Durable Construction Joint Sealing

Optimal Thermal-Hygric Performance of Materials Considering Different Climate Zones

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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 $h \cdot ft^2 \cdot {}^\circ F/Btu$ (U-Value of 0,3 $W/(m^2K)$).

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 glas used as example for the „Landstuhl-Project“ in 1979 - first results only published in 1989.

Approach: Sufficient insulation, but also use the <u>solar power</u> with <u>vapor open materials</u>!

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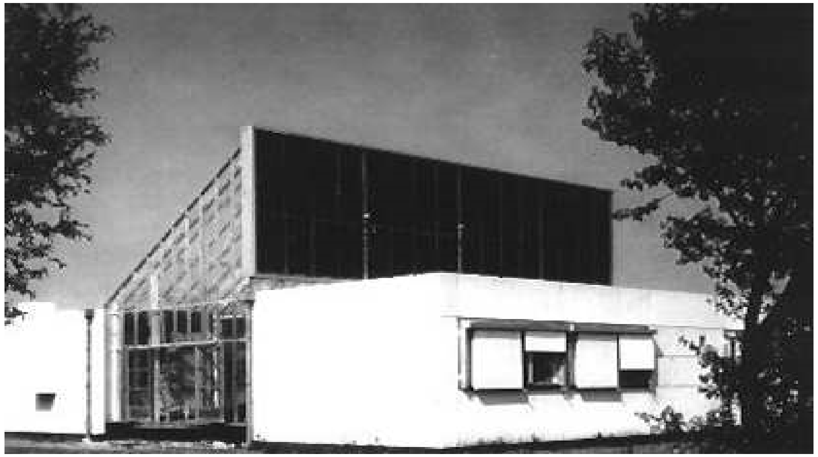
Durable Construction Joint Sealing

Reduction of Energy Losses



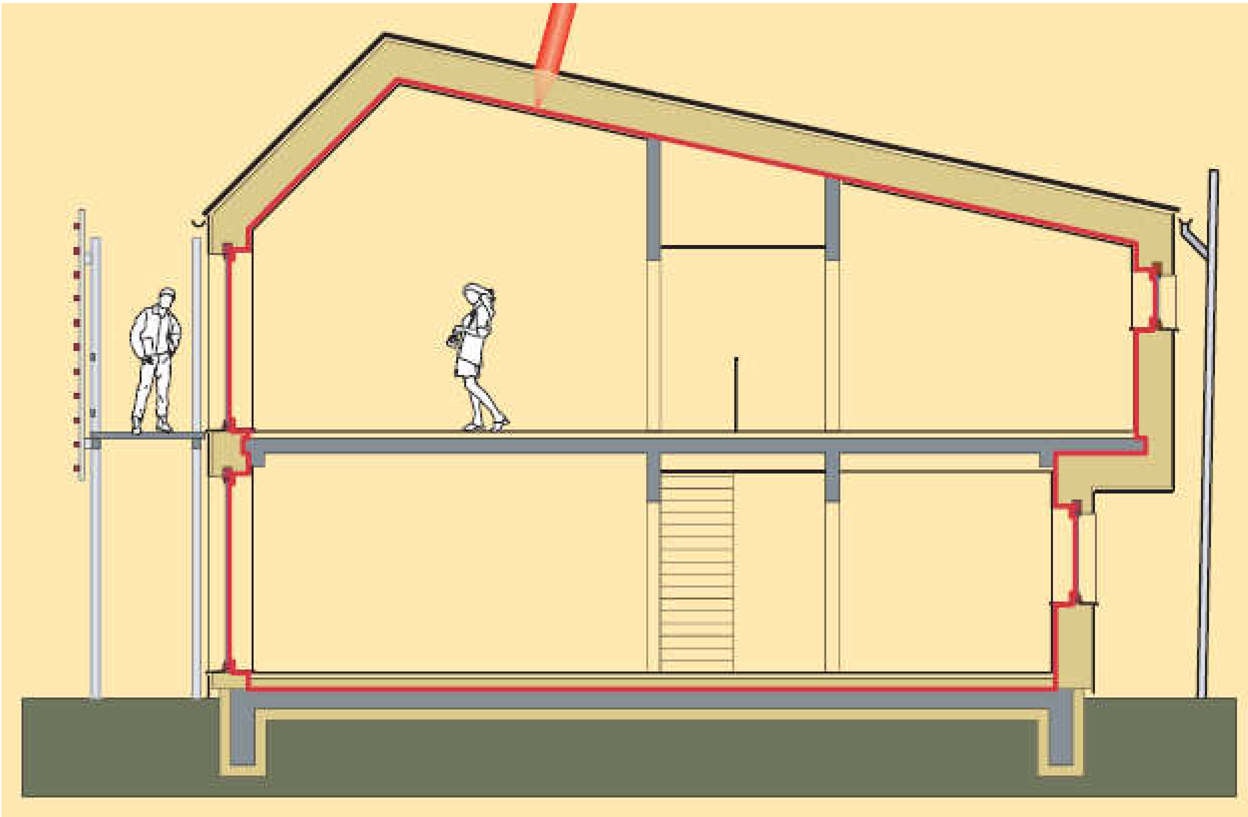
"DTH-Nullenergiehaus" by
Prof. Vagn Korsgaard
(Kopenhagen, 1973)

Amory Lovins 1982:
In 2164m (7,100feet) 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!

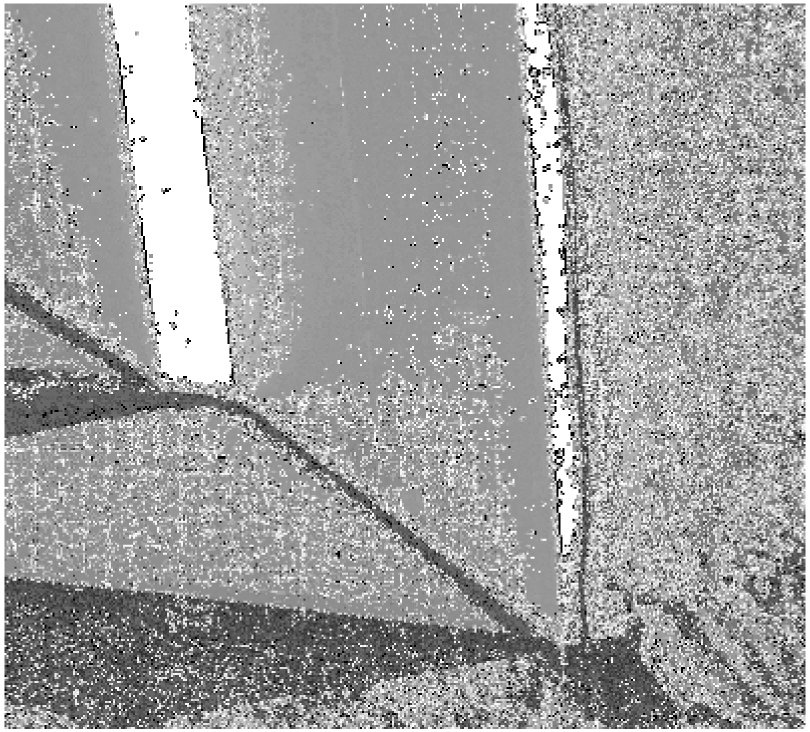


Durable Construction Joint Sealing

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

PU based Volume Adhesive

Multi-functional Tape

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)

Durable Construction Joint Sealing

Triple Layer Sealing System – Durable Rain Tightness

Erläuterung Bewegungen

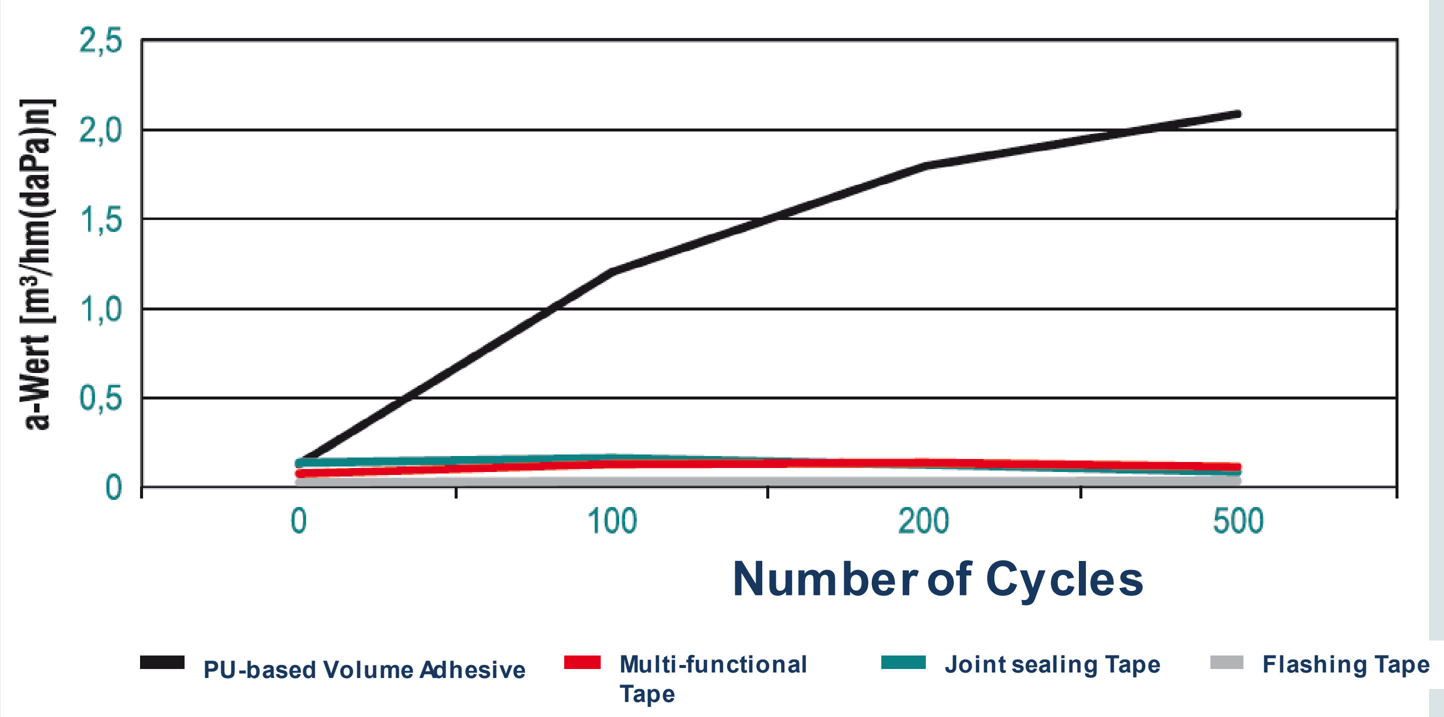
PU based Volume Adhesive **Multi-functional Tape**

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)

Durable Construction Joint Sealing

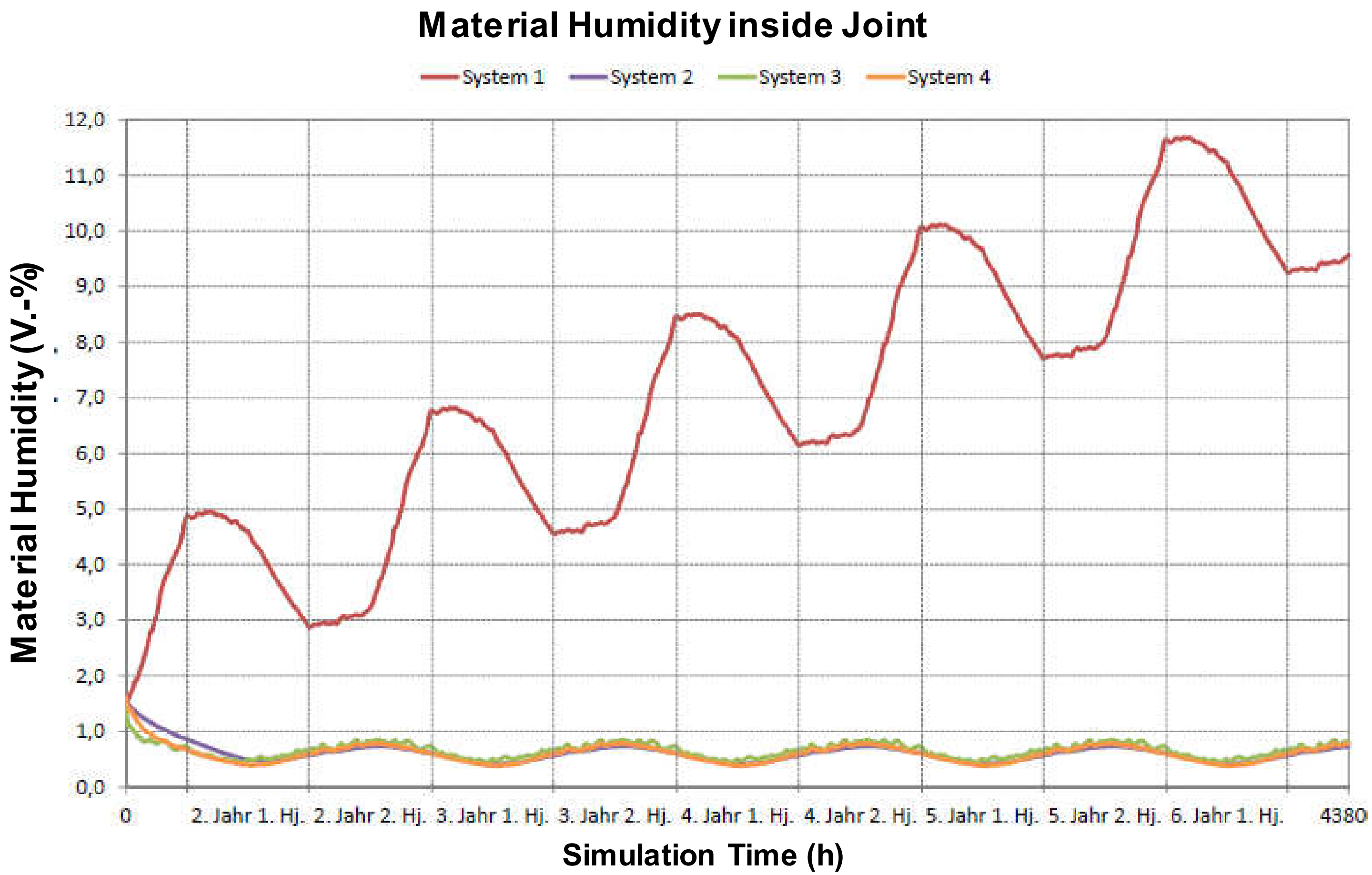
Long-lasting Air Tightness – Evaluation of Joint Movements

Air Permeability Values



Durable Construction Joint Sealing

Thermic-Hygric Simulation – What happens in the Joint?



Durable Construction Joint Sealing

Air Tightness – always tighter, but how?

NEW

CERTIFIED COMPONENT Passive House Institute

Passivhaus Institut

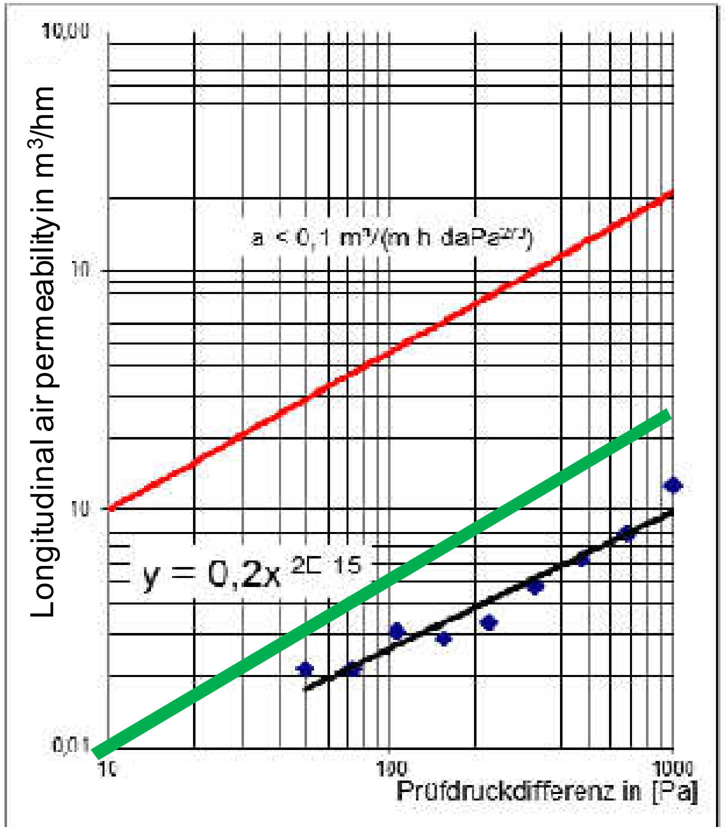
Certification of airtightness systems

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.

class	Permeability per unit length @ 50 Pa [m³/(hm)]
A+	≤ 0,05
A	≤ 0,30
B	≤ 0,50
C	≤ 0,80



At 50 Pa **HB 3E with 0,03**

Tested at ift Rosenheim → result: A+

Durable Construction Joint Sealing

Triple Layer Sealing System

1. **Weather protection layer :**

   Wind & rain tight, open for vapour diffusion

2. **Function layer :**

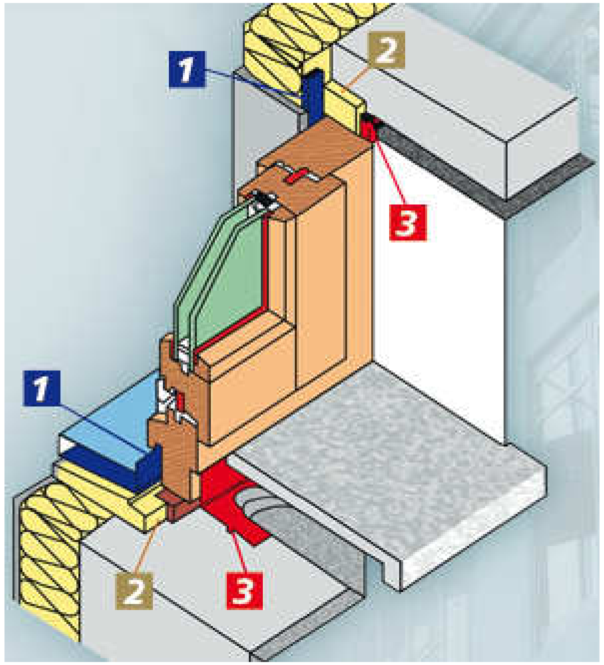
   Thermal insulation & soundproofing

3. **Inner layer :**

   Airtight & more vapour tight than on the outside

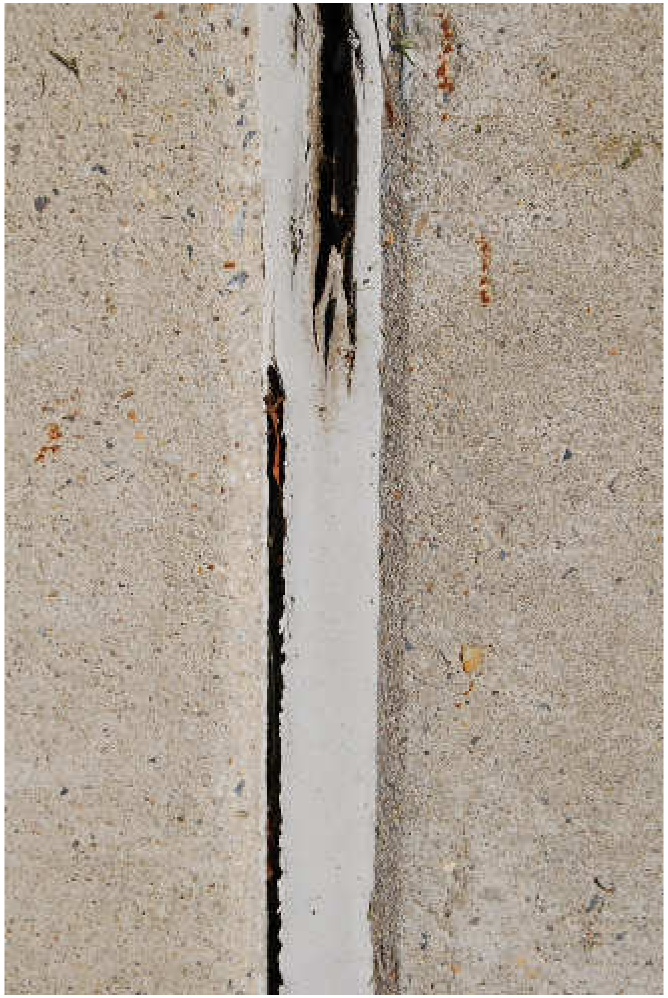
HANNO's product portfolio to achieve this:

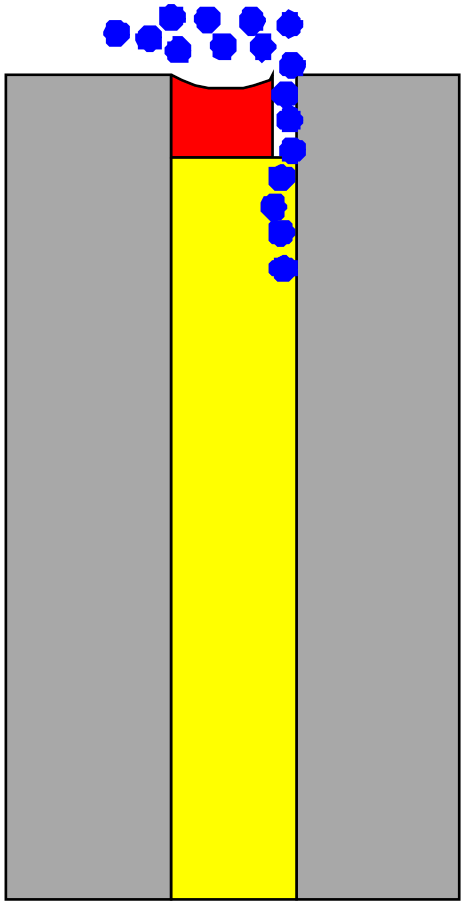
- Joint sealing tapes
- Foil tapes
- Complementary products such as Sealing compounds, glues & PU-foam



Durable Construction Joint Sealing

Joint sealed only with Caulk





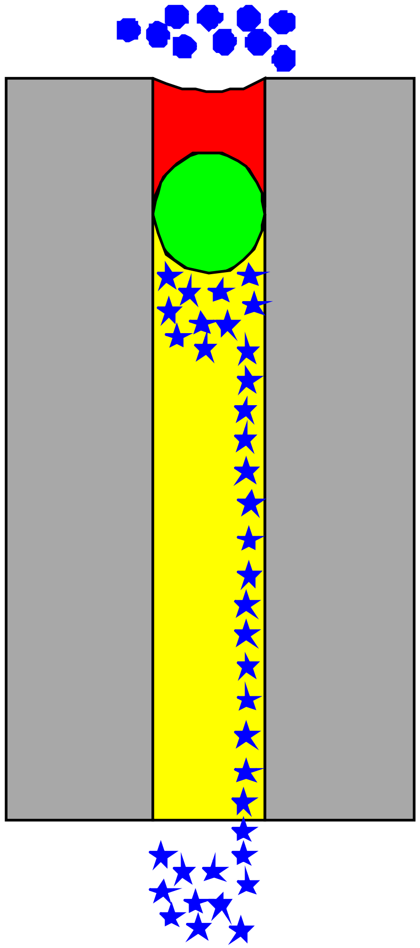
Water penetration from exterior

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

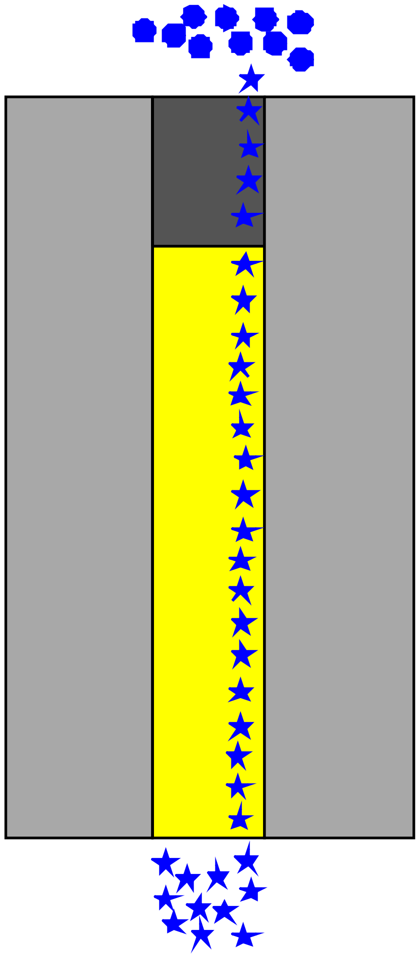
Possibility that vapor penetrates joint insulation from the interior and accumulates behind the caulk because it is vapour-tight

→ insulation becomes wet

→ reduced insulation functionality and mold may develop

Triple Layer System

Joint Sealed with Hannoband



No water penetration from the exterior

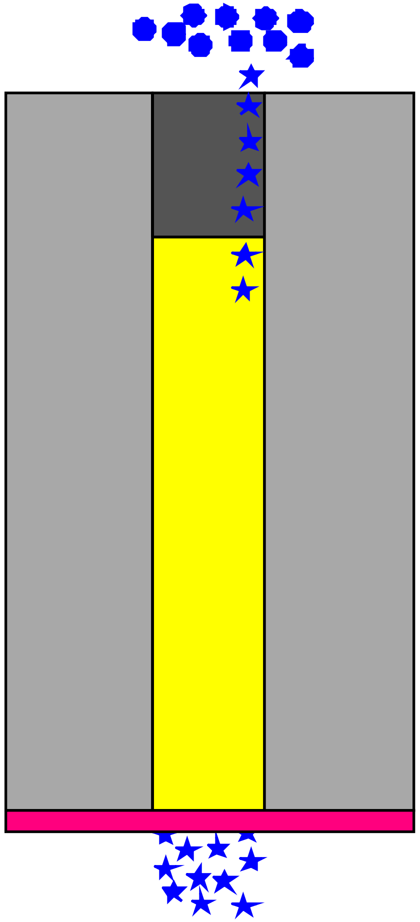
Only little vapor accumulation behind Hannoband because the tape is vapour open so that most of the vapour can pass through the joint!

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

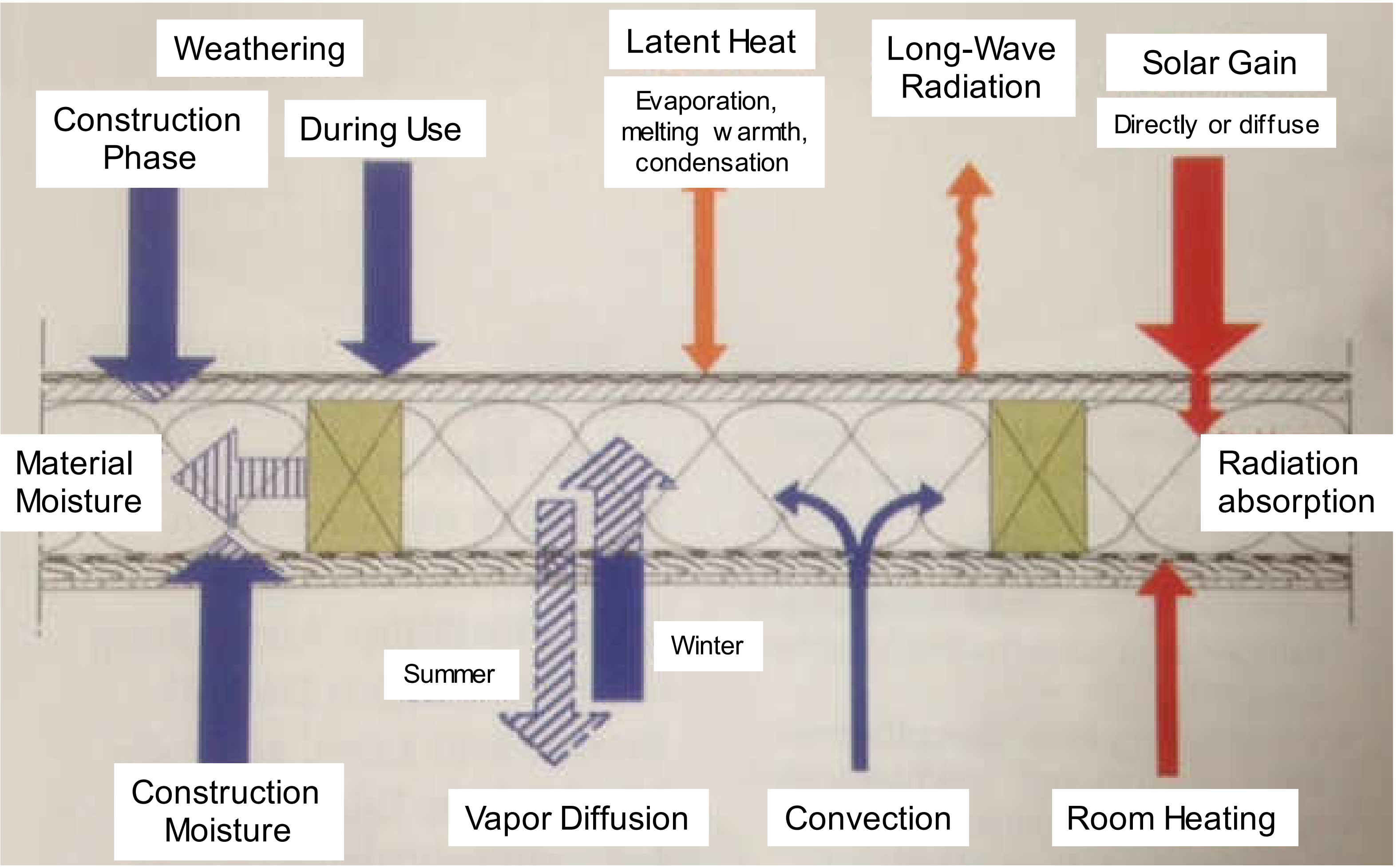
Potential water accumulation in joint will evaporate to the exterior

HANNO Passive House Study Part 4: Diffusion Behaviour

So far based on 1,000 Wufi Calculations!

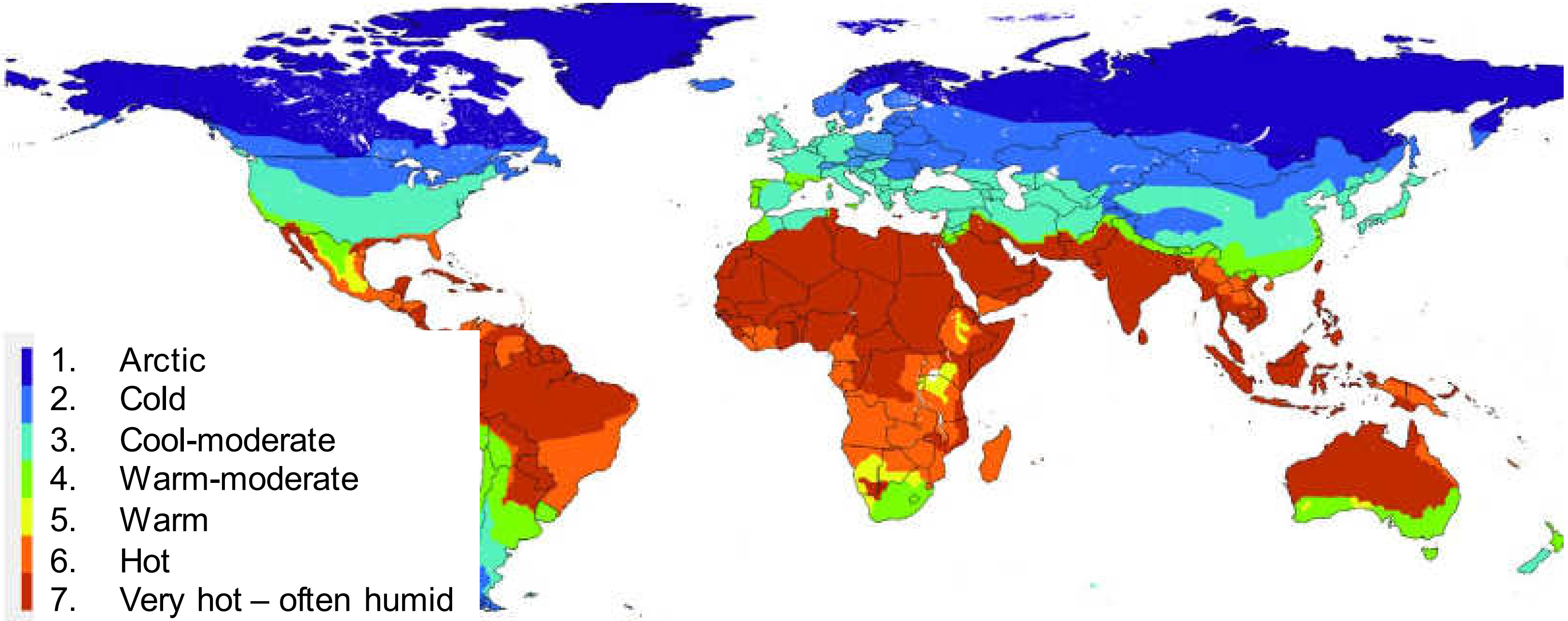
Sealing Development for Passive Houses

Consider the Influence and Flow of Moisture!



Sealing Development for Passive Houses

Considering Specific Climate Zones!

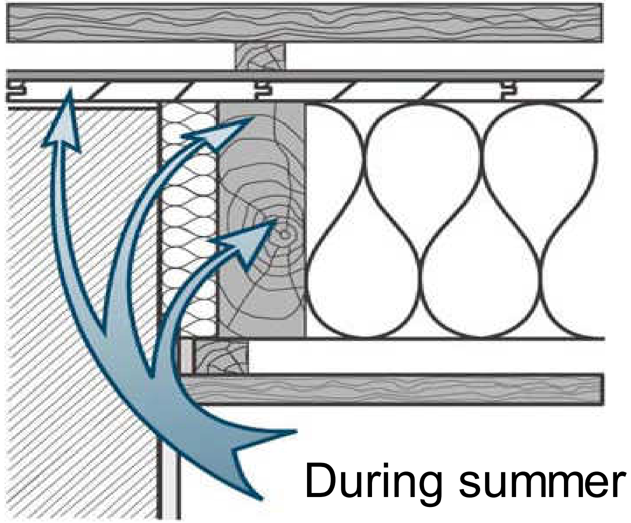


Climate zones classified by Passve House Institute Darmstadt
e.g. Seattlle
Vancouver – comparable to Tromsoe, Norway

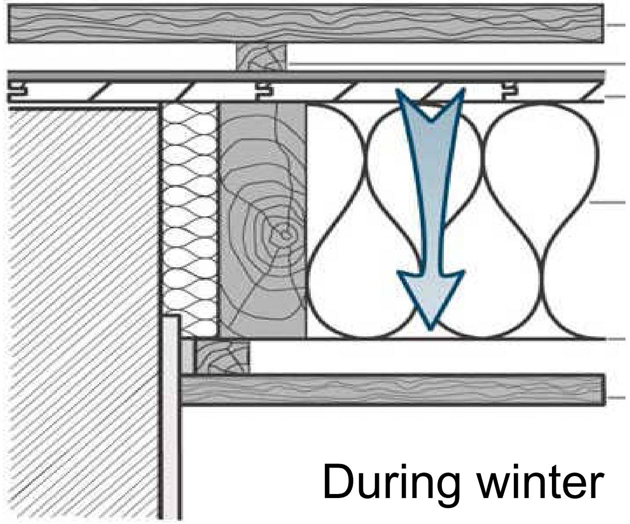
Sealing Development for Passive Houses

Consider the Influence and Flow of Moisture!

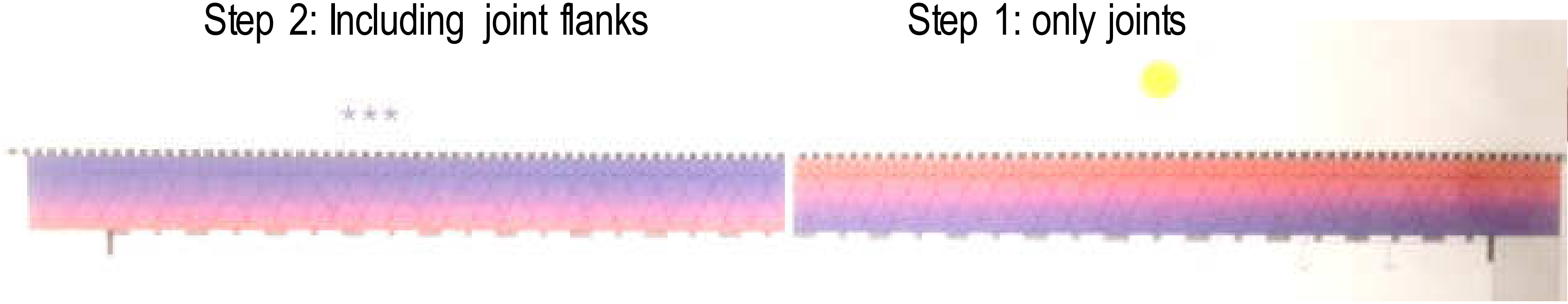
The impact of moisture has long been ignored. In roofs and window joints damages occurred, which were investigated! Prof. Feldmeier has acknowledged the inluence of moisture in this context.



Step 2: Including joint flanks

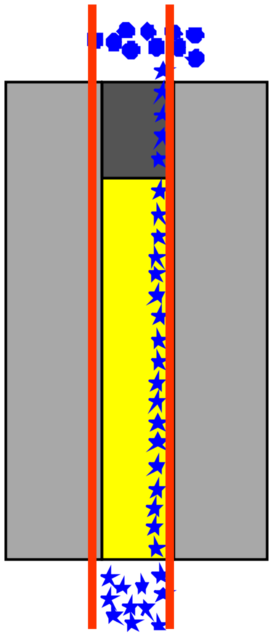


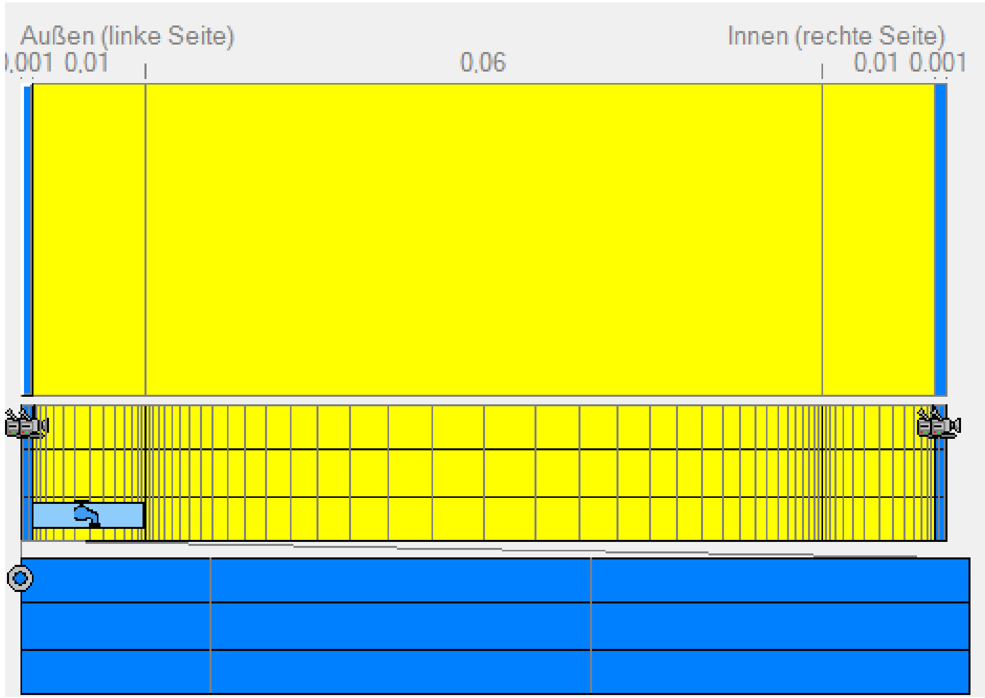
Step 1: only joints



Sealing Development for Passive Houses

Influence of Diffusion Behaviour



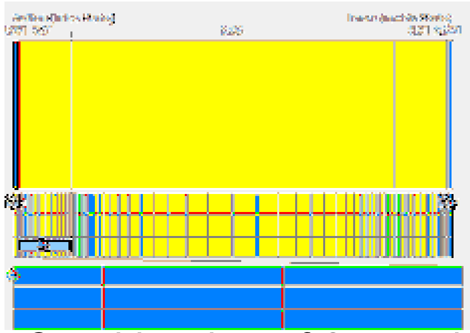


Step 1: Initial focus purely on joints to determine the diffusion behaviour for different combinations of loads – primarily:

- Rain acc. to ASHREA 160 incl. influence of solar gain depending on the location
- Air leakages

Sealing Development for Passive Houses

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. slighlty diffusion inhibiting competitor flashing tapes
4. sd-value of 10 m — e.g. flashing tape DUO Easy (variable) / sealant
5. sd-vaue of 1,500m — e.g. fleece tapes coated with metal / aluminum

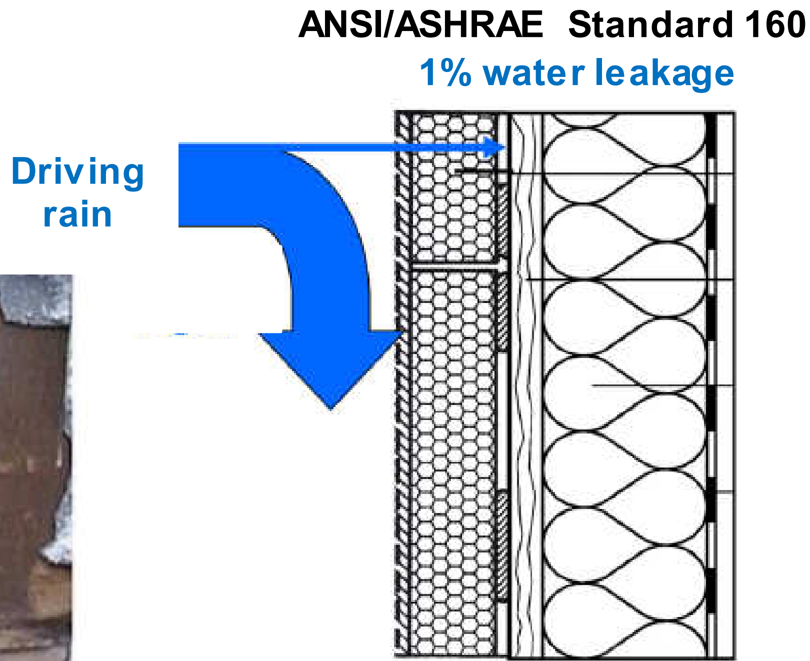
US-definition perm: one grain of water vapor per hour, per square foot, per inch of mercury;
Definition Fraunhofer Institute: 1 mm thick layer = 1 US-Perm ~ sd-Wert 3,3
1.0 US perm = 1.0 grain/square-foot·hour·inch of mercury ≈ 57 SI perm = 57 ng/s·m²·Pa

Sealing Development for Passive Houses

ASHREA 160/2009 – Useful Approach Applied in EU, too!

Construction damages due
to high moisture levels

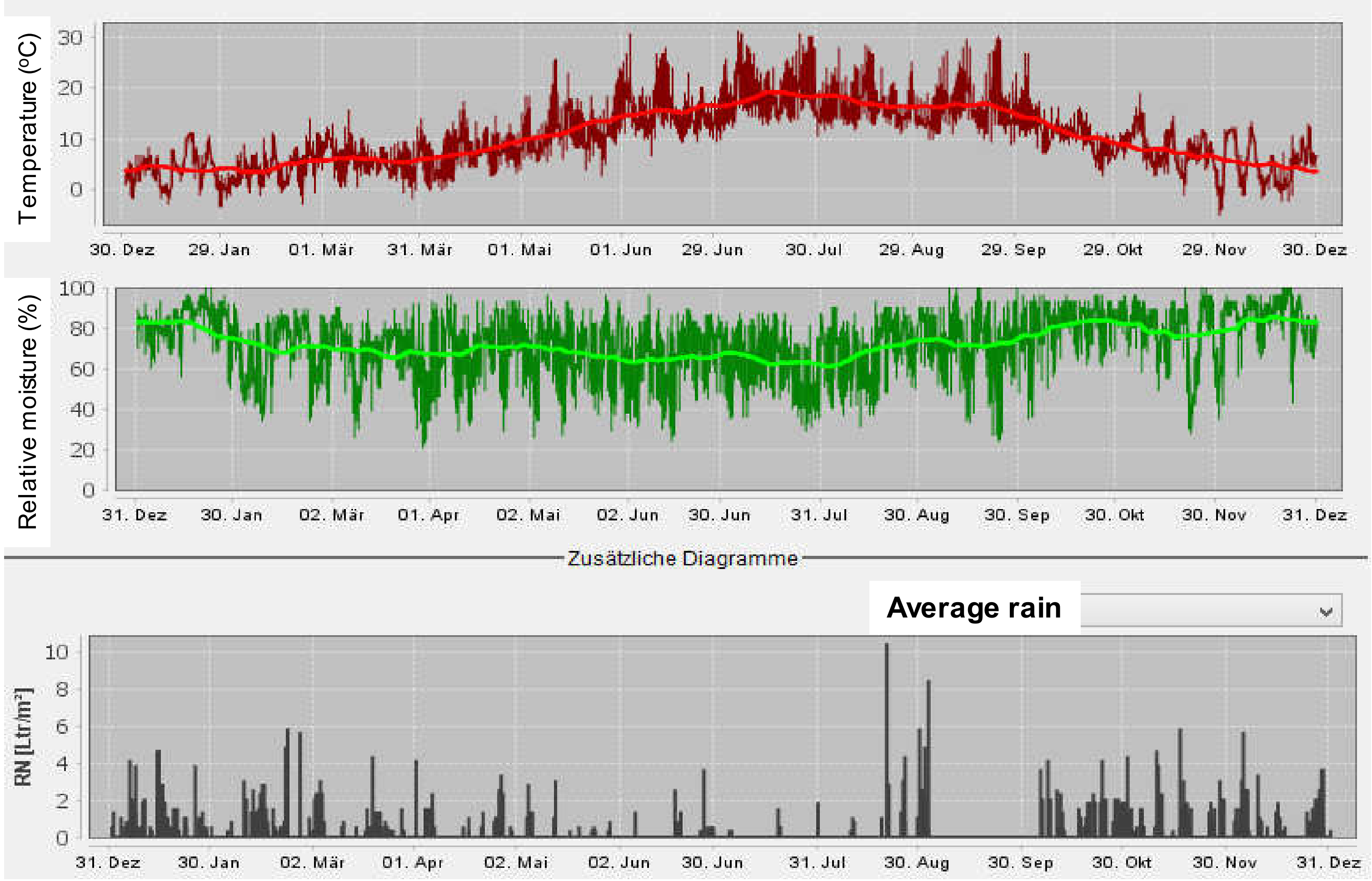
- Frost
- Decay



Penetration of rain water
behind integrated
insulation system

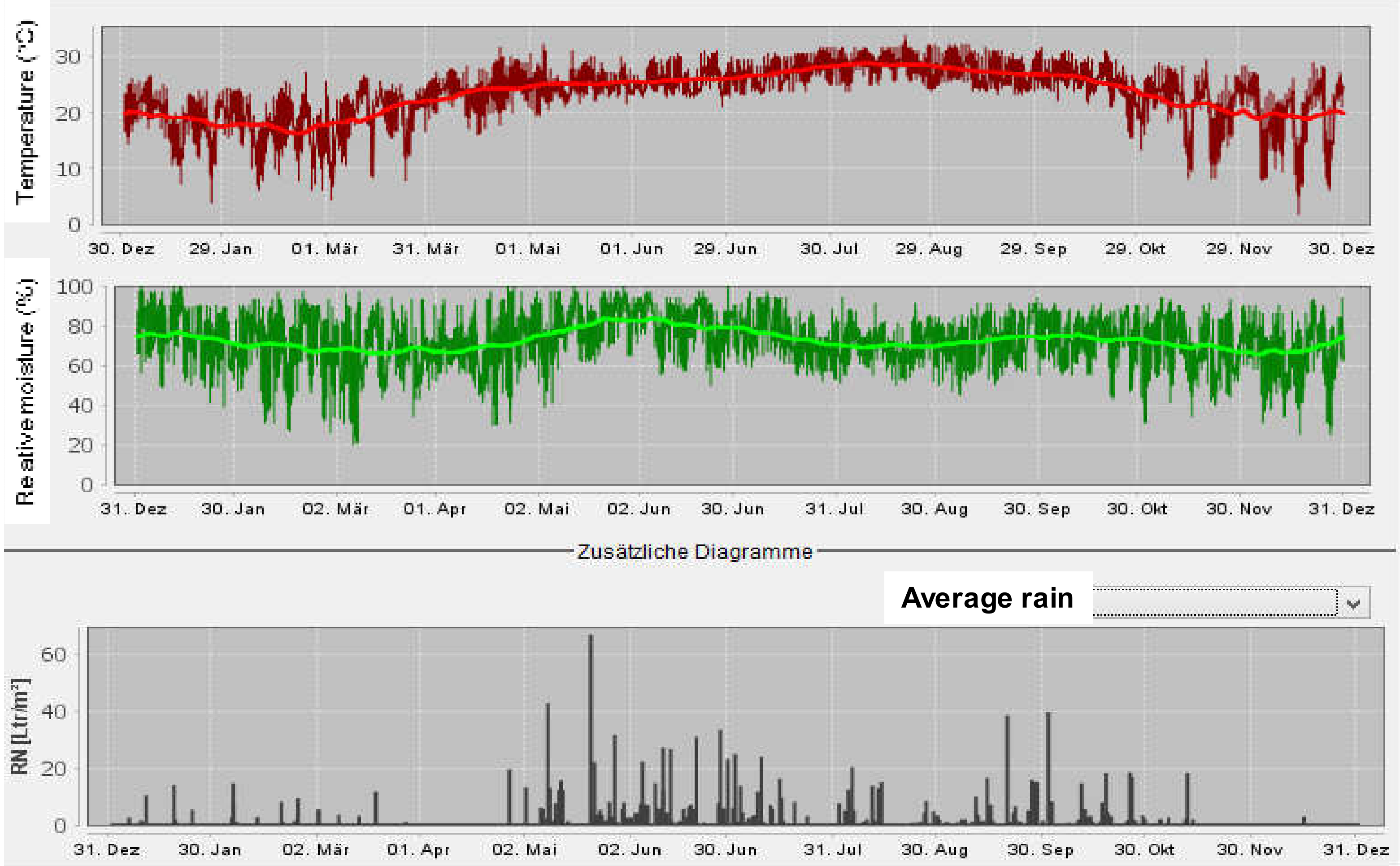
Sealing Development for Passive Houses

Climate for Seattle



Sealing Development for Passive Houses

Climate for Miami

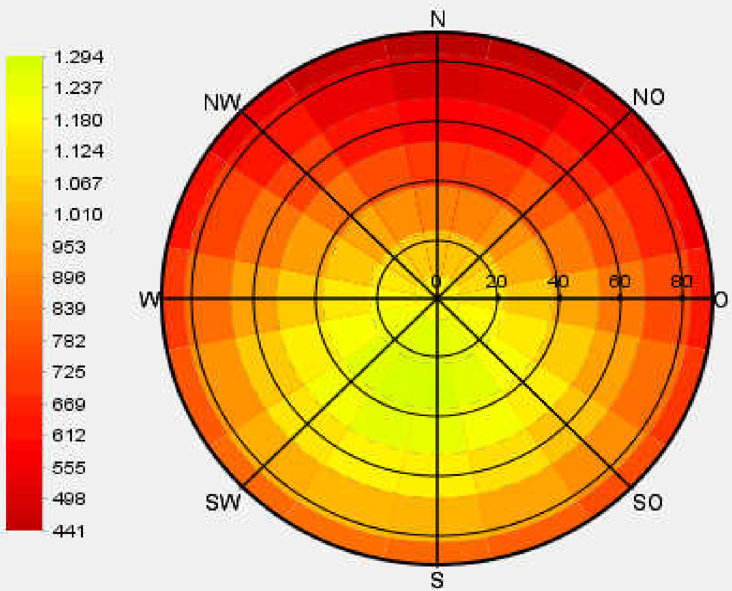


Sealing Development for Passive Houses

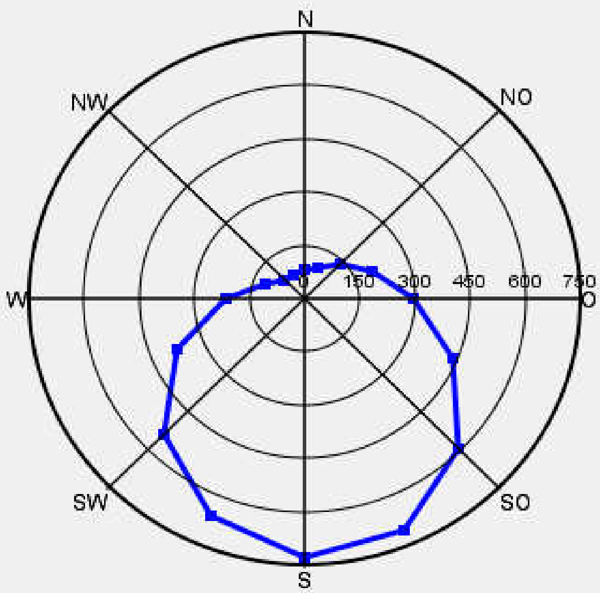
Climate for Seattle

Mittlere Temperatur [°C]:	10,39	Mittlere Relative Luftfeuchte [%]:	72,26
Max. Temperatur [°C]:	31,1	Max. Relative Luftfeuchte [%]:	100,0
Min. Temperatur [°C]:	-5,0	Min. Relative Luftfeuchte [%]:	21,0
Gegenstrahlungssumme [kWh/m²a]:	2816,29	Mittlere Windgeschwindigkeit [m/s]:	4,04
Mittlerer Bewölkungsgrad [-]:	0,72	Normalregensumme [mm/a]:	1141,4

Solare Strahlungssumme [kWh/m²a]



Schlagregensumme [mm/a]



HANNO
Dicht- und Dämmsysteme

→ www.hanno.com

HANNO ist zertifiziert nach
ISO/TS 16949 und ISO 9001

Sealing Development for Passive Houses

Climate for Miami

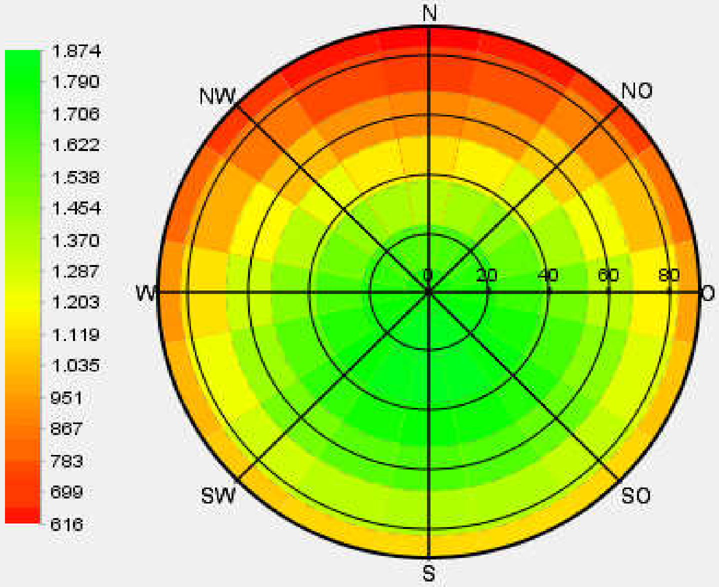
Average temperature (°C): 23.43
Max. temperature (°C): 33.9
Min. temperature (°C): 1.7

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

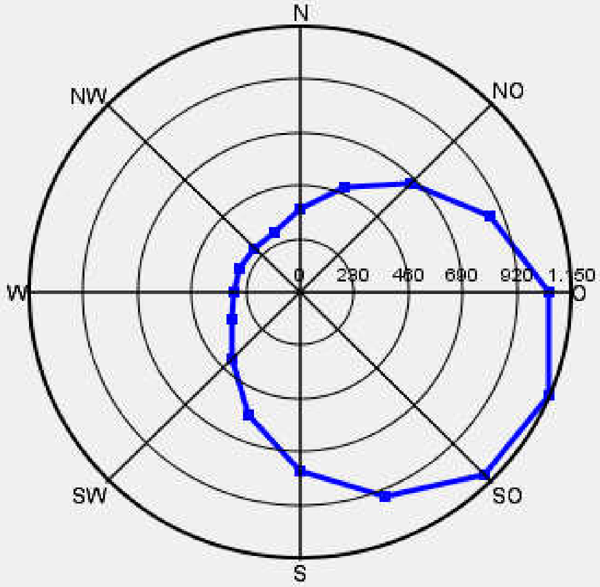
Accumulated back radiation (kWh/m²a): 3,278.69
Average cloud index (-): 0.53

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 rspectively 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 normale occupancy
Initial material humidity:	80% moisture

Sealing Development for Passive Houses

Scenario 1: Seattle, Washington

Scenario 1 final total moisture: Initial moisture 0.14 kg/m³		Diffusion resistance on the exterior:				
		μ=10	μ=100	μ=1000	μ=10000	μ=1500000
Diffusion resistance on the interior:	μ=10	0,06	0,07	0,08	0,09	0,09
	μ=100	0,06	0,06	0,08	0,09	0,09
	μ=1000	0,05	0,05	0,06	0,08	0,09
	μ=10000	0,05	0,05	0,05	0,06	0,12
	μ=1500000	0,05	0,05	0,05	0,05	0,13

Scenario max. moisture: Initial moisture 1.79 kg/m³		Diffusion resistance on the exterior:				
		μ=10	μ=100	μ=1000	μ=10000	μ=1500000
Diffusion resistance on the interior:	μ=10	5,99	21,03	203,71	260,64	267,10
	μ=100	4,72	10,24	97,39	151,77	158,18
	μ=1000	3,65	3,59	8,73	30,89	37,22
	μ=10000	3,57	3,44	4,72	8,60	12,15
	μ=1500000	3,56	3,45	4,74	8,23	10,37

Sealing Development for Passive Houses

Scenario 1: Miami, Florida

Scenario 1 final total moisture: Initial moisture 0.14 kg/m³		Diffusion resistance on the exterior: μ=10	μ=100	μ=1000	μ=10000	μ=1500000
Diffusion resistance on the interior:	μ=10	0,10	0,07	0,05	0,05	0,05
	μ=100	0,12	0,09	0,05	0,05	0,05
	μ=1000	0,27	0,15	0,08	0,05	0,05
	μ=10000	0,30	0,17	0,12	0,07	0,05
	μ=1500000	0,30	0,17	0,13	0,12	0,14

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)	50
Drywall (painted - latex paint)	2 - 3

Sealing Development for Passive Houses

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“.

Senario 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

Scenario 3 max. moisture:
Initial moisture 1.79 kg/m³

Diffusion resistance on the interior incl. joint direction (NE / SW):		Diffusion resistance on the exterior: μ=10	μ=100	μ=1000	μ=10000	μ=1500000
μ=10	V1	5,99	21,03	203,71	260,64	267,10
	NO	11,98	71,35	371,83	433,28	440,04
	SW	43,98	92,54	446,78	510,08	517,26
μ=100	V1	4,72	10,24	97,39	151,77	158,18
	NO	11,73	33,90	260,29	323,46	330,61
	SW	44,00	58,93	412,32	484,15	493,08
μ=1000	V1	3,65	3,59	8,73	30,89	37,22
	NO	11,44	11,44	148,60	574,85	672,28
	SW	44,02	55,51	390,78	665,15	704,05
μ=10000	V1	3,57	3,44	4,72	8,60	12,15
	NO	11,38	15,36	129,77	728,55	786,33
	SW	44,03	55,42	451,44	720,03	751,71
μ=1500000	V1	3,56	3,45	4,74	8,23	10,37
	NO	11,37	15,17	127,49	739,77	793,90
	SW	44,03	55,41	461,90	726,60	762,16

Sealing Development for Passive Houses

Scenario 3: Miami, Florida

Scenario max. moisture: Initial moisture 1.79 kg/m³			Diffusion resistance on the exterior:				
			μ=10	μ=100	μ=1000	μ=10000	μ=1500000
Diffusion resistance on the interior incl. joint direction (NE / SW):	μ=10	V1	5,29	2,82	2,93	3,37	3,43
		NO	41,47	42,83	43,87	43,92	43,93
		SW	38,18	40,12	40,42	40,44	40,44
	μ=100	V1	4,68	2,79	3,01	3,68	3,77
		NO	42,37	43,46	43,61	43,63	43,63
		SW	42,03	42,59	42,58	42,56	42,55
	μ=1000	V1	5,41	3,47	2,53	3,18	3,46
		NO	42,54	42,54	117,64	283,41	313,00
		SW	42,14	42,80	64,11	107,48	113,12
	μ=10000	V1	5,60	4,01	2,79	3,25	3,94
		NO	42,57	43,85	514,43	836,99	854,22
		SW	42,16	42,85	194,21	752,18	780,55
	μ=1500000	V1	5,63	4,10	3,18	4,90	6,83
		NO	42,57	43,86	589,85	884,22	896,53
		SW	42,16	42,86	229,16	816,69	843,30

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!