h/m
Conclusions:

- Windows class 4: not sufficient for very airtight buildings
- Average performance joint: air loss < 3.3 m³/h.m @ 50Pa
- Good performance joint: air loss < 0.33 m³/h.m @ 50Pa
- Foil: apply continuous, mind the corners
- SPF: mind the mounting brackets, moistening

Airtightness in practice: materials, training, coordination

Questions?
BUILDING AIRTIGHTNESS SOLUTIONS: SEALANTS AND PU-FOAMS

Filip Van Mieghem – Senior Product Manager

Soudal
**Sealants**

- Silicone (AC / Alcoxy / Oxime)
- Acrylics
- Hybrid polymers
- Polyurethane
- Polyisobutylene
- Bitumen
- Fire rated sealants
- Fast curing
- Primers & tools
PU Foams

- Handheld / gun / click & fix
- Construction foam
- Insulation foam
- Sound proofing foam
- All weather foam
- 2K-foam
- Isocyanate free foam
- PU mining foam
- Multi position foam
- Fire rated foam

Adhesives

- Contact neoprene & SBR
- 1K & 2K PU
- PVA wood
- Construction
- Floor / tile / glass fibre
- PVC
- Cyano
- Epoxy
- Chemical anchors
Hybrid polymers

- Industrial adhesives
- Parquet applications
- Sealing & bonding
- 2K
- High tack
- Crystal clear
- Ultra

Building chemicals in Europe

- Legislation on (level of) raw materials / chemicals (Reach, Biocides, ...)
- Construction Products Directive is basis for:
  - Harmonised norms (CE marking)
  - Energy Performance of Buildings (EPB)
  - Sustainability
- CPD becomes CPR as of 1/7/2013, and...
- EN ISO 11600 for sealants becomes basis for harmonised norm / CE marking: hEN15651-1 to -5
  - Function: glazing, facade (interior/exterior), sanitary, pedestrian walkways
  - Movement capacity: only applies to elastic sealants: movement capacity from 7.5% to 25%
Construction joints

- Important unimportance

- Function
  - Weather sealing / water tightness
  - Cosmetical
  - Thermal insulation (thermal bridges)
  - Fire proofing
  - Acoustics
  - Burglar resistance
  - Airtightness

- And mostly a combination thereof...

Sealants

BUILD THE FUTURE
PU-foams / adhesives

Condensation risk

- Cold surfaces inside: mould
- Often result from poorly executed building knots:
  - Air leaks
  - Thermal bridges
  - Or a combination of both
Airtightness

Airtightness of construction materials

- (Inter)national norms relating to airtightness of sealants and foams
  - NONEXISTENT
  - No specific norm on airtightness of sealants
  - Even no product norm on PU-Foams
- EN 12114: Air permeability of building components and building elements
  - General test method (in case there are no product specifications)
  - Only for laboratory testing (as opposed to ‘in situ’ testing)
  - Max. pressures can be chosen: 50, 100, 200, 500, 1.000Pa
  - 3 pulsations and then gradual steps both positive and negative pressure
Sealants and airtightness: cohesion/adhesion

- Cohesion: sealants are airtight from their nature:
  - can generally contribute a lot to airtightness
- Adhesion: you also need a bond to the substrate(s)/supports

- Sealants can easily take the form of all kinds of shapes when applied in a joint (or as adhesives if used in a thin layer)
- Check for CE marking (transition period: 1/7/2013 – 1/7/2014)
  - hEN15651-1: facade interior and exterior
  - hEN15651-2: glazing
- Check for quality labels
- Use the right product for the job and apply it the right way

Sealants and airtightness: movement capacity

- ISO EN 11600, now hEN15651: max % of total joint width a sealant can permanently take without shearing
  - Lowest category
    - 7,5% and 12,5%
    - Plastic or elastic (P or E)
    - Acrylics
  - All other sealants: silicones, PU’s, hybrids
    - 20% or 25%
    - All elastic
    - Softer sealants, or harder sealants (LM or HM)
    - Application: F or G (Facade or Glass)
Sealants and airtightness: adhesion

- Make sure supports are clean, free of dust and grease
- Check substrates:
  - Most sealants work better on some substrates
  - There are also sealants that work on almost all substrates: hybrid sealants for example, even on wet surfaces (see video at the end)
  - Typically problematic: PE, PP, PTFE
- Watch application temperature (acrylics can even freeze during storage)
- Check curing time of product
  - RH can also have major impact on curing (time)

Sealants & Adhesives

- Hybrid sealants: permanently elastic
  - Excellent adhesion on almost any substrate
  - Diverse, low modulus and high modulus
  - High movement capacity (20-25LM or HM – EN-ISO 11600)
  - No cracks under UV-radiation
  - Paintable
  - Adhesion on damp surfaces
- Silicone sealants: permanently elastic
  - Excellent adhesion on glass, metals
  - Ideal for airtight glass sealing
  - High movement capacity (20LM – 25LM)
  - Very resistant to UV
Sealants & Adhesives

- Excellent adhesion on mineral substrates (stone, cement)
- High movement capacity (20-25%)
- Mostly LM
- Cracks under UV

Acrylics: Mainly interior use/finishing
- Paintable, "elastic and airtight extension of plaster"
- Prevents cracks between window frame and plaster

New development: Meets with ISO 11600 12,5 E

Specialties
- Self adhesive acrylic to glue vapourbarriers

SWS: system approach

Window connection joints

Inside

Outside
Research at University of Ghent

- Testing according to EN12114

Airtightness

- Standard cavity wall construction
- Passive cavity wall construction
# Airtightness Results

<table>
<thead>
<tr>
<th>Façade element</th>
<th>Beschrijving opstelling</th>
<th>Flow at 50 Pa [m³/h/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>underpressure</td>
<td>abs. dev.</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>casing, empty</td>
<td>30.90</td>
<td>0.97</td>
</tr>
<tr>
<td>casing, mineral wool</td>
<td>2.61</td>
<td>0.13</td>
</tr>
<tr>
<td>casing, Flexifoam</td>
<td>0.95</td>
<td>0.09</td>
</tr>
<tr>
<td>casing, Flexifoam, Acryrub</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>plaster, profile, Acryrub</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>plaster, SWS-foil, inside</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>plaster, SWS-foil, side</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>Passive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pleister, flexifoam, droog,</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>

# Airtightness

**Timber frame**
PU-foams: airtight?

PU-foam can be airtight!

- If used in the correct joint dimensions
- If used between 2 airtight building elements
- If self-expanding
- If flexible

... Thus combining insulation and airtightness

Flexifoam®

- Elasticity: 9000 cycles at 12.5% movement (ift report 105 35276)
- Airtight: $A < 0.1 \text{ m}^3/\text{h.m.(daPa)}^{0.2}$ (ift report 105 33428 – EN12114)
- Thermal insulation: $\lambda = 0.0345 \text{ W/m.K}$ (MPA report 070598.1)
To moisten or not to moisten

Crucial for cell structure (insulation), adhesion and airtightness !!!

Without

With

Emission

- Indoor air quality is getting more of a concern with airtightness
- Sustainability: Leed, Breeam, …
- France: mandatory emissions class labelling
  - All construction products used indoors
  - Highest class is A+
  - Measured after 28 days
- Germany
  - GEV: adhesives for floor coverings
  - EC1(R), EC1 Plus are the highest classes
  - Harder to achieve
Websites

- General
  - www.soudal.com

- Airtight window installation
  - www.soudalwindowsystem.be

- Hybrids: sealing and bonding
  - www.fixall.eu
Content

- Tremco illbruck
- Technology Impregnated tapes
- DIN 18542:2009-07
- VOC Standards
Impregnated tapes: Applicable standards and properties

Content

• Tremco illbruck
• Technology Impregnated tapes
• DIN 18542:2009-07
• VOC Standards

Tremco illbruck – At a Glance

Business Area:
Sealing and Bonding for Construction and Industry

Strategic Segments:
Windows, Façades, Waterproofing, Fire Protection, Distribution, Industry

International Presence:
1,000 Employees
25 sites in Europe, Africa & Middle East

Turnover:
200 million €

Structure:
Part of RPM International Inc., USA
### Impregnated tapes: Applicable standards and properties

**Content**

- Tremco illbruck
- Technology Impregnated tapes
- DIN 18542:2009-07
- VOC Standards
The main principle of impregnated tapes

**Main components:**
- Water based Acrylic dispersion
- PU Foam

**Outside**
- Driving rain tight
- Wind tight

**Inside**
- Water vapour open

Impregnation process

- Impregnation bath
- Drying
- Cutting
- Compression rollers

PU foam before impregnation
PU foam after impregnation

Foam roll
Oven
Sealing tape
Once again how it works!

TP600 illmod 600
15 / 7–12 mm

Fully expanded Tape

Out of application Area 13-35 mm

Application Area 7 -12

As delivered 5 mm

Direction of Expansion

15mm

Once again how it works!

Illmod tape
15 / 7–12 mm

Out of application Area 13-35 mm

Application Area 7 -12

As delivered 5 mm

Dimensions illbruck illmod 600

<table>
<thead>
<tr>
<th>Bostoll-Nr.</th>
<th>Joint depth in mm</th>
<th>Application area in mm</th>
<th>m/box</th>
</tr>
</thead>
<tbody>
<tr>
<td>6305</td>
<td>8</td>
<td>10</td>
<td>13.75</td>
</tr>
<tr>
<td>6304</td>
<td>12</td>
<td>15</td>
<td>49.50</td>
</tr>
<tr>
<td>6303</td>
<td>15</td>
<td>20</td>
<td>49.50</td>
</tr>
<tr>
<td>6302</td>
<td>18</td>
<td>25</td>
<td>49.50</td>
</tr>
<tr>
<td>6301</td>
<td>21</td>
<td>30</td>
<td>49.50</td>
</tr>
<tr>
<td>6300</td>
<td>24</td>
<td>40</td>
<td>49.50</td>
</tr>
</tbody>
</table>
Handling all Potential Stresses

- **Movement due to wind**
  - Length changes due to temperature

**Joint width recommendation**

**Impregnated Sealing Tapes**

**Wet Sealants**

<table>
<thead>
<tr>
<th>Rahmenwerkstoff</th>
<th>$b_{32}$</th>
<th>$b_{36}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC hart (weiß)</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>bis 1,5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>bis 2,5</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>bis 3,5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bis 4,5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rahmenwerkstoff</th>
<th>$b_{32}$</th>
<th>$b_{36}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC hart und PMMA (dunkel, farbig extrudiert)</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>bis 1,5</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>bis 2,5</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>bis 3,5</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>bis 4,5</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>

**Quelle:** Leitfaden zur Planung und Ausführung von Fenstern und Haustüren, RAL Gütegemeinschaft Fenster und Haustüren
Impregnated tapes: Applicable standards and properties

Content

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- Technology Impregnated tapes
- DIN 18542:2009-07
- VOC Standards

German Standard DIN 18542: 2009-07

DIN 18542 Sealing of outside wall joints with impregnated sealing tapes made of cellular plastics - Impregnated sealing tapes - Requirements and testing

Legende:
- a  Exterior
- b  Interior
### Joint leakage coefficient, \( a \), at 10 a, in m³/(h·m·(daPa)²/3)

\[
0.1 \leq a \leq 1.0
\]

### Value, in m

\[
0.5 \leq \text{Value} \leq 0.1
\]

### BG R

Between -20°C and +60°C

### Impregnated Tapes – Stress Group Classification DIN 18542:2009-07

<table>
<thead>
<tr>
<th>No.</th>
<th>Property</th>
<th>BG 1</th>
<th>BG 2</th>
<th>BG R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Joint leakage coefficient, ( a ), at 10 a, in m³/(h·m·(daPa)²/3)</td>
<td>( \leq 1.0 )</td>
<td>( \leq 1.0 )</td>
<td>( \leq 0.1 )</td>
</tr>
<tr>
<td>2</td>
<td>Tightness to driving rain at ( A_p ), in Pa</td>
<td>Not less than 600 Pa</td>
<td>Not less than 300 Pa</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>Imperviousness of joint interactions to driving rain at ( A_p ), in Pa</td>
<td>Not less than 600 Pa</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>Resistance to temperature fluctuations</td>
<td>Between -20°C and +60°C</td>
<td>Between -20°C and +60°C</td>
<td>Between -20°C and +60°C</td>
</tr>
<tr>
<td>5</td>
<td>Resistance to the effects of light and moisture</td>
<td>To be ensured.</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>Compatibility with adjacent materials</td>
<td>Up to 80 °C</td>
<td>Up to 60 °C</td>
<td>Up to 60°C</td>
</tr>
<tr>
<td>7</td>
<td>Fire behaviour (building material class as in DIN 4102-1)</td>
<td>B1</td>
<td>B2</td>
<td>B2</td>
</tr>
<tr>
<td>8</td>
<td>( k_a )-Value, in m</td>
<td>( \leq 0.5 )</td>
<td>( \leq 0.5 )</td>
<td>Value to be measured</td>
</tr>
</tbody>
</table>
illbruck TP600 illmod 600

Material: Open-cell flexible polyurethane foam, impregnated with an acrylic polymer (flame-retardant)

UV-resistant

Colours: Anthracite / grey

Availability: On pre-compressed rolls, self adhesive on one side

Storage: 2 years shelf life

Application area: For the outside driving rain resistant sealing in facade and windows connections

Product advantages

- Independently monitored driving rain resistance over 600 Pa
- Open to water vapour diffusion
- Up to 40 mm joint width
- No preparation with primer
- Easy installation, possible in any weather
- Permanently elastic during movements
- Test from outdoor tapes since 1995
- 10-year performance warranty*
- BG 1 tested
illbruck TP680 illmod 600 green

Material: An open cell polyurethane soft foam impregnated with an acrylic based resin. The tape contains a proven percentage of bio-based material.

- Contains bio-based material (certified by DIN CERTCO)
- BG1 following DIN 18542
- Low emission certified by EMICODE® EC1Plus

illbruck TP680 illmod 600 green is an impregnated tape for use in a wide variety of movement joints for window installation and façade sealing.

### Impregnated Tapes – Stress Group Classification DIN 18542:2009-07

<table>
<thead>
<tr>
<th>No.</th>
<th>Property</th>
<th>BG 1</th>
<th>BG 2</th>
<th>BG R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Joint leakage coefficient, $a$, at 30 s, in $m^{3}/(m\cdot h\cdot Pa)^{2/3}$</td>
<td>$\leq 1.0$</td>
<td>$\leq 1.0$</td>
<td>$\leq 0.1$</td>
</tr>
<tr>
<td>2</td>
<td>Tightness to driving rain at A, in Pa</td>
<td>Not less than 600 Pa</td>
<td>Not less than 300 Pa</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>Imperviousness of joint intersections to driving rain at A, in Pa</td>
<td>Not less than 600 Pa</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>Resistance to temperature fluctuations</td>
<td>Between -20 °C and +80 °C</td>
<td>Between -20 °C and +60 °C</td>
<td>Between 20 and +60°C</td>
</tr>
<tr>
<td>5</td>
<td>Resistance to the effects of light and moisture</td>
<td>To be ensured.</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>Compatibility with adjacent materials</td>
<td>Up to 80 °C</td>
<td>Up to 60 °C</td>
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</tr>
<tr>
<td>7</td>
<td>Fire behaviour (building material class as in DIN 4102-1)</td>
<td>B1</td>
<td>B3</td>
<td>B2</td>
</tr>
<tr>
<td>8</td>
<td>$s^*$ Value, in m</td>
<td>$\leq 0.1$</td>
<td>$\leq 0.1$</td>
<td>Value to be measured</td>
</tr>
</tbody>
</table>
illbruck TP300 illac

Material: Open-cell flexible polyurethane foam, impregnated with an acrylic polymer

**Not UV-resistant / 300 Pa**

Colours: Anthracite / grey

Availability: On pre-compressed rolls, self-adhesive on one side

Application area: For sealing against sound, driving Rain, dust, draught and heat loss

In covered joint constructions around windows and window couplings

---

**Impregnated Tapes – Stress Group Classification DIN 18542:2009-07**

| No. | Property                                | BG 1   | BG 2   | BG R
|-----|-----------------------------------------|--------|--------|------
| 1   | Joint leakage coefficient, \( a \), at 30 s, in \( m^3/(m \cdot h \cdot Pa)^{2/3} \) | \( \leq 1.0 \) | \( \leq 1.0 \) | \( \leq 0.1 \)
| 2   | Tightness to driving rain at Ap, in Pa | Not less than 600 Pa | Not less than 300 Pa | –
| 3   | Imperviousness of joint intersections to driving rain at Ap, in Pa | Not less than 600 Pa | – | –
| 4   | Resistance to temperature fluctuations | Between -20 °C and +80 °C | Between -20 °C and +60 °C | Between -20 and +60°C
| 5   | Resistance to the effects of light and moisture | To be ensured. | – | –
| 6   | Compatibility with adjacent materials | Up to 80 °C | Up to 60 °C | Up to 60°C
| 7   | Fire behaviour (building material class as in DIN 4102-1) | B1 | B3 | B2
| 8   | \( k_2 \) Value, in m | \( \leq 0.5 \) | \( \leq 0.5 \) | Value to be measured
Illmod Trio – The one that provides all 3 principles in one

Outside:
• Driving rain tight
• No damage by weathering
• No cold wind pass through
• Water vapour open

Insulation:
• Sound protection
• Thermal insulation
• No condensation

Inside:
• No warm/humid air pass through
• „inside more water vapour tight than outside

Basic for the Connection Joint – Inside-Insulation-Outside
illbruck TP652 illmod triplex+

Characteristics
- Fast and easy application 1 min/m
- Application area from passive house, new buildings, renovation to insulation only

Description
Multi-functional Tape with side impregnation and additional compression tape for high requirements

Application
- 3 Layer in one tape
- DIN 18542
- BG1/BGR
- Degree of Compression [%]
  - 14% - 26%

Application time
- 1 min/m

Corner Solution
- Butt-joint

Illmod Trio – The one that provides all 3 principles in one
Application with Illbruck Projecting window system

Advantages for Tapes!

**Driving rain:**
Tight up to 600 Pa

**UV-Resistant and Durable:**
Weather test for aging running now since 1995, tested by an independent testing authority

**U-Value:**
Defined U-Value for the joint, depending on the depth of the tape e.g. Trio 56mm = 0.71 W/m²K; Trio 88 = 0.49 W/m²K

**Experience:**
More than 30 years of experience in production and application

**Breathable:**
Airtight but vapour open

**Application:**
Independent from weather conditions
No treatment of the substrates necessary (no primer, etc.)
Fast and easy
Impregnated tapes: Applicable standards and properties

Content
- Tremco illbruck
- Technology Impregnated tapes
- DIN 18542
- VOC Standards

VOC France

Obligation to label emissions in France

- The voluntary labeling of the conduct of emissions is compulsory since January 2012 for new building products
- Emission rating A+, A, B and C
- Transition period for existing products until September 2013
- Subject to certification are TVOCs, formaldehyde and further 9 single VOCs
VOC France

**French VOC regulation / Arrêté du 19 avril 2011 (decree as of 19th April 2011)**

**Limit values**

Additionally to the total of emissions of volatile organic compounds (TVOC) the list of the limit values focuses on the 10 following substances (in μg/m³):

<table>
<thead>
<tr>
<th>Substances/Emissions’ class</th>
<th>A+</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde</td>
<td>&lt;10</td>
<td>&lt;60</td>
<td>&lt;120</td>
<td>&lt;120</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>&lt;200</td>
<td>&lt;300</td>
<td>&lt;400</td>
<td>&lt;400</td>
</tr>
<tr>
<td>Toluene</td>
<td>&lt;300</td>
<td>&lt;450</td>
<td>&lt;600</td>
<td>&lt;600</td>
</tr>
<tr>
<td>Tetrachlorethene</td>
<td>&lt;250</td>
<td>&lt;350</td>
<td>&lt;500</td>
<td>&lt;500</td>
</tr>
<tr>
<td>Xylene</td>
<td>&lt;200</td>
<td>&lt;300</td>
<td>&lt;400</td>
<td>&lt;400</td>
</tr>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>&lt;1000</td>
<td>&lt;1500</td>
<td>&lt;2000</td>
<td>&lt;2000</td>
</tr>
<tr>
<td>1,4-Dichlorethene</td>
<td>&lt;60</td>
<td>&lt;90</td>
<td>&lt;120</td>
<td>&gt;120</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>&lt;750</td>
<td>&lt;1500</td>
<td>&lt;1500</td>
<td>&lt;1500</td>
</tr>
<tr>
<td>2-Butoxyethanol</td>
<td>&lt;1000</td>
<td>&lt;1500</td>
<td>&lt;2000</td>
<td>&lt;2000</td>
</tr>
<tr>
<td>Styrene</td>
<td>&lt;250</td>
<td>&lt;350</td>
<td>&lt;500</td>
<td>&lt;500</td>
</tr>
<tr>
<td>TVOC</td>
<td>&lt;1000</td>
<td>&lt;1500</td>
<td>&lt;2000</td>
<td>&lt;2000</td>
</tr>
</tbody>
</table>

**The following products are subject to marking:**

- **Floor coverings, walls and ceilings:** carpets, parquets, laminate, linoleum, wallpapers, tapestries, wall claddings, paints, varnishes, oils, mordants, gypsum, crown moulding, etc.
- **Partition walls and intermediate ceilings:** wall panel, PVC, wood, gypsum, flexible partition walls, drop ceilings, skirting and wooden boards, etc.
- **Insulation materials:** every kind of insulation, interior insulation, thermic and acoustic insulation materials, etc.
- **Windows and doors:** interior doors, windows, doors, etc.
- **Products for installation or preparation:** adhesives, sealings, sealing compounds, etc.

**Not subject to marking are:**

- **Furniture**
- **Furnishings such as rods, curtains, lamps, roller blinds**
- **Sanitary fittings and armatures**
- **Electrical appliances, cables, switches**
- **Detergents for floor coverings**
- **Metal goods (e.g. fitting) and glass**
- **Products for outdoor use**
VOC France

French VOC regulation / Arrêté du 19 avril 2011 (decree as of 19th April 2011)

Products with certificate:

- TP600
- TP650
- ME500
- SP050
- SP150
- FA101
- LD705
- FM330
- FM610
- ...

VOC in Germany

GEV – the Association for the Control of Emissions in Products for Flooring Installation, Adhesives and Building Materials – was founded in 1997. Through the EMICODE® it offers consumers, planners, architects and professional craftsmen guidance for the selection of flooring installation products, adhesives and building materials. It provides independent and impartial assessments designed to assure the highest level of consumer and environmental protection.
VOC in Germany

GEV classification criteria
The emissions must lie below stringent limits. Emitted VOCs are individually identified and their concentrations are summated. The resulting emission concentrations give the TVOC value (total volatile organic compounds) and TSVOC (total semi-volatile organic compounds) and are definitive for the EMICODE classification.

<table>
<thead>
<tr>
<th>EMICODE</th>
<th>TVOC after 3 days</th>
<th>TVOC / TSVOC after 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC 1<strong>PLUS</strong> - very low emission</td>
<td>≤ 750</td>
<td>≤ 60 / 40</td>
</tr>
<tr>
<td>EC 1 - very low emission</td>
<td>≤ 1000</td>
<td>≤ 100 / 50</td>
</tr>
<tr>
<td>EC 2 - low emission</td>
<td>≤ 3000</td>
<td>≤ 300 / 100</td>
</tr>
</tbody>
</table>

Tests performed to other specifications, e.g. during approval procedures for construction products by the German DIBt approval body, may also be submitted as supporting evidence, provided they demonstrate compliance with the GEV requirements.
VOC Germany

Products tested so far EC1+:

illbruck FM812 Pistolenschaum Öko
illbruck JF100 Fugenfüller
illbruck ME500 TwinAktiv
illbruck ME501 TwinAktiv HI
illbruck ME503 TwinAktiv VZ
illbruck ME904 Butyl- & Bitumenprimer Öko
illbruck SP150 Universalklebstoff Plus
illbruck TP600 illmod 600
illbruck TP610 illmod eco
illbruck TP650 illmod trioplex

illbruck TP652 illmod trioplex+
illbruck TP680 illmod 600 green
Tremco FA870 Natursteinsilikon
illbruck FM820 Fensterschaum+
illbruck PU700 Steinkleber
illbruck SP025 Fenster-Folienkleber Öko
illbruck SP525 Hochbau- und Anschlussfugen Dichtstoff
Perennator FA101 Fenster- und Anschlussfugen-Silikon

Summary

Impregnated Tapes

Sealants

Foams

Membranes

Hybrids