

WUFI® How to

Assessing condensation problems in hydrophobic mineral fiber

Issued: 2017-07

1. Basics

2. Proceeding in WUFI®

3. Example

4. Collection of critical values

The international standard EN ISO 13788 as well as for example the German standard DIN 4108-3 provide assessment methods („Glaser“) for the condensation risk in building assemblies.

A building assembly passes, if

1. there occurs no dew water at all, or
2. the amount of dew water during the condensation period remains below the threshold values and the construction is drying out during the summer period

The methods use some simplifications, like:

- Constant boundary conditions for temperature and rel. humidity (summer, winter or monthly averages - without rain water or radiation)
- No moisture dependencies of the material parameters (e.g. the thermal conductivity)
- No built-in moisture within the component
- Moisture buffering effects are neglected

The hygrothermal simulation tool WUFI® on the other hand takes the moisture storage capacity (sorption isotherm) of the building materials into account. However, „dew water“ is not really a correct term, when it comes to sorptive materials.

In materials with moisture storage, liquid condensate hardly appears in the virtual condensation pane. The moisture content increases continuously with increasing RH. The moisture storage function characterizes the correlation between the water content in the building material and the relative humidity of the ambient air.

Within the hygroscopic range up to approx. 95 % RH, the water molecules are bound to the inner surface of the porous material.

In the moisture range between 95 % and 100 % RH, the pores are increasingly saturated and the liquid water within the open volume of the pores is retained by capillary forces.

When the free saturation level of the material is approached or exceeded, weakly bound liquid water may run off.

Basics – Water retention in fiber insulations

For fiber based insulation materials, e.g. mineral wool, there is no clear distinction between free saturation and super saturation. In insulation materials with a very fine fiber “mesh”, water contents, exceeding the free saturation, may be retained by not by capillary forces but by the flow resistance of the fiber mesh.

A simple test method to determine the limit of free saturation in that case is not yet available.

Therefore, as a simplification, the “water absorption” according to EN 12087 can be used in these cases as free saturation value. Here, the material is stored under water for 28 days and then set on an inclined surface for 10 ± 0.5 min to let the free water run off and the remaining amount of water is weighed.

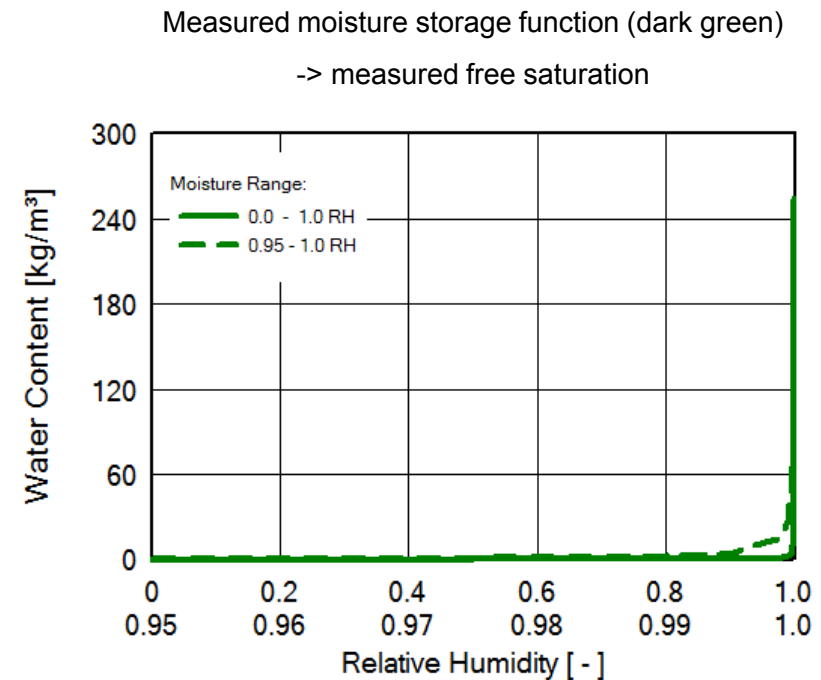
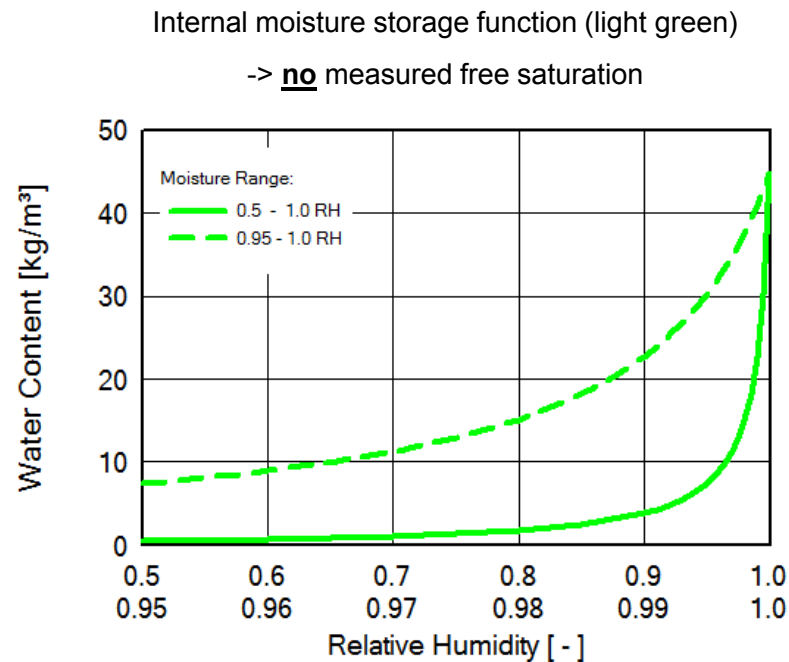
The water content, determined by that method, lays in-between the classical free saturation and the maximum saturation.

However, it seems to be an reasonable approach, as the test represents the amount of water which remains in the material while resisting gravity.

Basics - Moisture storage function (mineral wool)

If a material in den WUFI®-database has measured values for the moisture storage function (sorption isotherm) as well as for the free water saturation, they are tabulated and the plot of the moisture storage function is **dark green**.

If the moisture storage function is **light green**, the so called internal moisture storage function is used. This function is applied even for non sportive materials and isn't based on specific measured values, but on the porosity of the material (see WUFI online help).



Basics - Collection of critical values for the amount of condensate

DIN EN ISO 13788: 2012 (steady state calculation)

Maximum amount of condensate in order to prevent a run off of liquid water from watertight surfaces.

$< 200 \text{ g/m}^2$

DIN 4108-3: 2014 (steady state calculation)

Maximum amount of condensate per surface (general)

$< 1000 \text{ g/m}^2$

Maximum amount of condensate in order to prevent a run off of liquid water from watertight surfaces.

$< 500 \text{ g/m}^2$

BSI 5250: 2011 (British Standard)

Fine mist, no dropping of liquid water

$< 30 \text{ g/m}^2$

Drop formation and draining on vertical surfaces

$< 30 - 50 \text{ g/m}$

Drop formation and draining on inclined surfaces

$51 - 250 \text{ g/m}^2$
 70 g/m^2 inclination of 45°
 150 g/m^2 inclination of 23°

Prevention of the formation of big drops on horizontal surfaces which can drainage

$\leq 250 \text{ g/m}^2$

Basics - Collection of critical values for the amount of condensate

Dissertation Arnold Janssens; Reliable control of interstitial condensation in lightweight roof systems; 1998

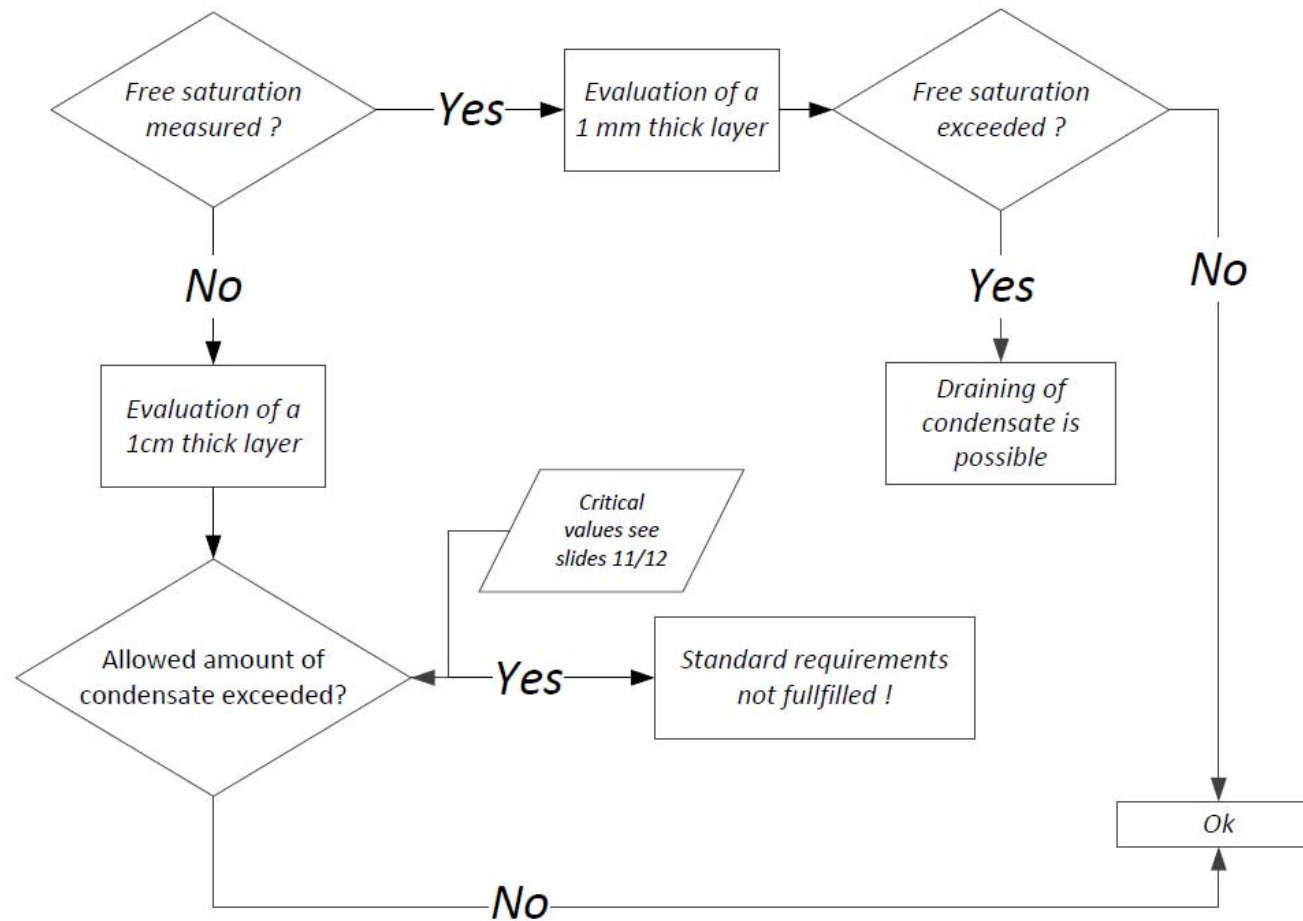
Maximum amount of condensate in order to prevent drainage of liquid water

$< 100 \text{ g/m}^2$
Inclination $> 20^\circ$

Two different evaluation criteria for materials with and without measured moisture storage function and „water absorption“ according to EN 12087

<p>2. Material data with internal moisture storage function</p> <p>(no measured „water absorption“)</p>	<p>No specific limit value available. For evaluation, the maximum dew water amount from one of the different standards can be used.</p> <p>The internal moisture storage function artificially increases the moisture content level especially at lower RH values. Therefore we recommend to define the whole water content in the exterior part of the insulation material as dew water and compare this amount with the threshold.</p> <p>⇒ Evaluation of the water content of the exterior 1 cm thick sub layer of the mineral fiber insulation related to the surface area (kg/m^2).</p>
<p>1. Material with moisture storage function including measured „water absorption“ as final value.</p>	<p>The measured „water absorption“ (kg/m^3) can be used as limit value!</p> <p>However, the lab test lasts only a few minutes, while condensation can occur in winter over several weeks. For safety reasons, this high water content should only be accepted directly at the critical condensation pane.</p> <p>⇒ Evaluation of the water content in the exterior 1 mm thick sub layer of the mineral fiber insulation (kg/m^3).</p>

How to proceed in WUFI

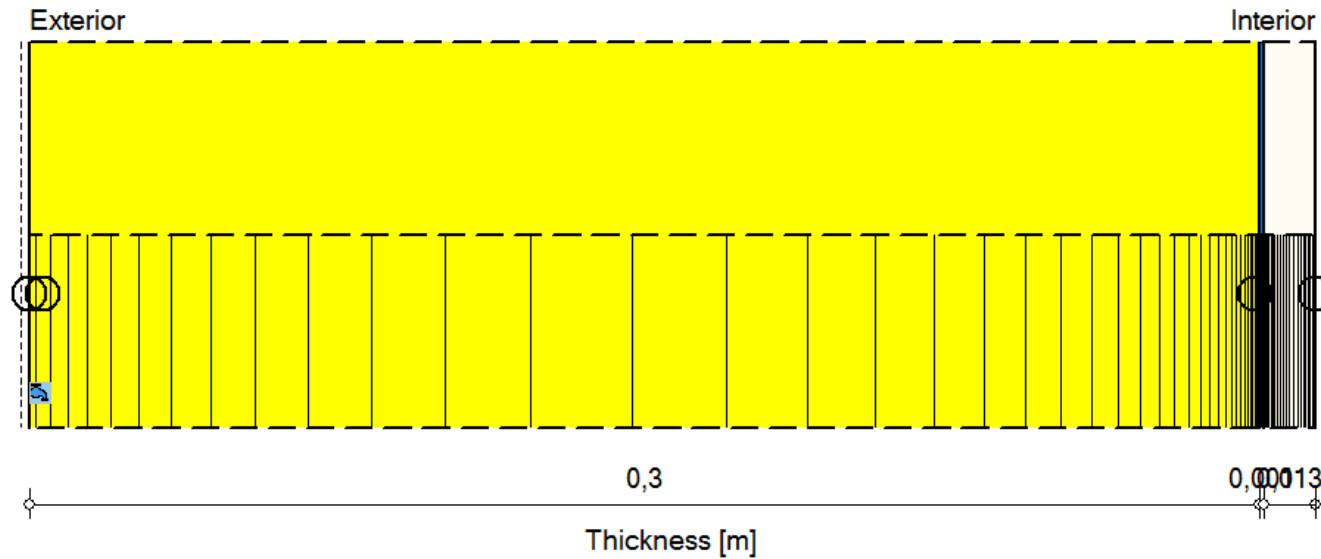


In case of hydrophobic fiber insulation materials, the free saturation is measured alike the „water absorption“ in accordance to the EN 12087

Evaluation of the amount of condensate in mineral wool:

- 1. Identification of the condensation pane in WUFI® motion (relative Humidity reaches 100 %)**
- 2. Separation of a:**
 - A) 1 cm thick layer in the dew point level if the internal moisture storage function is used. Suggestion for evaluation: Limit of 200 g/m² according to EN 13788 (further values in the tables under Basics)**
 - B) 1 mm thick layer if the material has a measured moisture storage function**
- 3. Calculation and evaluation of the water content within this layer and comparison with the critical values from the standards.**

Example Flat roof



○ - Monitor positions

💡/🌀 - Heat/Moisture source/sink positions

Materials:



- *Mineral wool (thermal conductivity.: 0,04 W/mK)

0,3 m



- vapour retarder (sd=1m)

0,001 m



- *Gypsum board

0,013 m

Example Flat roof

Boundary condition:

Location:	Holzkirchen
Orientation:	North
Inclination:	5°
Short wave absorptivity α:	0,8 (dark)
Long wave emissivity ε:	0,9
Roofing membrane:	$s_d = 300$ m (surface s_d-value)
Rain absorption:	no / (switched off)

Indoor climate according to EN 15026 with high moisture load

Initial condition: **20 °C and 80 % r.F.**

Start of the evaluation: **1st of October**

Convective moisture source flat roof

The German wood protection standard DIN 68800-2 requires the consideration of an additional moisture source due to air infiltration and proposes two possibilities to consider:

1. A transient model for the air infiltration for hygrothermal simulations (like IBP infiltration model which is directly implemented in WUFI®)
2. A fixed amount of additional condensation for the steady state “Glaser” evaluations

steady state	transient
Additional drying potential required – 100 or 250 g/m ² a per Winter	Calculation of the hourly condensation by a transient model (like Zirkelbach et.al., 2009)

Zirkelbach, et.al.; 2009: Modelling the effect of air leakage in hygrothermal envelope simulation

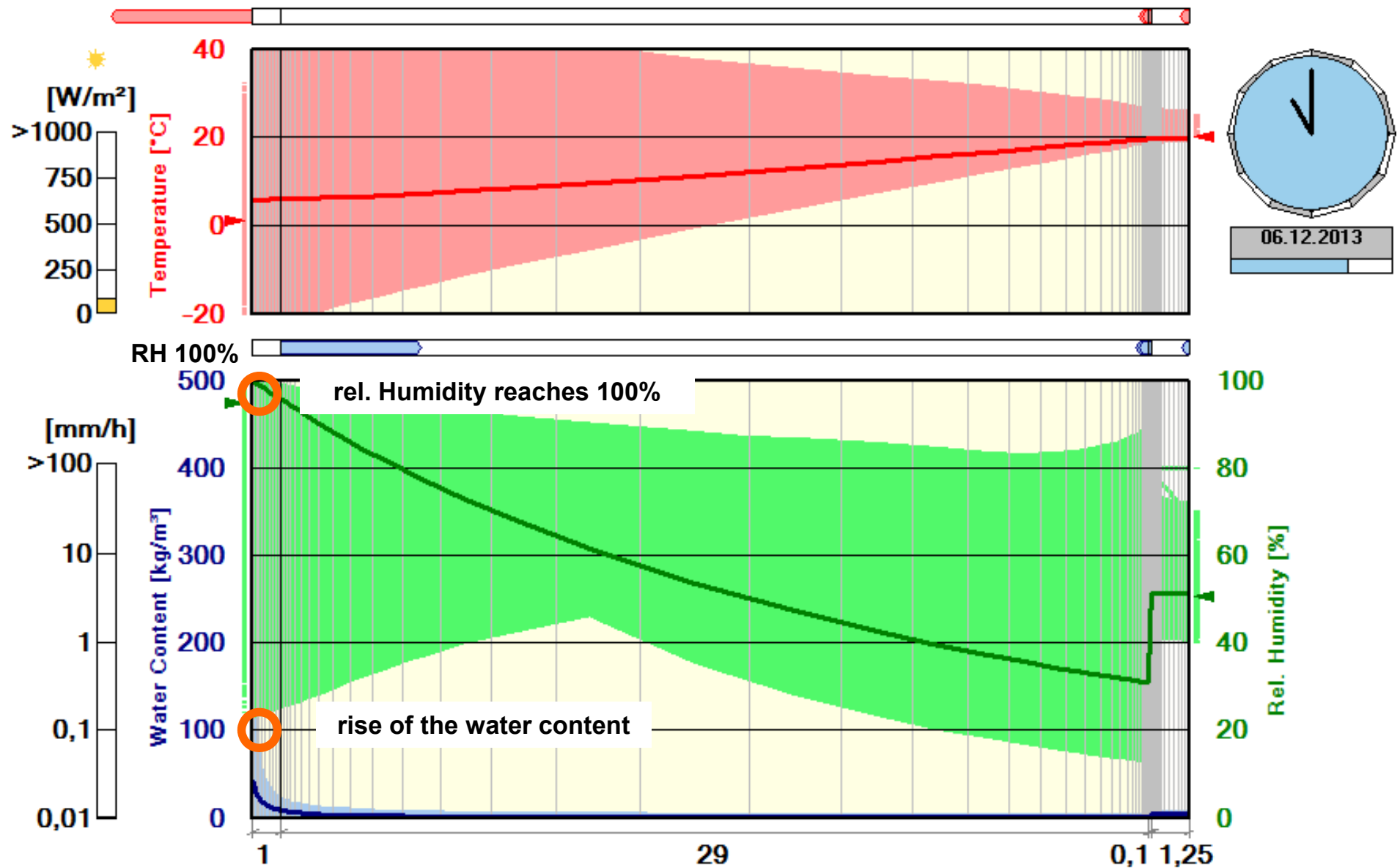
Convective moisture source flat roof

For the transient hygrothermal simulation the infiltration model is used for this example. The boundary conditions are:

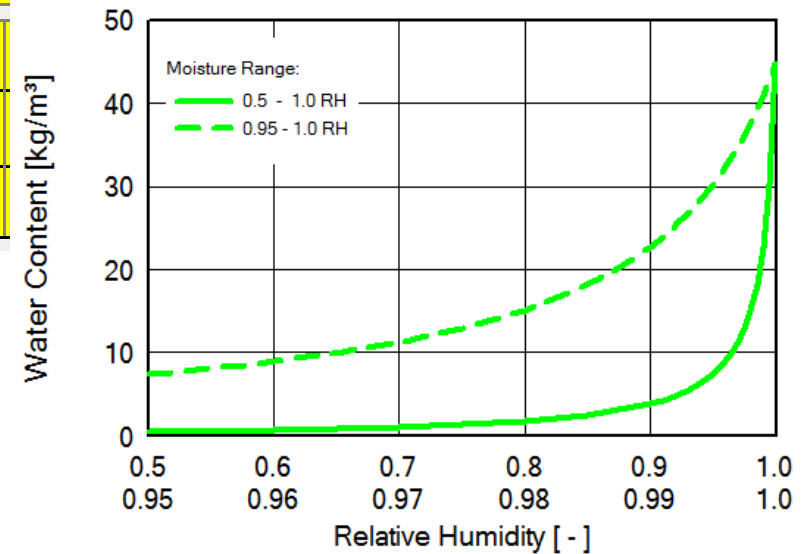
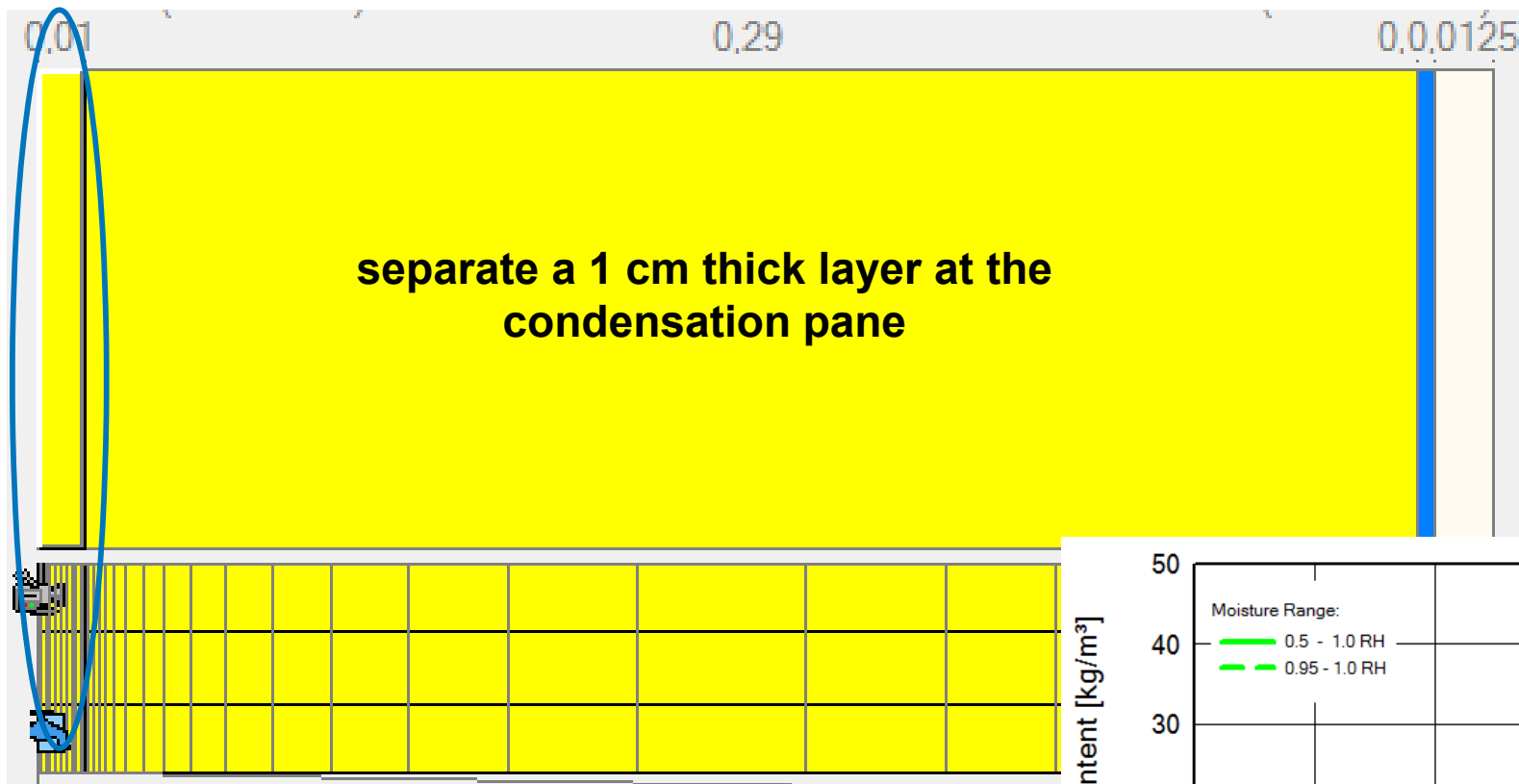
For the following example

- Heated & connected indoor air space height: 5 m
- Air tightness level: B ($q_{50} = 3 \text{ m}^3/\text{m}^2\text{h}$)
- Source area: outer 5 mm of the insulation

Example Flat roof



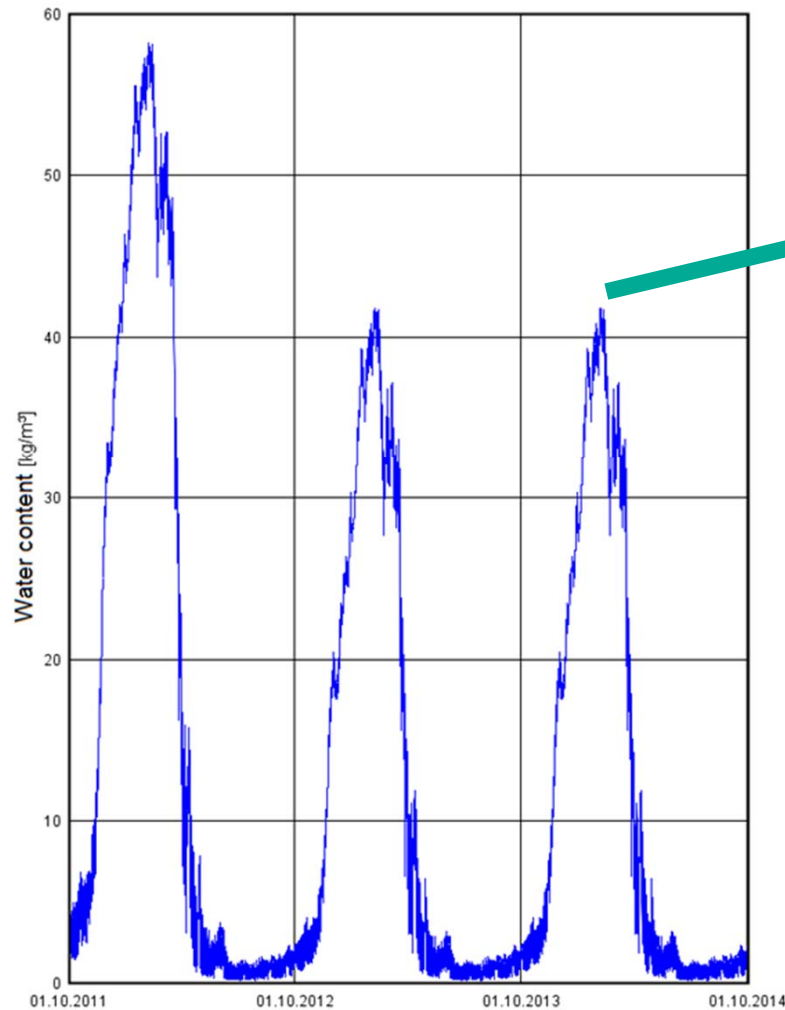
Example A unknown “water absorption” level



Internal moisture storage function

Example A unknown “water absorption” level

Water content exterior 1 cm



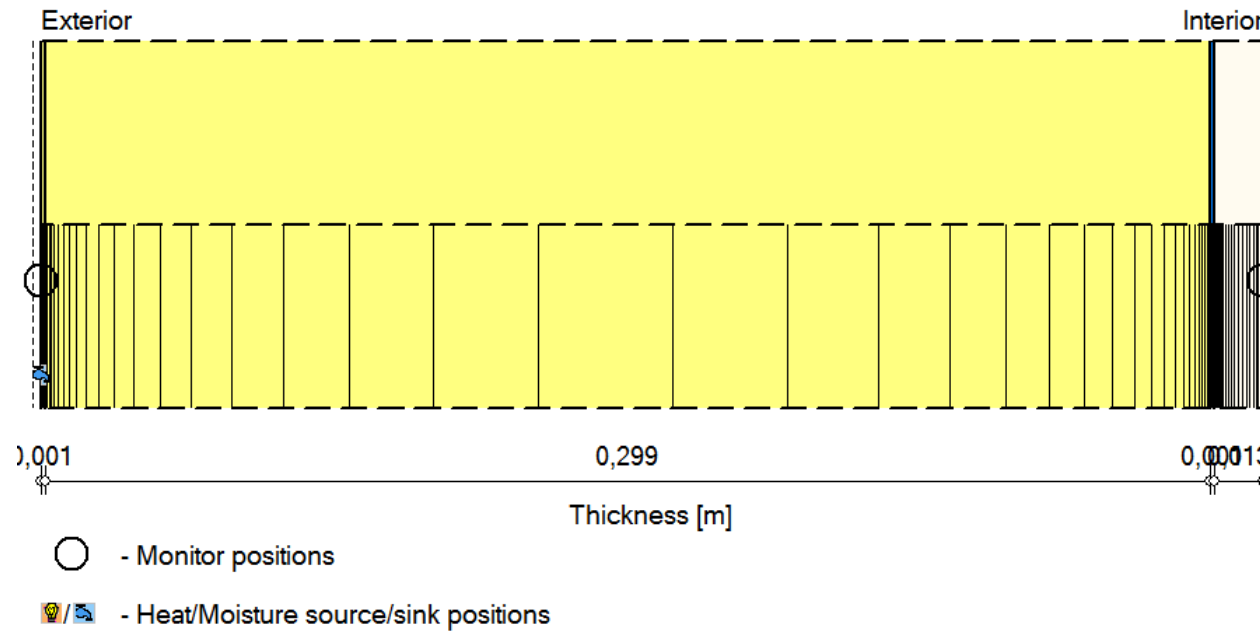
Maximum water content (dynamic equilibrium)
= 42 kg/m³

$$42 \frac{\text{kg}}{\text{m}^3} \cdot 0,01 \text{ m (layer thickness)} = 0,420 \frac{\text{kg}}{\text{m}^3} = \underline{420 \frac{\text{g}}{\text{m}^2}}$$

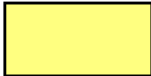
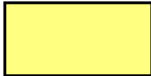


$$420 \text{ g/m}^2 > 200 \text{ g/m}^2$$

**Amount exceeds the limit – run off
cannot be excluded!**

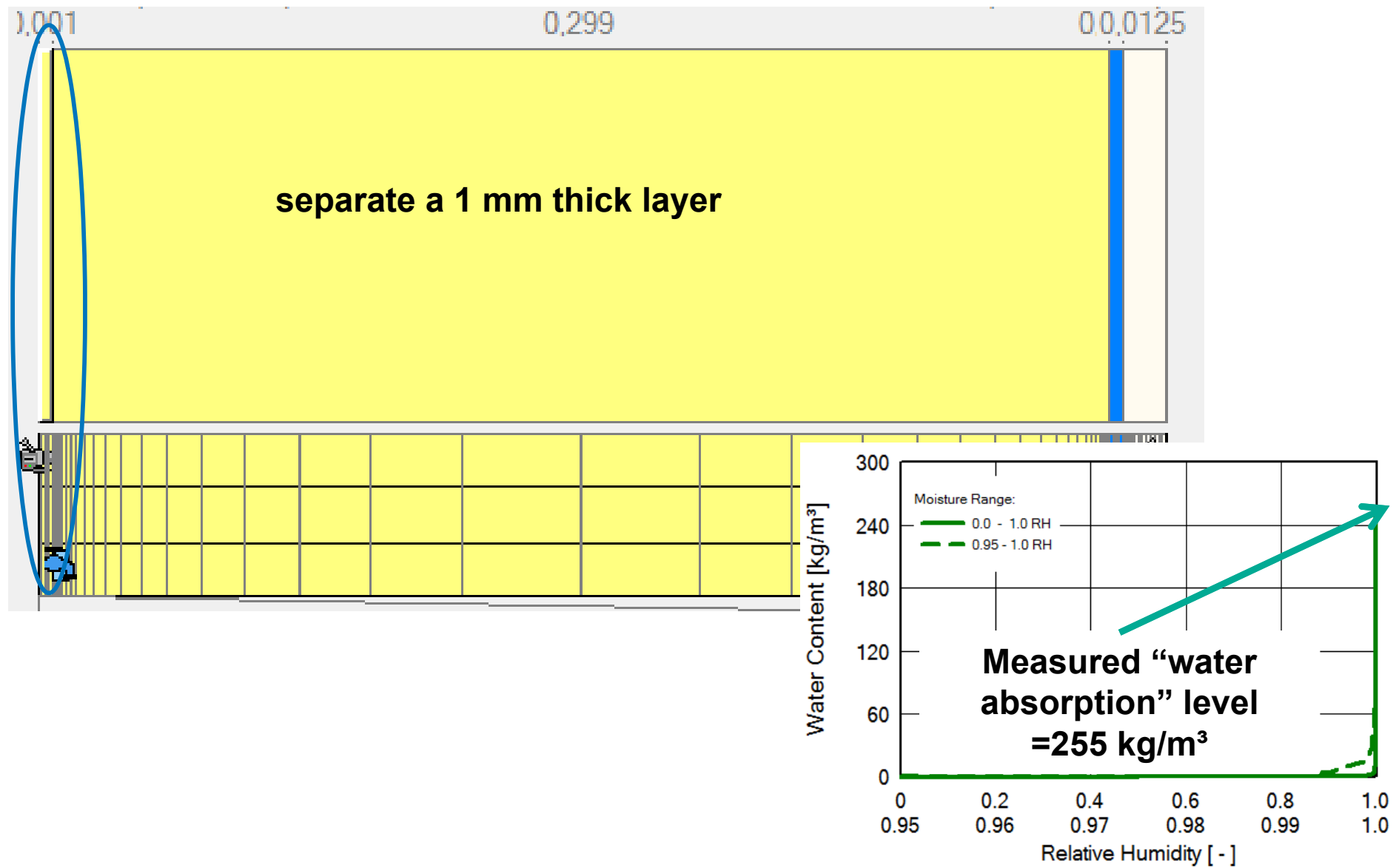
Example B measured “water absorption” level



Materials:

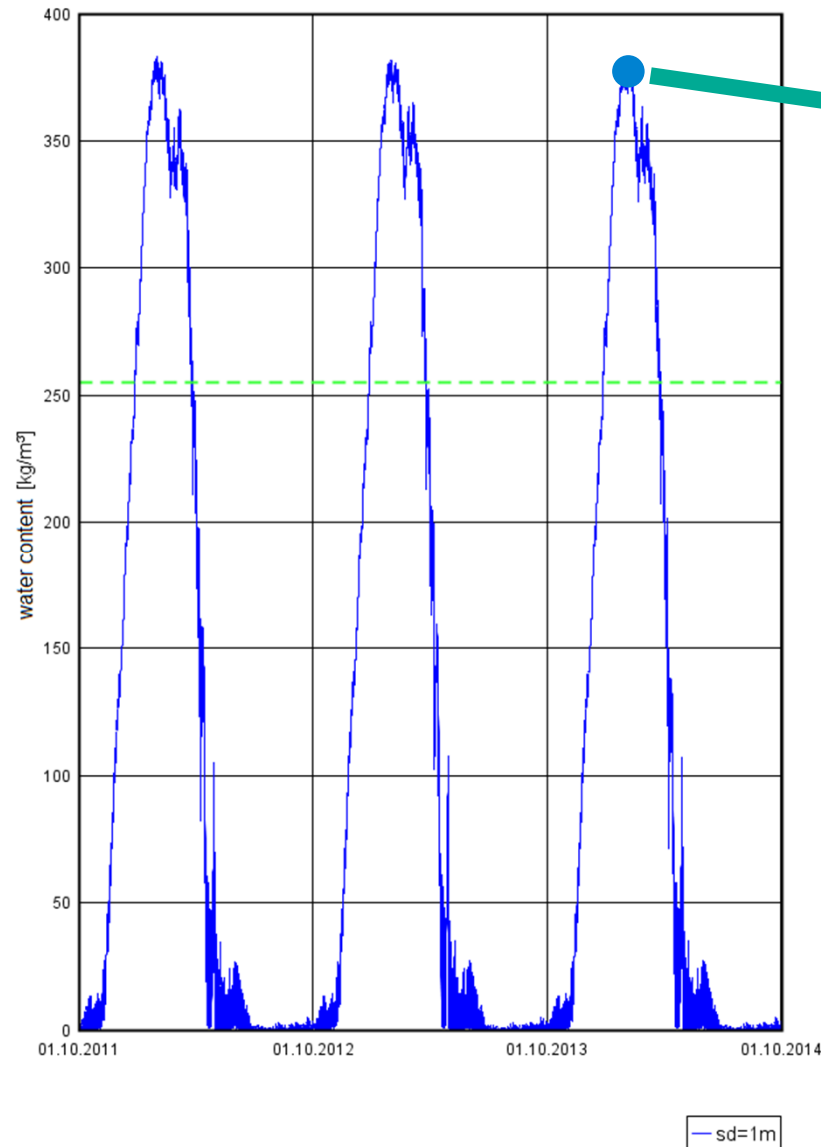
	- *measured mineral wool (thermal conductivity: 0.035 W/mK)	0,001 m
	- *measured mineral wool (thermal conductivity: 0.035 W/mK)	0,299 m
	- vapour retarder (sd=1m)	0,001 m
	- Gypsum Board	0,013 m

Example B measured “water absorption” level



Example B measured “water absorption” level

Water content mineral wool



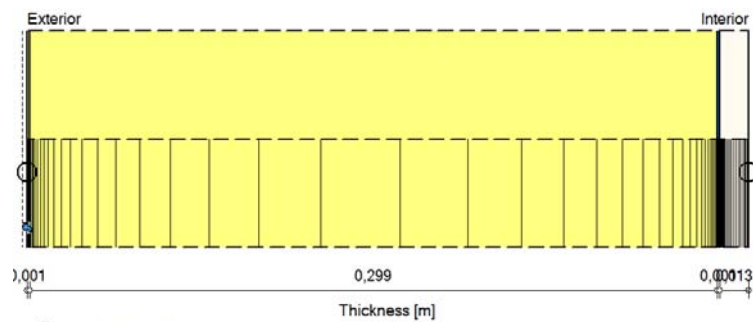
Maximum water content = 380 kg/m³

$$380 \frac{\text{kg}}{\text{m}^3} > 255 \frac{\text{kg}}{\text{m}^3}$$

Higher than free saturation resp. the amount which can be retained by the fibers (“water absorption”)

Threshold exceeded!

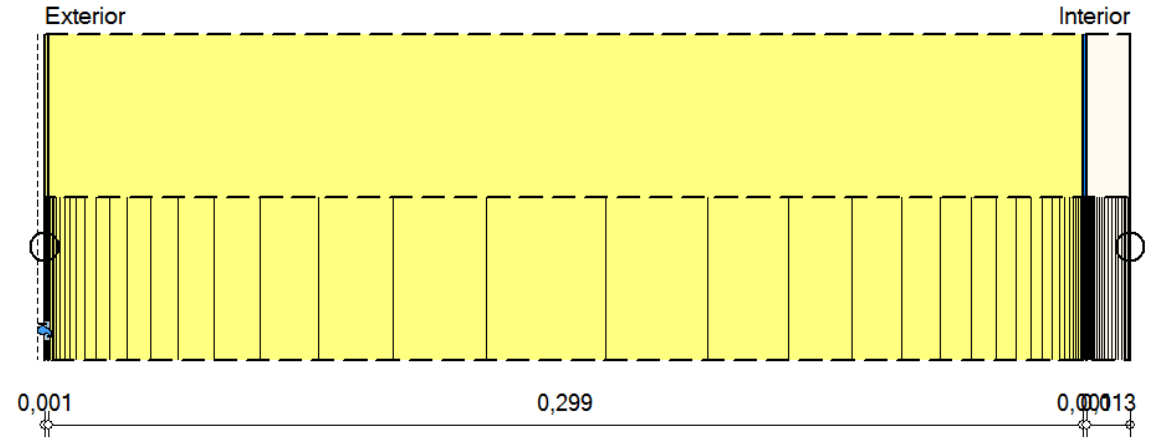
Example B measured “water absorption” level



○ - Monitor positions
 - Heat/Moisture source/sink positions

Materials:

	- *measured mineral wool (thermal conductivity: 0.035 W/mK)	0,001 m
	- *measured mineral wool (thermal conductivity: 0.035 W/mK)	0,299 m
	- vapour retarder (sd=1m)	0,001 m
	- Gypsum Board	0,013 m



○ - Monitor positions
 - Heat/Moisture source/sink positions

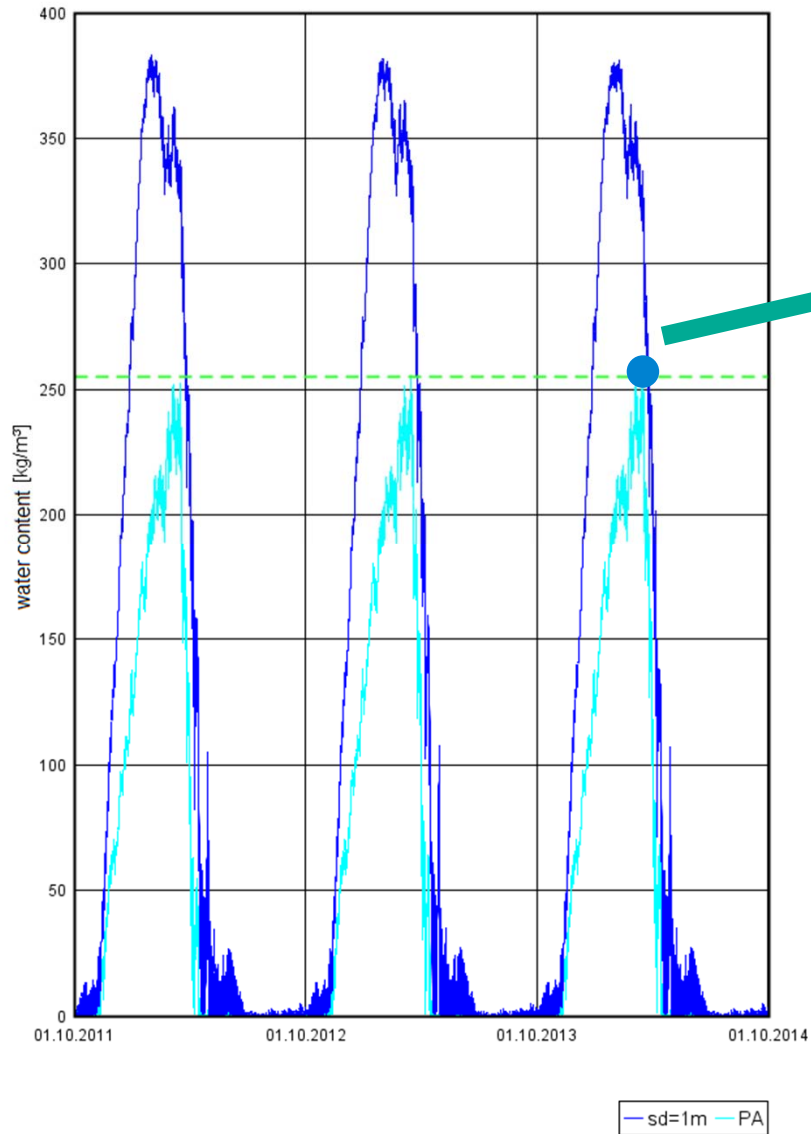
Materials:

	- *measured mineral wool (thermal conductivity: 0.035 W/mK)	0,001 m
	- *measured mineral wool (thermal conductivity: 0.035 W/mK)	0,299 m
	- PA-Membrane	0,001 m
	- Gypsum Board	0,013 m

Change of vapour retarder

Example B measured “water absorption” level

Water content mineral wool

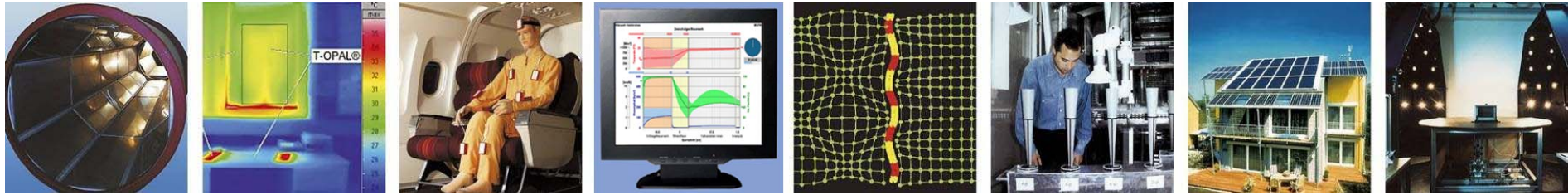


Maximum water
content = 253 kg/m³

$$253 \frac{\text{kg}}{\text{m}^3} < 255 \frac{\text{kg}}{\text{m}^3}$$

No exceeding of the
“water absorption”

✓ OK – no dew water runoff!



WUFI® How to

Assessing condensation problems in hydrophobic mineral fiber