Durable Construction Joint Sealing
Optimal Thermal-Hygric Performance of Materials Considering Different Climate Zones

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→ www.hanno.com
Durable Construction Joint Sealing

Questions

1. What are typical construction / window connecting joint movements and is it possible to define a useful movement absorption capacity for joint sealing products?

2. Can an optimal diffusion behavior be defined for joints, i.e. which product is to be used on the exterior respectively interior?

3. Is there a difference for various climate zones – in this context for Seattle, WA and Miami, FL

4. What is the influence of a minor water penetration acc. to ASHREA 160 [2] on questions 2 & 3?

5. Can general parameters / recommendations be set / made based for these questions?
Durable Construction Joint Sealing

Insulation was always possible

During Bronze Age around 3,400 years ago, the r-value of a wall was approximately 20 h·ft²·°F/Btu (U-Value of 0,3 W/(m²K)).

Were air tightness and raintightness unknown?

NO, since walls were plastered with clay every year!

Annual = durable? „only“ airtight?
Durable Construction Joint Sealing

„First Passive House“

THE FRAM - late 19th century...

...technically a passive house: The rooms were kept warm well through numerous layers of different insulating materials and airtight construction.
Durable Construction Joint Sealing
Reduction of Energy Losses

US-Building example with clay and glass used as example for the „Landstuhl-Project“ in 1979 - first results only published in 1989.

Approach: Sufficient insulation, but also use the solar power with vapor open materials!
Durable Construction Joint Sealing
Reduction of Energy Losses

"DTH-Nullenergiehaus" by Prof. Vagn Korsgaard (Kopenhagen, 1973)

Amory Lovins 1982:
In 2164m (7,100 feet) altitude he built in Old Snowmass, Colorado, an extremely well thermally insulated and also passive solar house.
Durable Construction Joint Sealing

Air tightness – tight, but how?

Air tightness must be planned and verified via blower door testing!
Durable Construction Joint Sealing

Triple Layer Sealing System – Durable Rain Tightness
Durable Construction Joint Sealing
Triple Layer Sealing System – Durable Rain Tightness

„Caulk and walk“
Durable Construction Joint Sealing
Triple Layer Sealing System – Durable Rain Tightness

Initial joint measurement was 15mm (11/32") – joints were charged with 100, 200 and 500 cycles of 3mm (15/64") movements (common movements for standard windows)

PU based Volume Adhesive
Multi-functional Tape
Durable Construction Joint Sealing
Triple Layer Sealing System – Durable Rain Tightness

PU based Volume Adhesive
Initial joint measurement was 15mm (11/32”) – joints were charged with 100, 200 and 500 cycles of 3mm (15/64”) movements (common movements for standard windows)

Multi-functional Tape

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Long-lasting Air Tightness – Evaluation of Joint Movements

Air Permeability Values

Number of Cycles

- PU-based Volume Adhesive
- Multi-functional Tape
- Joint sealing Tape
- Flashing Tape
Durable Construction Joint Sealing
Thermic-Hygric Simulation – What happens in the Joint?

Material Humidity inside Joint

Material Humidity (V-% )

Simulation Time (h)

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Air Tightness – always tighter, but how?

Certification of airtightness systems

Preliminary requirements

Airtightness Window connection

Products for air tight and thermal bridge reduced installation of windows in wall openings. The evaluation of the airtightness of window-to-wall connections takes place for both massive and framed walls. Wooden and plastic window frames are examined. The requirements for the PH-certification category window connection are listed in the table below.

<table>
<thead>
<tr>
<th>class</th>
<th>Permeability per unit length @ 50 Pa [m³/(hm)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>≤ 0.05</td>
</tr>
<tr>
<td>A</td>
<td>≤ 0.30</td>
</tr>
<tr>
<td>B</td>
<td>≤ 0.50</td>
</tr>
<tr>
<td>C</td>
<td>≤ 0.80</td>
</tr>
</tbody>
</table>

At 50 Pa

HB 3E with 0.03

Tested at ift Rosenheim → result: A+

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Durable Construction Joint Sealing

Triple Layer Sealing System

1. **Weather protection layer**:
   - Wind & rain tight, open for vapour diffusion

2. **Function layer**:
   - Thermal insulation & soundproofing

3. **Inner layer**:
   - Airtight & more vapour tight than on the outside

HANNO’s product portfolio to achieve this:

- Joint sealing tapes
- Foil tapes
- Complementary products such as Sealing compounds, glues & PU-foam
Durable Construction Joint Sealing
Joint sealed only with Caulk

Water penetration from exterior
Triple Layer System
Joint Sealed only with Caulk – Issues with Water Penetration
Triple Layer System
Joint Sealed with Caulk and Backer Rod

No water penetration from the exterior, but:
→ proper preparation and cleaning of joint necessary
→ plenty of high quality caulk has to be applied
→ backer rod has to be placed behind caulk
→ primer has to be applied to surrounding wall

Possibility that vapor penetrates joint insulation from the interior and accumulates behind the caulk because it is vapour-tight
→ insulation becomes wet
  → reduced insulation functionality and mold may develop
Triple Layer System
Joint Sealed with Hannoband

No water penetration from the exterior

Only little vapor accumulation behind Hannoband because the tape is vapor open so that most of the vapour can pass through the joint!
Passive House Component Development
Air Tightness – always tighter, but how?
**Triple Layer System**

Joint Sealed with Hannoband + Flashing Tape DUO Easy

or Alternatively Sealed just with Hannoband 3E

- No water penetration from the exterior
- No vapor behind the Hannoband
- Potential water accumulation in joint will evaporate to the exterior

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HANNO Passive House Study Part 4: Diffusion Behaviour

So far based on 1,000 Wufi Calculations!
Sealing Development for Passive Houses
Consider the Influence and Flow of Moisture!

- Weathering
- Latent Heat: Evaporation, melting warmth, condensation
- Long-Wave Radiation
- Solar Gain: Directly or diffuse
- Construction Phase
- Construction Moisture
- During Use
- Vapor Diffusion
- Convection
- Room Heating
- Radiation absorption

- Material Moisture
- Summer
- Winter
Sealing Development for Passive Houses
Considering Specific Climate Zones!

Climate zones classified by Passive House Institute Darmstadt
e.g. Seattle
Vancouver – comparable to Tromsoe, Norway
Sealing Development for Passive Houses
Consider the Influence and Flow of Moisture!

The impact of moisture has long been ignored. In roofs and window joints damages occurred, which were investigated! Prof. Feldmeier has acknowledged the influence of moisture in this context.

**Sealing Development for Passive Houses**

**Consider the Influence and Flow of Moisture!**

The impact of moisture has long been ignored. In roofs and window joints damages occurred, which were investigated! Prof. Feldmeier has acknowledged the influence of moisture in this context.

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**Step 2: Including joint flanks**

**Step 1: only joints**

During summer

During winter
Sealing Development for Passive Houses
Influence of Diffusion Behaviour

Step 1: Initial focus purely on joints to determine the diffusion behaviour for different combinations of loads – primarily:
- Rain acc. to ASHREA 160 incl. influence of solar gain depending on the location
- Air leakages
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Influence of Diffusion Behaviour

Consideration of 25 combinations with different sd-values (µ-values) for the interior and exterior – including five sealing examples:

1. sd-value of 0.01 m  e.g. HANNOBAND BG1
2. sd-value of 0.1 m  e.g. HANNOBAND 3E / flashing tape DUO Easy (variable)
3. sd-value of 1.0 m  e.g. slightly diffusion inhibiting competitor flashing tapes
4. sd-value of 10 m  e.g. flashing tape DUO Easy (variable) / sealant
5. sd-value of 1,500m  e.g. fleece tapes coated with metal / aluminum

US-definition perm: one grain of water vapor per hour, per square foot, per inch of mercury;
Definition Fraunhofer Institute: 1 mm thick layer = 1 US-Perm ~ sd-Wert 3,3
1.0 US perm = 1.0 grain/square-foot·hour inch of mercury = 57 SI perm = 57 ng/s·m²·Pa
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Construction damages due to high moisture levels

- Frost
- Decay

ANSI/ASHRAE Standard 160

1% water leakage

Driving rain

Penetration of rain water behind integrated insulation system
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Climate for Seattle

Temperature (°C)

Relative moisture (%)

Average rain
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Climate for Miami

Temperature (°C)

Relative humidity (%)

Average rain (mm)

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Sealing Development for Passive Houses

Climate for Seattle

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mittlere Temperatur [°C]</td>
<td>10,39</td>
</tr>
<tr>
<td>Max. Temperatur [°C]</td>
<td>31,1</td>
</tr>
<tr>
<td>Min. Temperatur [°C]</td>
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<td>Gegenstrahlungsumme [kWh/m²a]</td>
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<tr>
<td>Mittlerer Bewölkungsgrad [%]</td>
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<tr>
<td>Mittlere Relative Luftfeuchte [%]</td>
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</tr>
<tr>
<td>Max. Relative Luftfeuchte [%]</td>
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<tr>
<td>Min. Relative Luftfeuchte [%]</td>
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<tr>
<td>Mittlere Windgeschwindigkeit [m/s]</td>
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<tr>
<td>Normalregensumme [mm/a]</td>
<td>1141,1</td>
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</tbody>
</table>
Sealing Development for Passive Houses
Climate for Miami

Average temperature (°C): 23.43
Min. temperature (°C): 1.7
Max. temperature (°C): 33.9

Average relative humidity (%): 72.38
Min. relative humidity (%): 20.0
Max. relative humidity (%): 100.0

Accumulated back radiation (kWh/m²a): 3,278.69
Average cloud index (-): 0.53

Average wind speed (m/s): 3.94
Average rain accumulation (mm/a): 2,125.5

Accumulated solar radiation (kWh/m²a)
Accumulated driving rain (mm/a)
Sealing Development for Passive Houses

Goal of this Study / Questions

1. Is the rule “tighter on the interior than on the exterior” justified and does it apply to all climate zones?

2. Can the rule “tighter on the interior than on the exterior” even be applied, if there is already a very high diffusion resistance on the exterior respectively how could an optimal “diffusion more open on the exterior” design look like sign

3. Up to what diffusion resistance can a “tighter on the interior” effect be detected and is an sd-value of 1,500m useful / necessary for standard connecting joint applications?

4. Is there an optimal sd-value respectively µ-value for the interior / exterior based on questions 2 & 3?

5. Does a moisture variable diffusion behaviour have advantages and if it does, for which climate respectively constructions situations?
## Scenario 1:

**Joint construction:**
- **Sealing on the interior:** 1 mm layer with different µ-values (sd-values)
- **Thermal insulation layer:** 80 mm layer made of mineral wool
- **Sealing on the exterior:** 1 mm layer with different µ-values (sd-values)

**Exterior influence factors:**
- Actual temperature conditions during the course of the year;
- Actual relative humidity of the exterior air during the course of the year;
- Interior climate EN 15026 based on normal occupancy

**Initial material humidity:** 80% moisture
### Sealing Development for Passive Houses

#### Scenario 1: Seattle, Washington

<table>
<thead>
<tr>
<th>Scenario 1 final total moisture: Initial moisture 0.14 kg/m³</th>
<th>Diffusion resistance on the exterior:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>μ=10</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>μ=100</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>μ=1000</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>μ=10000</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>μ=15000000</td>
<td>0.05</td>
<td>0.05</td>
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</table>

<table>
<thead>
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<th>Diffusion resistance on the interior:</th>
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<td>0.06</td>
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<td>μ=15000000</td>
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<table>
<thead>
<tr>
<th>Scenario max. moisture: Initial moisture 1.79 kg/m³</th>
<th>Diffusion resistance on the exterior:</th>
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</thead>
<tbody>
<tr>
<td>μ=10</td>
<td>5.99</td>
<td>21.03</td>
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<tr>
<td>μ=100</td>
<td>4.72</td>
<td>10.24</td>
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<td>μ=1000</td>
<td>3.65</td>
<td>3.59</td>
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<td>3.57</td>
<td>3.44</td>
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<td>μ=15000000</td>
<td>3.56</td>
<td>3.45</td>
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Sealing Development for Passive Houses
Scenario 1: Miami, Florida

<table>
<thead>
<tr>
<th></th>
<th>Diffusion resistance on the exterior:</th>
<th></th>
<th>Diffusion resistance on the interior:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>µ=10</td>
<td>µ=100</td>
<td>µ=1000</td>
</tr>
<tr>
<td>Initial moisture</td>
<td>0.14 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td>µ=100</td>
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<tr>
<td>µ=10</td>
<td>0.10</td>
<td>0.07</td>
<td>0.05</td>
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<td>0.09</td>
<td>0.05</td>
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<td>µ=1000</td>
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<td>0.30</td>
<td>0.17</td>
<td>0.12</td>
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<tr>
<td>µ=1500000</td>
<td>0.30</td>
<td>0.17</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Sealing Development for Passive Houses

Scenario 1: Miami, Florida

Vapor Barrier Placement By Geographical Location

In most cold climates, vapor barriers should be placed on the interior (warm-in-winter) side of walls. However, the map shows that in some southern climates, the vapor barrier should be omitted, while in hot and humid climates, such as along the Gulf coast and in Florida, the vapor barrier should be placed on the exterior of the wall.

Perm Ratings of Different Materials
(Rating of 1 or less qualifies as a vapor barrier)

- Asphalt-coated paper backing on insulation: 0.40
- Polyethylene plastic (6 mil): 0.06
- Plywood with exterior glue: 0.70
- Plastic-coated insulated foam sheathing: 0.4 to 1.2
- Aluminum foil (.35 mil): 0.05
- Vapor barrier paint or primer: 0.45
- Drywall (unpainted): 0.0
- Drywall (painted - latex paint): 2.3
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Conclusions Scenario 1:

Seattle:
1. A higher diffusion resistance on the interior has in general a positive influence on all parameters

2. The material moisture level behind the exterior seal increases for all installations except for the one with a very low sd-value of 10. Therefore this is the recommended material property on the exterior.

Miami:
1. The recommendation in this case is clearly „tighter on the exterior than on the interior“!

2. In addition materials with a very high diffusion resistance (> µ=1,000) increase the negative effect of the traditional German rule „tighter on the interior than on the exterior“.

→ www.hanno.com
**Scenario 2:**

**Joint construction:**
- **Sealing on the interior:** 1 mm layer with different µ-values (sd-values)
- **Thermal insulation layer:** 80 mm layer made of mineral wool
- **Sealing on the exterior:** 1 mm layer with different µ-values (sd-values)

**Exterior influence factors:**
- Same as for scenario 2, but in addition...
  - + short waved solar absorptivity 0.4 [-]
  - + long waved solar absorptivity 0.9
  - + joint orientation „North-East“ und „South-West“
  - + Driving rain 1% acc. to ASHREA 160 (resp. WTA data sheet 6-2)

**Initial material humidity:** 80% moisture
# Sealing Development for Passive Houses

## Scenario 3: Seattle, Washington

<table>
<thead>
<tr>
<th>Scenario 3 max. moisture: Initial moisture 1.79 kg/m³</th>
<th>Diffusion resistance on the exterior:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>µ=10</td>
</tr>
<tr>
<td></td>
<td>V1</td>
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<tr>
<td></td>
<td>µ=10</td>
</tr>
<tr>
<td>V1</td>
<td>5,99</td>
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<td>NO</td>
<td>11,37</td>
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<tr>
<td>SW</td>
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Sealing Development for Passive Houses
Scenario 3: Miami, Florida

<table>
<thead>
<tr>
<th>Scenario max. moisture: Initial moisture 1.79 kg/m³</th>
<th>Diffusion resistance on the exterior:</th>
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<tbody>
<tr>
<td></td>
<td>µ=10                   µ=100          µ=1000          µ=10000          µ=1500000</td>
</tr>
<tr>
<td></td>
<td>V1</td>
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<tr>
<td>Diffusion resistance on the interior incl. joint direction (NE / SW):</td>
<td>µ=10</td>
</tr>
<tr>
<td></td>
<td>µ=10</td>
</tr>
<tr>
<td>µ=10</td>
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<td>µ=100</td>
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<td></td>
<td>SW</td>
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</tbody>
</table>
Sealing Development for Passive Houses

Conclusions Scenario 3:

**Seattle:**
1. Drying appears realistic on the exterior (sd < 1.0)

2. The rule „tighter in the interior“ applies only to a certain level. If the interior and exterior become too tight, an accumulation of moisture will happen in the joint!

**Miami:**
1. At least on one side a drying of the joints is possible (sd < 1.0) even though the maximum moisture increases in the joint, but can dry out again and does not accumulate.

2. As soon as the joint is relatively tight, the maximum moisture level increases quickly and a construction damage is likely!

**Acc. to ASHREA the joint must be able to completely dry out!**