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Report

Induzero – moisture assessment

Hygrothermal calculations

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ABSTRACT

SINTEF has performed hygrothermal calculations in WUFI Pro and WUFI2D to analyse and assess the dry-out ability and risk of moisture damage in an exterior wall construction. The construction consists of a traditional wood-frame wall with an exterior retrofit insulation system based on EPS.

The calculations show a reduction in moisture level (RH) in the construction over time, for different interior and exterior climate conditions. Given a low moisture level in the construction before retrofit insulation is installed and a vapour and airtight interior vapour barrier (with no deficiencies or air leakages), the calculations indicate that the moisture levels will remain low over time. However, some of the calculated cases show a risk of mould growth in the construction. Excess moisture in the construction seems to be of great importance since moisture is not allowed to dry outwards (due to the rather vapour tight retrofit insulation). Summarized, the construction is vulnerable to moisture exposure.

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D Technical data: Mineral strips
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1 Introduction

SINTEF has performed hygrothermal calculations in WUFI Pro and WUFI2D to analyse and assess the dry-out ability and risk of moisture damage in an exterior wall construction. The construction consists of a traditional wood-frame wall with an exterior retrofit insulation system based on EPS. It is desired to investigate if the retrofit insulation may be mounted directly on exterior air barrier in the wood-frame wall or if the moisture conditions require a ventilated air cavity between the retrofit insulation and the wood-frame wall.

2 Method

2.1 Simulation programs

The calculations are performed in WUFI®Pro 6.5 and WUFI2D 4.3, which are simulation programs for evaluation of moisture conditions in building envelopes. WUFI calculates simultaneous heat and moisture transport in one- or two-dimensional building component cross sections, taking into account (if appropriate) built-in moisture, driving rain, solar radiation, long-wave radiation, capillary moisture transport and summer condensation. WUFI Pro performs one-dimensional hygrothermal calculations, while WUFI2D performs two-dimensional calculations. Most simulations were performed in WUFI Pro in order to study the sensitivity of different parameters. Extended calculations were carried out in WUFI2D for more exact simulation of some specific cases.

The bulk of the calculations were performed for a period of 3 years in order to investigate the dry-out capacity of the construction over time. The calculation period is from 1. October in year 1 to 1. October in year 3. In addition, some calculation cases were performed with a calculation period of 5 or 10 years to study long time development in moisture levels in the wall construction. An overview of all calculation cases is given in Section 2.6.

2.2 Construction

Calculations are performed for an exterior wall constructed as a traditional wood-frame wall with a retrofit insulation system of EPS with exterior cladding added at the outside of the wood-frame wall. The construction consists of the following from interior to exterior (from warm side to cold side):

- Interior wooden cladding
- Vapour barrier (PE foil)
- Insulated wood-frame wall (98 mm or 148 mm)
- Exterior air barrier (asphalt impregnated wood fibre board)
- Exterior retrofit insulation system of EPS, shown in Figure 1

Calculations are performed on models with or without a ventilated air cavity between the exterior air barrier and the retrofit insulation.

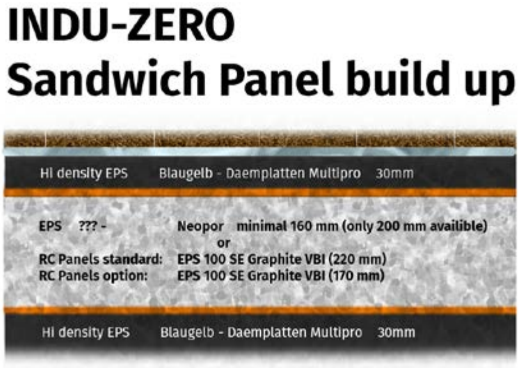

Figure 1. Exterior retrofit insulation system of EPS with 3exterior cladding of mineral strips

2.3 Material characteristics

The material parameters used in the calculations are given in Table 1. Most parameters are given by the database in WUFI, while some are given in technical data sheets (see Appendix B, C and D).

Table 1. Material parameters

Material layer	**Density**	**Thermal conductivity**	**Vapour resistance factor**	**Sd-value**	**Thickness**
	[kg/m^3]	[W/mK]	[-]	[m]	[mm]
Existing wall					
Interior wooden cladding (spruce)	420	0,13	50	-	12
Vapour barrier (PE foil)	130	2,2	70 000		
Mineral wool	60	0,04	1,3	-	Varying
Wooden frame (spruce), one-dimensional layer	420	0,13	50	-	Varying
Exterior air barrier (impregnated wood fibre board)	250	0,05	20	-	12
Exterior air barrier (membrane of laminated polyethylene and polypropylene)	130	3	14	-	
Additional exterior insulation					
EPS	15	0,04	400[1)]	-	30
PU foam	70	0,028	50	-	1
Neowall (EPS)	15	0,032	57	-	180
STO Binding and pointing mortar	1400 – 1600	1,2	200 – 300	0,5[2)]	-
Mineral strips (STO Steenstrips)	1600 – 1800	?	110	0,5[3)]	-

[1)]Given interval 380 – 550 in technical data sheet provided by the client, see Appendix D.
[2)]Given interval 0,4 – 0,6 in technical data sheet provided by the client, see Appendix B.
[3)]Given interval 0,49 – 0,58 in technical data sheet provided by the client, see Appendix C.

2.4 WUFI Pro Calculations

2.4.1 Model

The WUFI Pro model of the wall construction is shown in Figure 2. Since the calculations are one-dimensional, the wood in the wood-frame wall must be modelled as a single one-dimensional layer placed inside the insulation layer (between two insulation section), as shown in Figure 2. This approach allows for simulation of dry-out of the wood materials in the wood-frame wall. A wood fraction of 12 % is assumed. This corresponds to a wall height of 2.4 m, wooden studs with centre-to-centre distance c/c 600 mm, single top and bottom sills and 48 mm thick wood-frame components, i.e. studs and sills, in a wall section without windows and doors (in a section with windows or doors, the wood fraction will be larger and the dry-out time potentially longer).

The exterior cladding (mineral strips and binding mortar, see Figure 1) is modelled as an exterior resistance (not as a material layer) with a total Sd-value of 1 m (vapour resistance corresponding to 1 m of air). Hence, these materials are not shown in the model in Figure 2. It is assumed that the exterior cladding protects the underlaying EPS from all precipitation, i.e. that no rain water is absorbed in the EPS. It is assumed that the EPS is in direct contact with the exterior air barrier. Any bonding/fixing (such as glue) is not included.

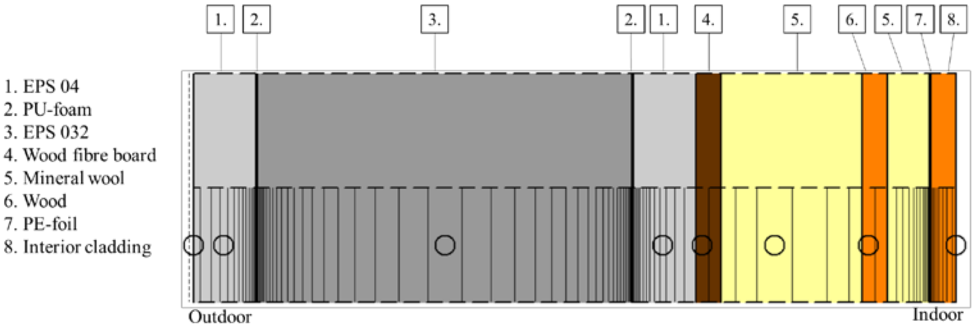

Figure 2. The model with the different material layers simulated in WUFI Pro. The model shows a vertical section of the wood-frame wall with retrofit insulation. The circles in the lower part of the figure shows the monitoring positions, i.e. the positions in the construction where calculated data is analysed.

2.4.2 Indoor and outdoor climate

On the exterior side of the wall construction climate data for Trondheim, Oslo, Tromsø, Røros, Kristiansund or Mo i Rana is used. The calculations are performed with an orientation towards north, as this assumed as most critical.

On the interior side of the wall construction a constant indoor temperature of 20°C is applied. Moisture supply in indoor air is used to represent the moisture load in the indoor climate. The bulk of the calculations are performed with an interior moisture production as for moisture class 2 (dimensional value for residential buildings) according to ISO 13789. This corresponds to a moisture supply of 4 g/m^3 and is considered a conservative estimate in Norwegian buildings with ventilation in accordance with Norwegian regulations. The impact of a drier indoor climate with a moisture supply of 2 g/m^3 (moisture class 1 according to ISO 13789) is also investigated.

2.4.3 Initial moisture conditions

The situation is most critical if the construction has excess moisture at the beginning of the calculation period. Therefore, a moisture content of the materials at equilibrium with 80% RH at 10°C at the beginning of the calculations is used. In addition, cases with a moisture level of 60% RH and 100% RH are investigated.

2.4.4 Calculated cases

Table 2 shows an overview of the cases calculated in WUFI Pro and the parameters that have been varied.

Table 2. Calculated one-dimensional cases (WUFI Pro).

Case		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Outdoor climate	Trondheim	×						×			×			×			×		
	Oslo		×						×			×			×			×	
	Tromsø			×						×			×			×			×
	Røros				×														
	Kristiansund					×													
	Mo i Rana						×												
Interior moisture supply	4 g/m^3 (normal)	×	×	×	×	×	×				×	×	×	×	×	×	×	×	×
	2 g/m^3 (dry)							×	×	×									
Building moisture (start)	60 %										×	×	×						
	80 %	×	×	×	×	×	×	×	×	×									
	100 %													×	×	×			
Existing wall thickness	100 mm	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	150 mm																×	×	×
Ventilated air cavity	None	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	25 mm																		
	50 mm																		
Air change in cavity	-	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	1h^{-1}																		
	5 h^{-1}																		
	10 h^{-1}																		
	20 h^{-1}																		
Calculation period	3 years	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	5 years																		
	10 years																		

Case		19	20	21	22	23	24	25	26	27	28	29	30	31
Outdoor climate	Trondheim	×	×			×	×	×			×			×
	Oslo			×					×			×		
	Tromsø				×					×			×	
	Røros													
	Kristiansund													
	Mo i Rana													
Interior moisture supply	4 g/m^3 (normal)	×	×	×	×	×	×	×	×	×	×	×	×	×
	2 g/m^3 (low)													
Building moisture (start)	60 %													
	80 %	×	×	×	×	×	×	×	×	×	×	×	×	×
	100 %													
Existing wall thickness	100 mm	×	×	×	×	×	×	×	×	×	×	×	×	×
	150 mm													
Ventilated air cavity	None										×	×	×	×
	25 mm	×	×	×	×	×	×							
	50 mm							×	×	×				
Air change in cavity	-										×	×	×	×
	1h^{-1}	×												
	5 h^{-1}		×	×	×			×	×	×				
	10 h^{-1}					×								
	20 h^{-1}						×							
Calculation period	3 years	×	×	×	×	×	×	×	×	×				
	5 years										×	×	×	
	10 years													×

2.5 WUFI2D Calculations

2.5.1 Model

The WUFI2D model of the wall construction is shown in Figure 3. As in the WUFI Pro calculations, the exterior cladding (mineral strips and binding mortar, see Figure 1) is modelled as an exterior resistance (not as a material layer) with an Sd-value of 1 m (vapour resistance corresponding to 1 m of air) and it is assumed that the exterior cladding protects the underlaying EPS from all precipitation. It is supposed that the EPS is in direct contact with the exterior air barrier. Any bonding/fixing (such as glue) is not included.

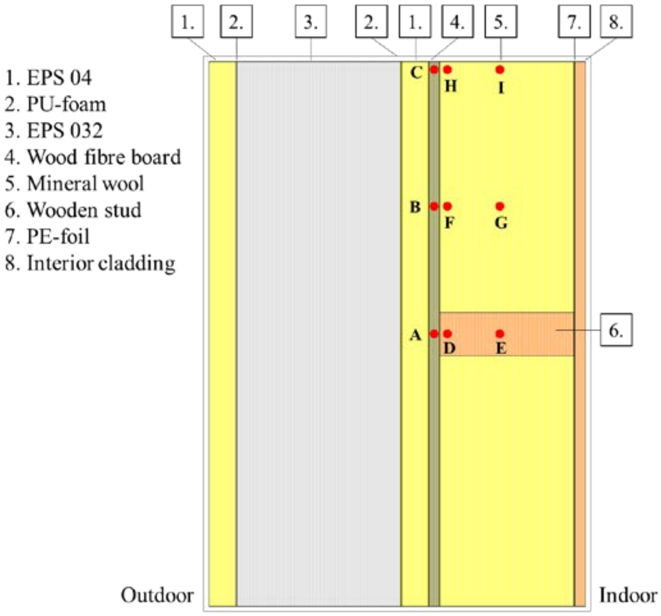

Figure 3. The model simulated in WUFI2D. The model shows a *horizontal* section of the wood frame wall with retrofit insulation. The red dots (A – I) shows the monitoring positions, i.e. the positions in the construction where calculated data is analysed.

2.5.2 Indoor and outdoor climate

As the WUFI Pro calculations showed little influence of the exterior climate on the results, the WUFI2D calculations were only carried out with climate data for Trondheim on the exterior side of the wall construction. The calculations are performed with an orientation towards north, as this assumed as most critical.

The indoor climate applied in the WUFI2D calculations corresponds to the conditions used in WUFI Pro calculations, see Section 2.4.2. In addition, calculations with an interior moisture production as for moisture class 3 according to ISO 13789 is performed. This corresponds to a moisture supply of 6 g/m^3.

2.5.3 Initial moisture conditions

In order to explore possible existing moisture levels in the materials in the wall construction before installation of the retrofit insulation a calculation (Case 0) was carried out on a model of a wood-frame construction (with ventilated exterior cladding) without the retrofit insulation system. The resulting equilibrium moisture levels at the end of the calculation period (i.e. end of October in year 3) derived from

Case 0 are shown in Table 3. Note that the equilibrium moisture levels in the wall construction is different in other points of time during the year.

In addition, calculations with a moisture content of the materials at equilibrium with 60% RH and 80% RH at 10°C at the beginning of the calculations were performed.

Table 3. Moisture levels in the different material layers in the existing wood frame construction according to Case 0 calculations (equilibrium moisture levels in October).

Layer	**Moisture level, RH [%]**
Wood fibre board (exterior air barrier)	≈ 85
Mineral wool insulation	≈ 60
Wooden studs	≈ 60
PE-foil	≈ 60
Interior cladding	≈ 60

2.5.4 Calculated cases

Table 4 shows an overview of the cases calculated in WUFI2D and the parameters that have been varied.

Table 4. Calculated cases in WUFI2D.

Case		0[1)]	1	2	3	4	5	6	7	8
Outdoor climate	Trondheim	×	×	×	×	×	×	×	×	×
Interior moisture supply	6 g/m^3 (normal/high)			×						
	4 g/m^3 (normal)	×	×			×	×	×	×	×
	2 g/m^3 (dry)				×					
Building moisture (start)	60 %					×			×	
	In accordance with Case 0[2)]		×	×	×					
	80 %	×					×	×		×
Existing wall thickness	150 mm	×	×	×	×	×	×	×	×	×
Exterior air barrier	Wood fibre board	×	×	×	×	×	×	×		
	Flexible air barrier foil								×	×
Ventilated air cavity	None	×	×	×	×	×	×	×	×	×
	25 mm									
	50 mm									
Air change in cavity	-	×	×	×	×	×	×	×	×	×
	1h^{-1}									
	5 h^{-1}									
	10 h^{-1}									
	20 h^{-1}									
Calculation period	3 years	×	×	×	×	×	×		×	×
	5 years							×		
	10 years									

[1)]Case 0 is calculated with a model of the existing wood frame wall construction without the retrofit insulation system

[2)]The moisture levels are shown in Table 3

2.6 Evaluation criteria

Mould leads to discolouring and potentially wood decay given suitable hygrothermal conditions. Mould requires certain conditions in order to develop and grow. To initiate mould growth, favourable conditions regarding water, exposure time, nutrition, temperature and oxygen level is needed. The risk of mould growth is largest when the temperature is around 30°C and the wooden moisture content is 30–40 weight-% (90–100 %RH). Wood materials present in buildings normally have a temperature between -10°C and 25°C. The risk of mould growth is typically low if the wooden moisture content is kept below 20 weight-% (80% RH at 20°C) (Tronstad, 2006)[1]. To initiate mould growth on wood, investigations by Viitanen (1997)[2] shows that the RH must be higher than 80% at 20°C (i.e. approx. 20 weight-% at 20°C) for about 5 months. If the RH is increased to 90% at the same temperature, an exposure time of 4 weeks is sufficient to initiate mould growth. By lowering the temperature to 5°C, the RH must increase to 95% to initiate mould growth after 4 weeks. Based on the investigations by Viitanen (1997) and information in the SINTEF building design guidelines (Byggforskserien), the following criteria for initiation of mould growth used in assessment of the results:

- Wooden moisture content (minimum 20 weight-%)
- Exposure period (minimum 4 weeks)
- Temperature (minimum 5°C)

These criteria are assumed to be conservative.

3 Results

Selected results from calculations in WUFI Pro is given in Figure 4–Figure 15 in Appendix A. Selected results from calculations in WUFI2D are shown in Figure 16–Figure 23 in Appendix B. The results show calculated temperature and RH in different monitoring positions in the construction. Most results concern the critical parts of the construction, i.e. the outer parts of the existing wood-frame wall. Most of the diagrams show RH above 80% and temperature above 5°C. If no curve is shown for a given parameter in a given diagram, the parameter is not above the presented limits and therefore not visible in the diagram.

4 Evaluation

4.1 WUFI Pro (1D) calculations

General observations

The retrofit insulation system based on EPS panels will reduce the dry-out capacity of the existing wall construction. In general, the results show a reduction in moisture level (RH) over time. Both temperature, moisture level and type of material is of importance for potential mould growth. The RH level is above 80% during long periods for many of the calculated cases, also combined with temperatures that are favourable when evaluating mould growth.

Installation of the retrofit insulation system makes the existing wall structure warmer and is striving towards a lower moisture level in equilibrium state. Because the retrofit system is rather vapour tight the moisture level will increase in the exterior parts of the existing wood frame wall.

Generally, the highest moisture values were found in the external layers of EPS. Since EPS is non-organic, the risk of mould growth is low in these material layers. Regarding risk of mould growth, the wood fibre board (exterior air barrier located between the wood frame wall construction and the retrofit insulation) was found to be the most critical with long periods with RH above 80 % in combination with temperatures between 10 and 18°C.

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[1] Tronstad, S. (2006) Tre og fuktighet – fra produsent til forbruker. Teknisk håndbok nr. 2, Norsk Treteknisk Institutt
[2] Viitanen, HA. (1997) Modelling the time factor in the development of mould fungi-The effect of critical humidity and temperature conditions on pine and spruce sapwood, Holzforschung-International Journal of the Biology, Chemistry, Physics and Technology of Wood, 51, 1, 6-14.

Outdoor climate (case 1 – 6):
Dry-out ability and dry-out rate of the construction is dependent on the geographic location. However, the results imply that the outdoor climate is of little importance of the RH level on the wood fibre board (critical position) in the given construction. The temperature on the wood fibre board is above 10°C during the entire calculation period for Cases 1, 2, 3, 5 and 6. For Case 4 (Røros) the temperature on the wood fibre board is lower during winter than for the other cases, but it is always above 5°C.

Interior moisture supply (case 1 – 3 versus case 7 – 9):
The interior moisture supply (interior climate) is of little importance for the RH levels in the wood fibre board, given an air and vapour tight interior vapour barrier (assuming no air leakages from the interior into the wall construction).

Initial moisture conditions (case 1 – 3 versus case 10 – 12 (low) and case 13 – 15 (high)):
The situation is most critical if the construction has excess moisture at the beginning of the calculation period. Dry-out of built-in moisture may require time, especially when a material layer with high vapour resistance is installed on the exterior side of the insulation. This will affect the RH in the wood fibre board. The calculations show that the initial moisture conditions are of large importance for the moisture level development in the construction. Given low initial moisture level (60% RH), the RH in the wood fibre board is below 70% in equilibrium with the surroundings. Given higher initial moisture level (80% RH), the RH in the wood fibre board is above 85% during long periods and reaches levels above 90% RH. If it is possible to ensure low moisture level in the construction before retrofit insulation is installed, this will affect the development in moisture levels in the construction over time. It is, however, important to note that the calculations assume an air and vapour tight interior vapour barrier with no deficiencies or possibilities of air leakages from the interior. Humid air from the interior through air leakages may change the moisture conditions and result in larger risk of mould growth when moisture is not allowed to dry outwards (due to the rather vapour tight exterior retrofit insulation).

Existing wall thickness (case 1 – 3 vs case 16 – 18):
Larger wall thickness results in more built-in moisture, hence a larger moisture redistribution, higher RH and an increased risk of mould growth. The results underline that a low built-in moisture content is favourable and that the exterior air barrier should not be moistened prior to installation of the retrofit insulation.

Ventilated air cavity (case 1 – 3 vs case 19 – 27):
A ventilated air cavity between the existing wall and the retrofit insulation seems to be effective, even if the air change rate is low, in regard to lowering the RH in the outer part of the existing construction. However, WUFI has been developed for modelling heat and moisture flows in porous materials. Therefore, the properties of air layers must be described by sets of material parameters which has been intended to describe porous materials, and calculations including air layers may be less exact.

4.2 WUFI2D Calculations

In line with the WUFI Pro calculations, the WUFI2D calculations in general show a reduction in moisture level (RH) over time. Both temperature, moisture level and type of material is of importance for potential mould growth. The RH level is above 80% during periods in some of the calculated cases, also combined with temperatures that are favourable when evaluating mould growth (the temperature is always above 5°C in the material layers inside of the retrofit insulation system).

Generally, the highest moisture levels in each material layer were found in the monitoring positions furthest from the studs, i.e. in monitoring positions C, H and I according to Figure 3. Regarding risk of mould growth, the wood fibre board (exterior air barrier located between the wood frame wall construction and the retrofit insulation) was found to be the most critical. Given initial RH levels equal to 60% for all materials or 85% for the wood fibre board (exterior air barrier on existing wall) and 60% for the remaining materials, the calculations show a low risk of mould growth. Given an initial RH of 80%, however, the calculations show a high risk of mould growth in the outer part of the wood-frame wall. Hence, the same conclusion applies as in the WUFI Pro calculations; if it is possible to ensure a low moisture level in the construction before retrofit insulation is installed, the calculations indicate that the moisture levels will remain low over time. This is based on an assumption of an air and vapour tight interior vapour barrier with no deficiencies and no possibilities of air leakages from the interior. Humid air from the interior through air leakages may change the moisture conditions and result in larger risk of mould growth when moisture is not allowed to dry outwards.

The 2D calculations show little influence of the interior moisture supply (the interior climate), as also shown in the 1D calculations. This might, however, be of larger importance if the interior vapour barrier is less vapour tight. Comparing calculations with wood fibre board or flexible foil as exterior air barrier, the latter cases give higher RH in the outer part of the studs and mineral wool insulation. This is most likely due to the hygroscopic properties of the wood fibre board.

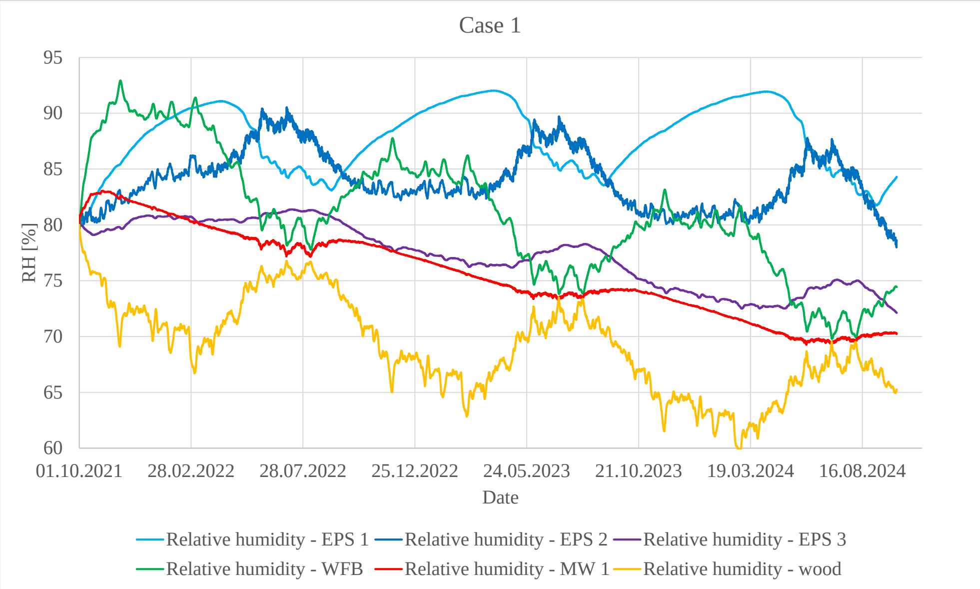
5 Conclusion

WUFI calculations of a wood-frame wall with the given exterior retrofit insulation system show a reduction in moisture level (RH) in the construction over time, for different interior and exterior climate conditions. The RH level is above 80% during periods in some of the calculated cases, also combined with temperatures that are favourable when evaluating mould growth. The temperature is generally above 5°C, and often above 10°C, in the material layers inside of the retrofit insulation system. Hence, some of the calculated cases show a risk of mould growth in the construction. Regarding risk of mould growth, the wood fibre board (exterior air barrier located between the wood frame wall construction and the retrofit insulation) was found to be the most critical. In 2D calculations it was discovered that positions furthest from the studs have larger risk of high RH.

The initial moisture level in the construction seems to be of great importance. Hence, the thickness of the wood-frame wall construction is also significant. Given that it is possible to ensure a low moisture level in the construction before retrofit insulation is installed, the calculations indicate that the moisture levels will remain low over time. This is based on an assumption of an air and vapour tight interior vapour barrier with no deficiencies and no possibilities of air leakages from the interior. Humid air from the interior through air leakages may change the moisture conditions and result in larger risk of mould growth when moisture is not allowed to dry outwards (due to the rather vapour tight retrofit insulation). Summarized, the construction is vulnerable to moisture exposure.

A Results from WUFI Pro Calculations

A.1 Material

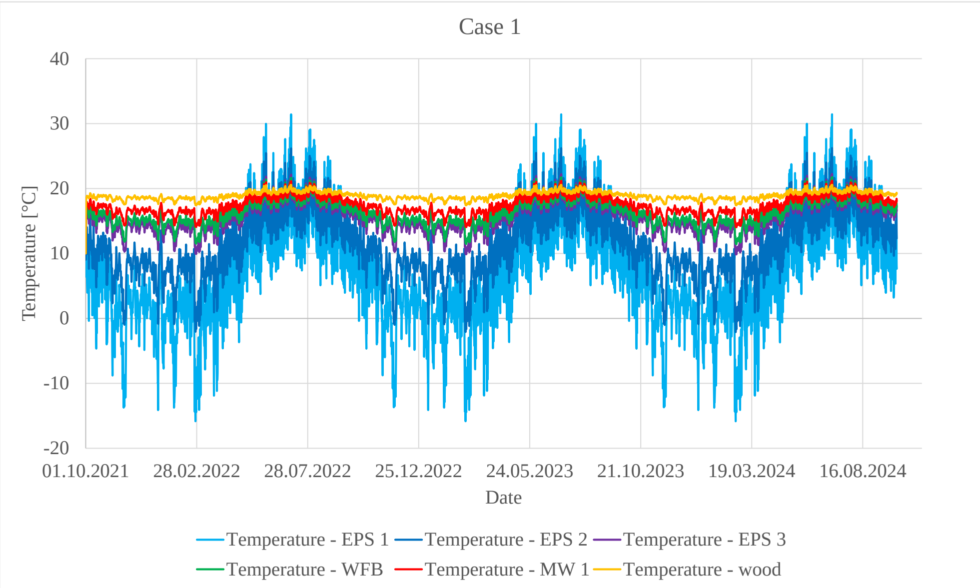


Position:
Various

Climate:
Trondheim

EPS1:
First layer of EPS (from exterior)
EPS2:
Second layer of EPS
EPS3:
Third layer of EPS
WFB:
Wood fibre board
MW1:
First layer of mineral wool
Wood:
Wooden frame

Figure 4. Development in RH in different materials in the construction for case 1.



Position:
Various

Climate:
Trondheim

EPS1:
First layer of EPS (from exterior)
EPS2:
Second layer of EPS
EPS3:
Third layer of EPS
WFB:
Wood fibre board
MW1:
First layer of mineral wool
Wood:
The wood in the wooden frame

Figure 5. Development in temperature in different materials in the construction for case 1.

A.2 Outdoor climate

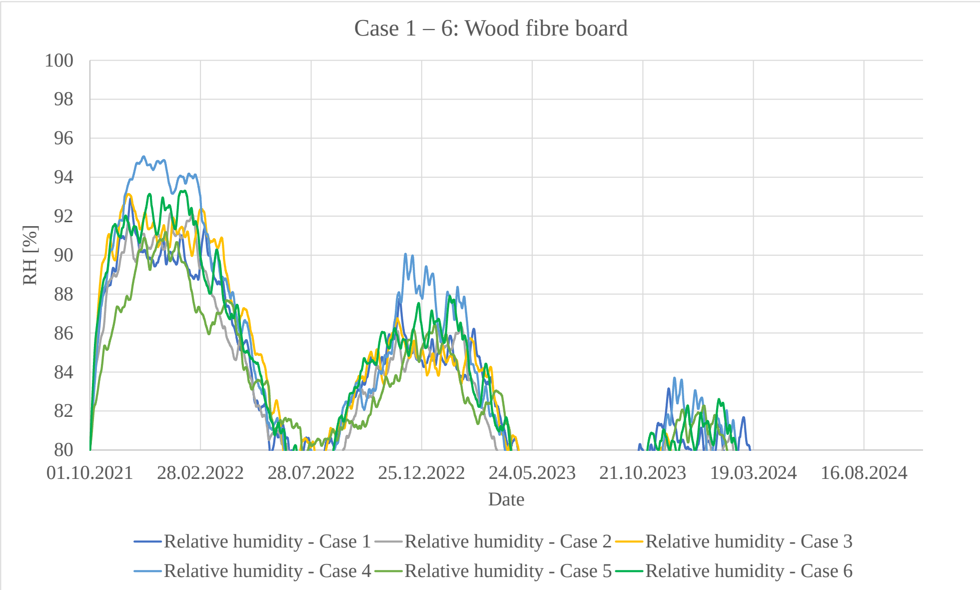


Figure 6. Development in RH for cases with different outdoor climates.

Position:
Wood fibre board
(exterior air barrier)

Case 1:
Trondheim
Case 2:
Oslo
Case 3:
Tromsø
Case 4:
Røros
Case 5:
Kristiansund
Case 6:
Mo i Rana

A.3 Interior moisture supply

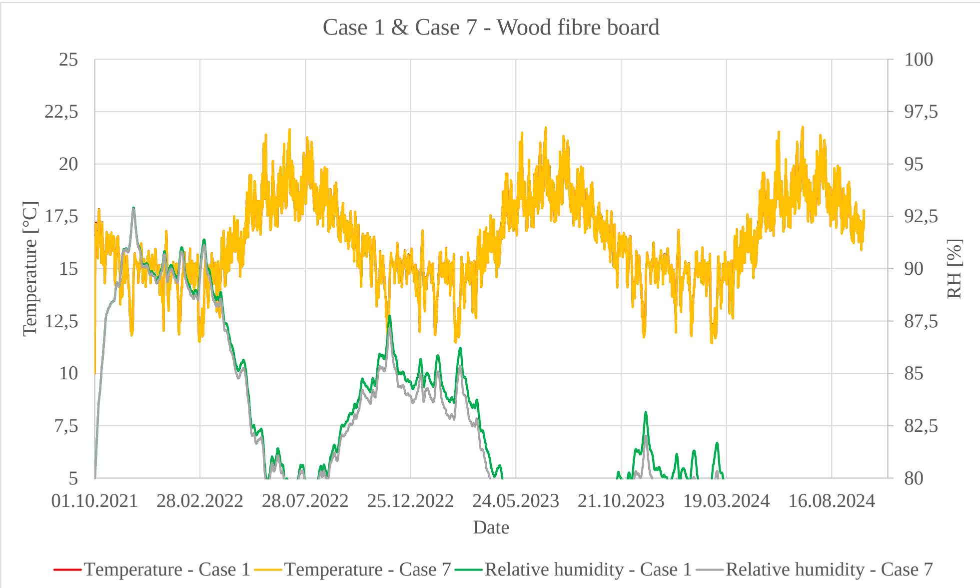


Figure 7. Development in temperature and RH for cases with different interior moisture supply.

Position:
Wood fibre board
(exterior air barrier)

Climate:
Trondheim

Case 1:
normal interior moisture supply
Case 7:
low interior moisture supply

A.4 Initial moisture conditions

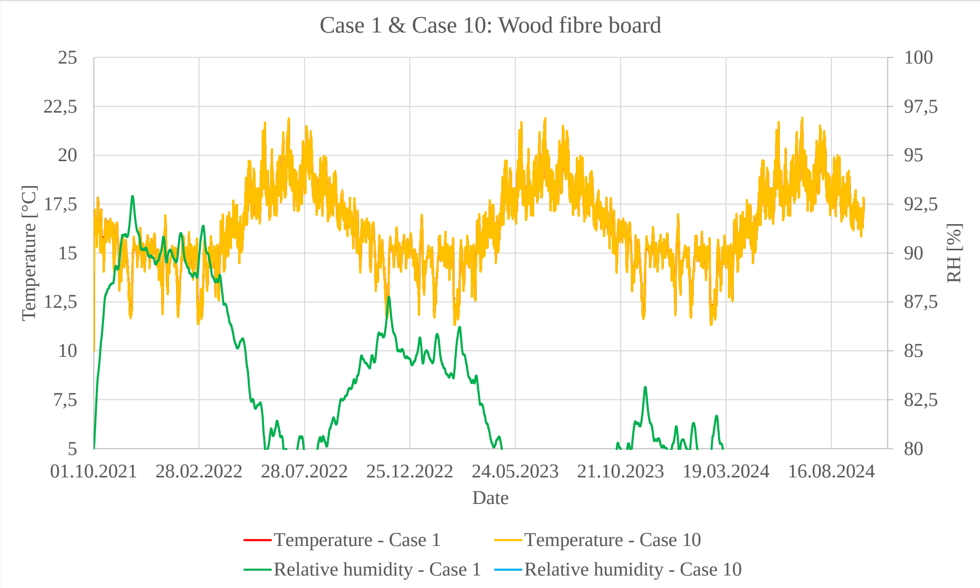


Figure 8. Development in temperature and RH for cases with different initial moisture levels.

Position:
Wood fibre board (exterior air barrier)

Climate:
Trondheim

Case 1:
80% RH initial moisture
Case 10:
60% RH initial moisture

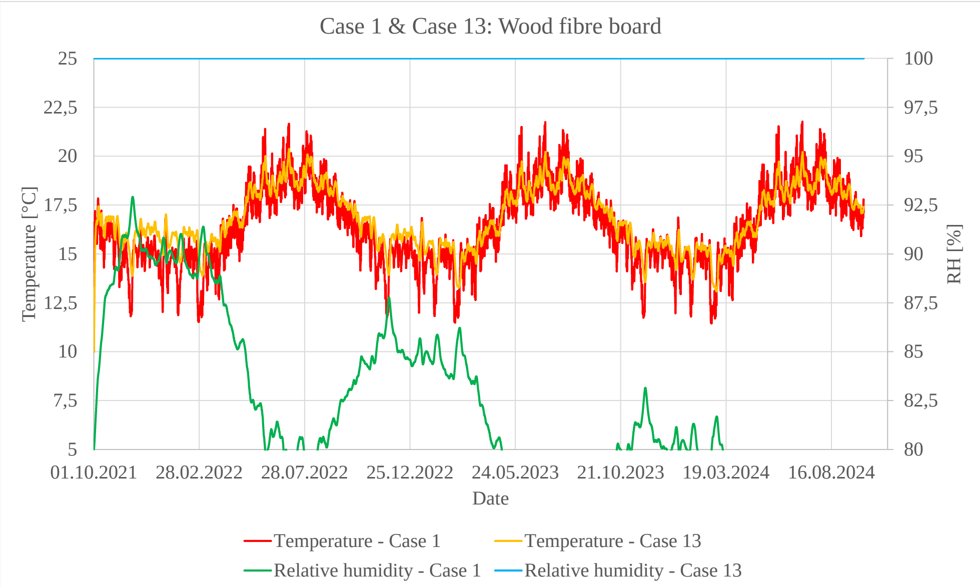


Figure 9. Development in temperature and RH for cases with different initial moisture levels.

Position:
Wood fibre board (exterior air barrier)

Climate:
Trondheim

Case 1:
80% RH initial moisture
Case 13:
100% RH initial moisture

A.5 Existing wall thickness

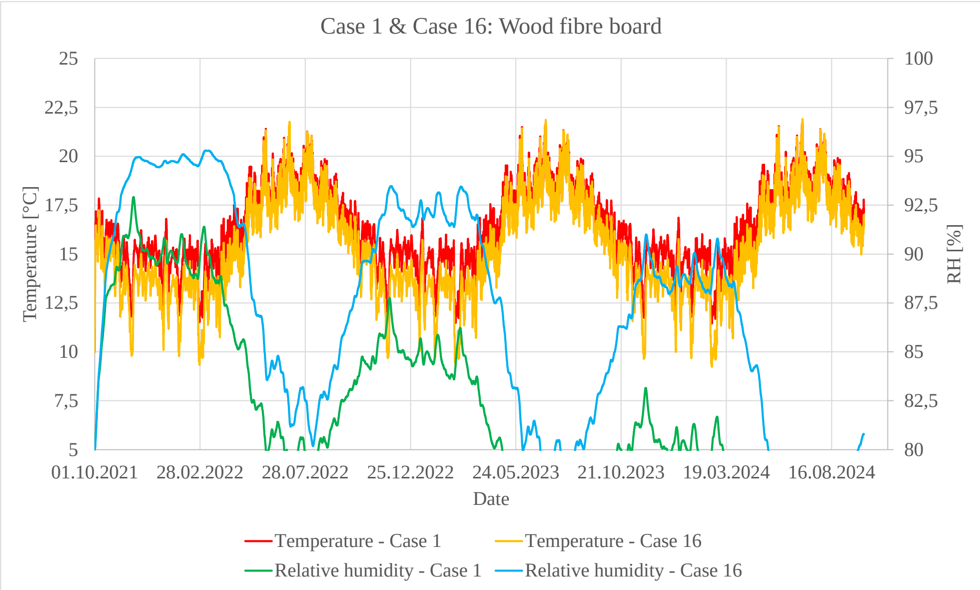


Figure 10. Development in temperature and RH for cases with different wall thicknesses.

Position:
Wood fibre board (exterior air barrier)

Climate:
Trondheim

Case 1:
Wall thickness 100 mm

Case 16:
Wall thickness 150 mm

A.6 Ventilated air cavity

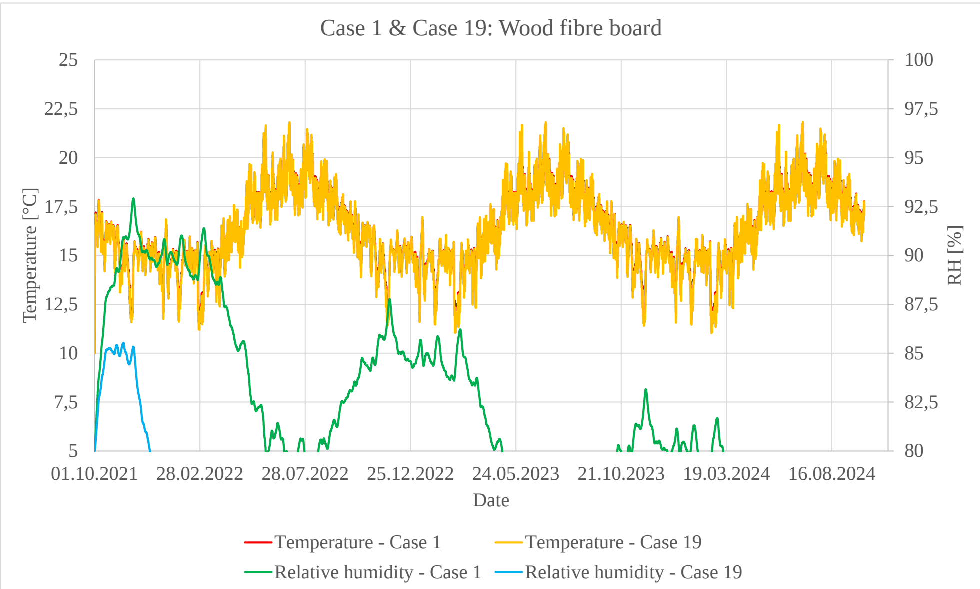


Figure 11. Development in temperature and RH for cases with different air cavities.

Position:
Wood fibre board (exterior air barrier)

Climate:
Trondheim

Case 1:
No air cavity

Case 19:
25 mm air cavity
1h^{-1} air change

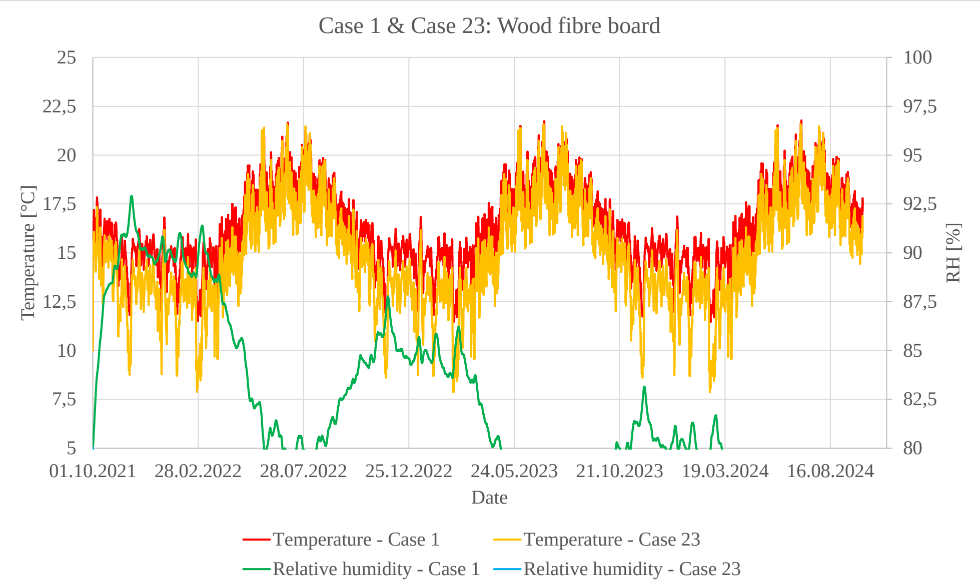


Figure 12. Development in temperature and RH for cases with different air cavities.

Position:
Wood fibre board (exterior air barrier)

Climate:
Trondheim

Case 1:
no air cavity
Case 23:
25 mm air cavity
$10h^{-1}$ air change

A.7 Calculation period

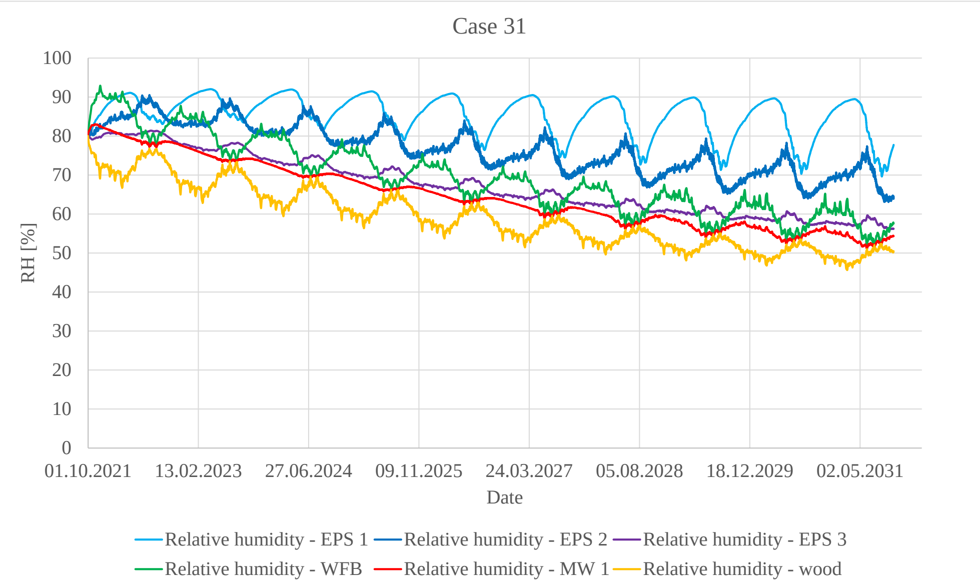


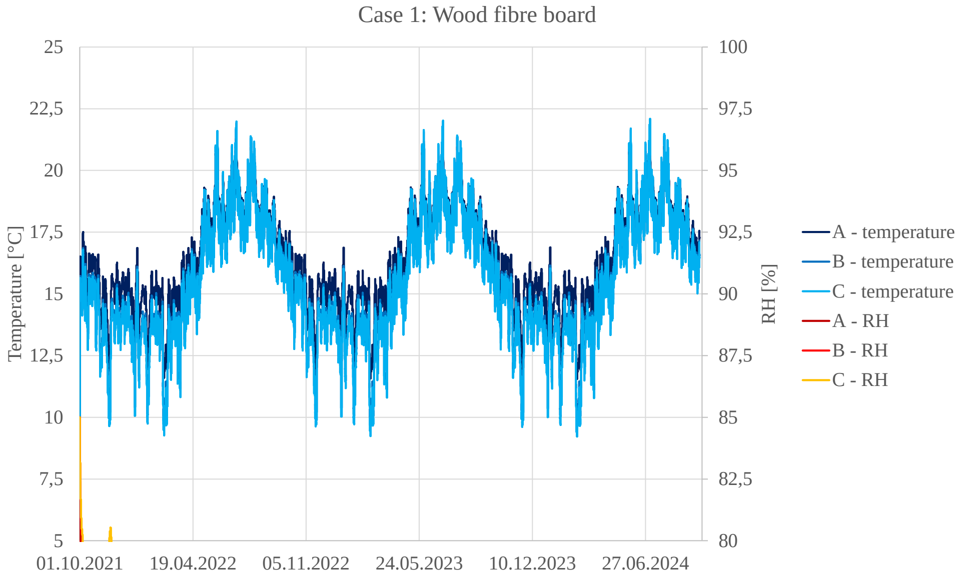
Figure 13. Development in RH in different materials in the construction for case 31.

Position:
Various

Climate:
Trondheim

EPS1:
First layer of EPS (from exterior)
EPS2:
Second layer of EPS
EPS3:
Third layer of EPS
WFB:
Wood fibre board
MW1:
First layer of mineral wool
Wood:
Wooden frame

B Results from WUFI2D calculations



Case 1:
Base case

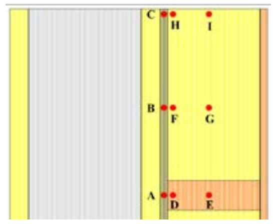
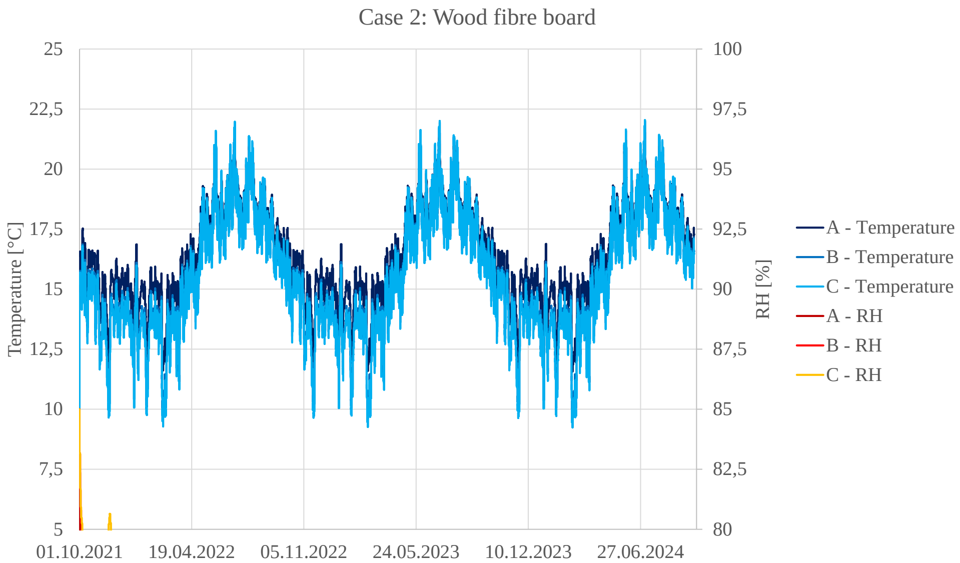


Figure 14. Development in RH and temperature in monitoring positions A, B and C in the wood fibre board (exterior air barrier) for Case 1.



Case 2:
High interior moisture supply

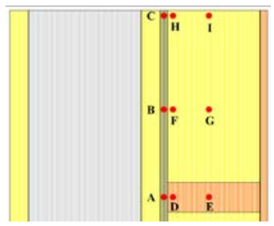
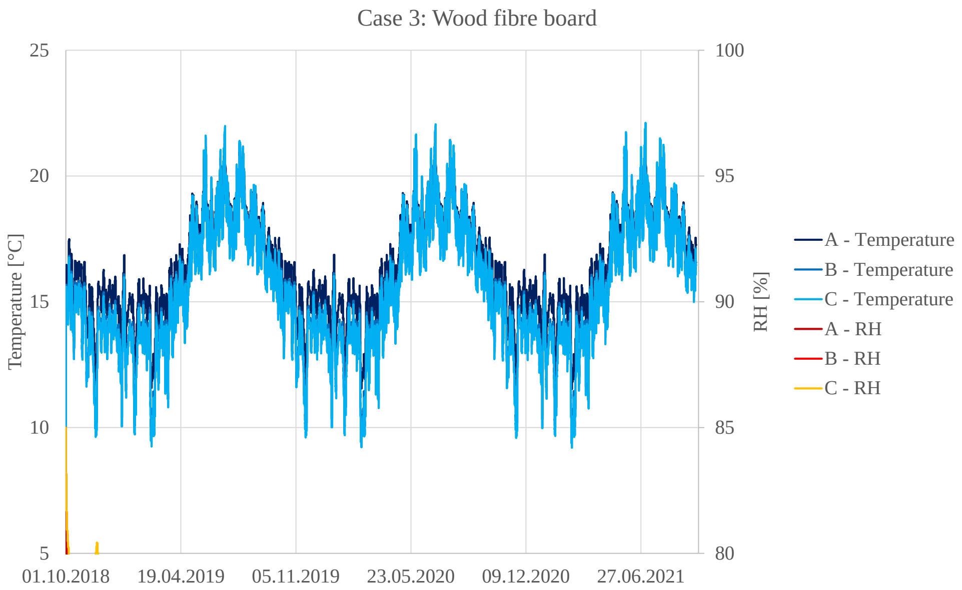


Figure 15. Development in RH and temperature in monitoring positions A, B and C in the wood fibre board (exterior air barrier) for Case 2.



Case 3:
Low interior moisture supply

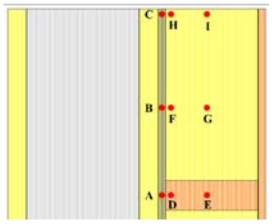
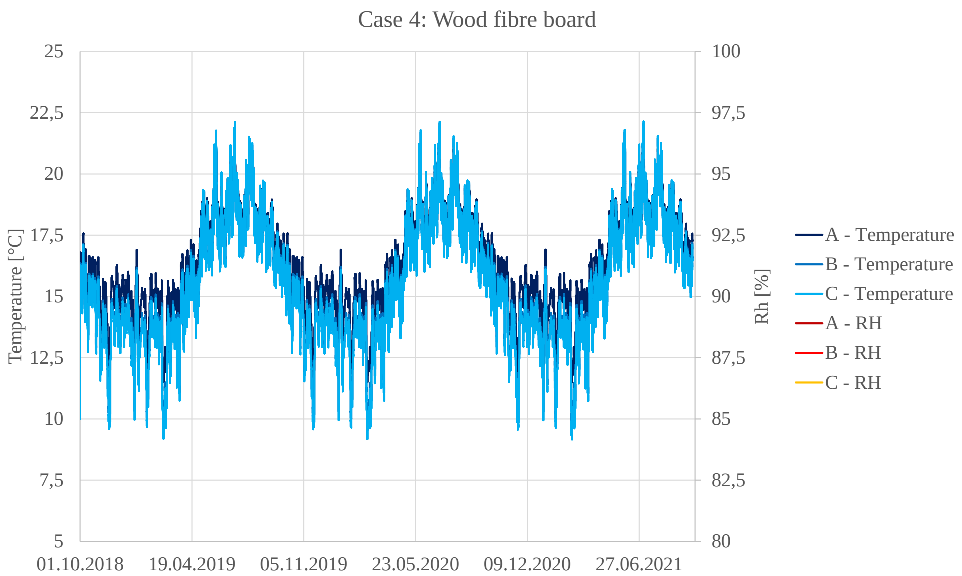


Figure 16. Development in RH and temperature in monitoring positions A, B and C in the wood fibre board (exterior air barrier) for Case 3.



Case 4:
Initial moisture level = 60% RH

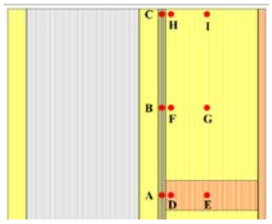
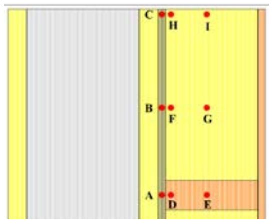


Figure 17. Development in RH and temperature in monitoring positions A, B and C in the wood fibre board (exterior air barrier) for Case 4.

Case 5:
Initial moisture level = 80% RH



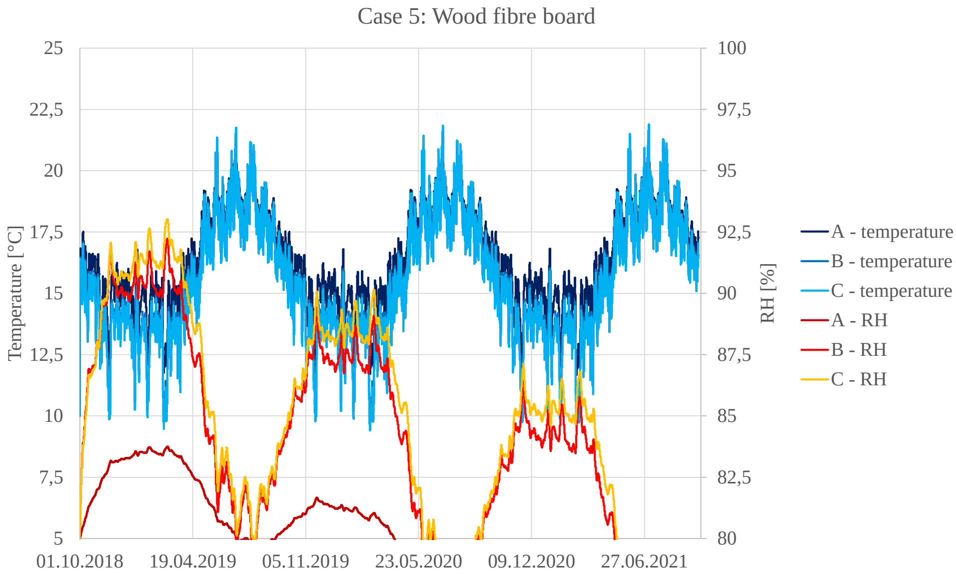
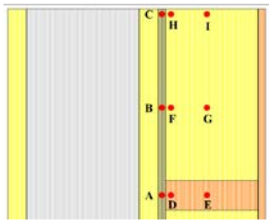


Figure 18. Development in RH and temperature in monitoring positions A, B and C in the wood fibre board (exterior air barrier) for Case 5.

Case 6:
Initial moisture level = 80% RH



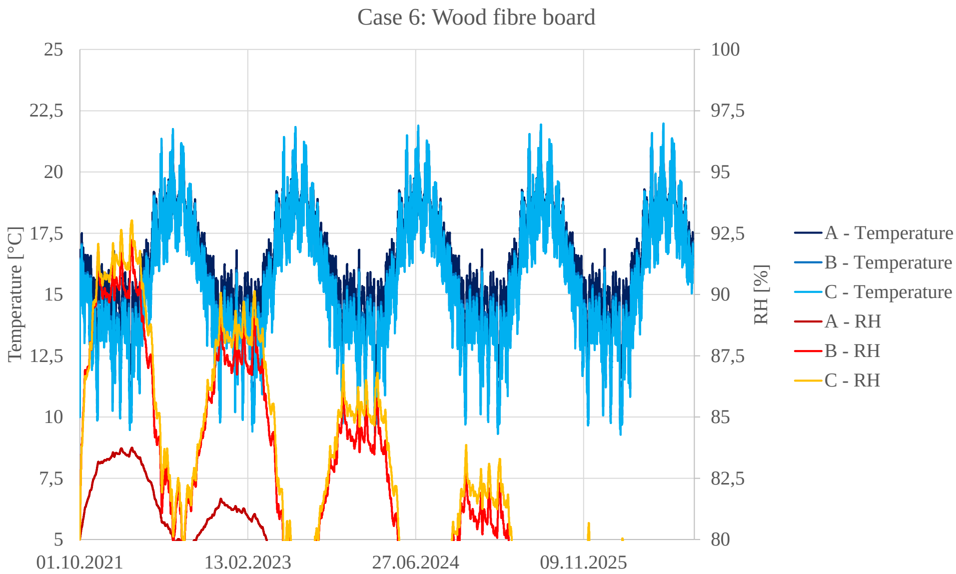
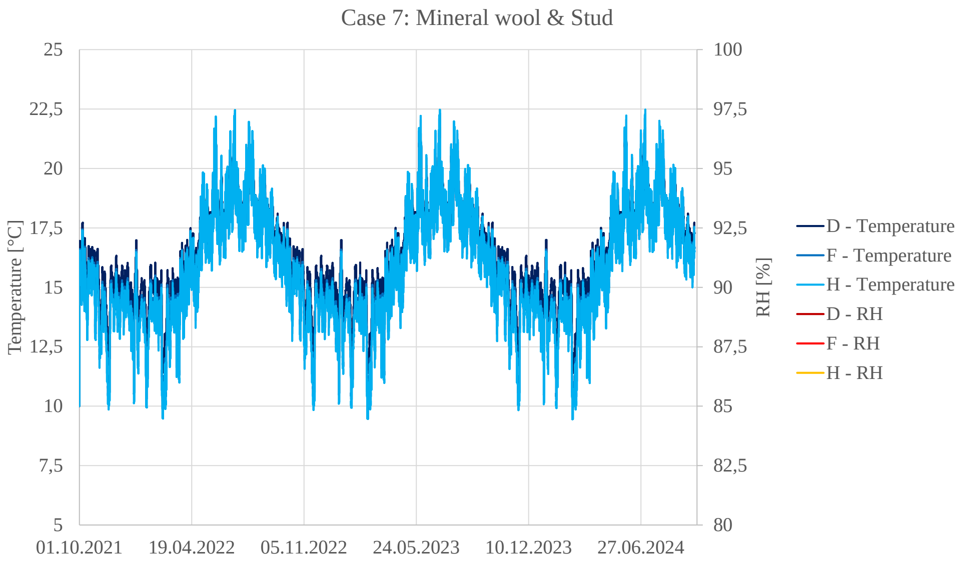


Figure 19. Development in RH and temperature in monitoring positions A, B and C in the wood fibre board (exterior air barrier) for Case 6.



Case 7:
Air barrier foil. Initial moisture level = 60% RH

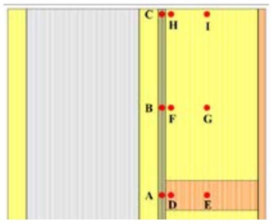
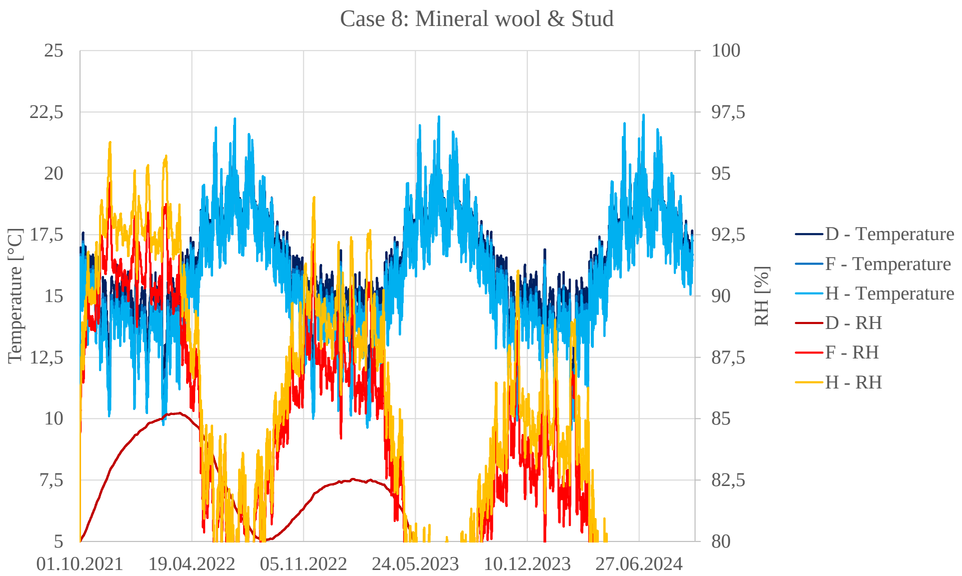


Figure 20. Development in RH and temperature in monitoring positions D (stud), and B and C (mineral wool) for Case 7.



Case 8:
Air barrier foil. Initial moisture level = 80% RH

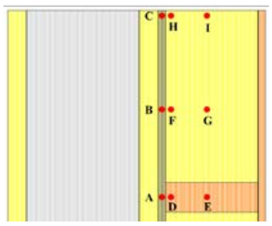


Figure 21. Development in RH and temperature in monitoring positions D (stud), and B and C (mineral wool) for Case 7.

C Technical data: Binding and pointing mortar

sto

Technisch informatieblad
Sto-Lijm- en voegmortel

Organische, cementvrije, lijmmortel voor het lijmen en voegen van Sto-Steenstrips en Sto-Ecoshapes

CE

Kenmerk

Toepassing	• buiten • als lijm- en voegmortel voor Sto-Ecoshapes, Sto-Steenstrips, Sto-Steenstrips Hoekstrip en Sto-Steenstrips Lateistrip
Eigenschappen	• dun aanbrengen

Technische gegevens

Criterium	Norm/ testvoorschrift	Waarde/ Eenheid	Opmerkingen
Dichtheid	EN ISO 2811	1,40 - 1,60 g/cm³	
Diffusie-equivalente luchtlaagdikte	EN ISO 7783	0,4 - 0,6 m	V2 gemiddeld
Waterdampdiffusieweerstand μ	EN ISO 7783	200 - 300	

Bij de opgave van de specificaties betreft het gemiddelde waarden resp. ca.-waarden. Vanwege het gebruik van natuurlijke grondstoffen in onze producten kunnen de opgegeven waarden per levering iets afwijken, zonder dat de geschiktheid van het product wordt beïnvloed.

Ondergrond

Eisen

Ondergrond algemeen:
- Vast, vlak, droog, draagkrachtig
- Vrij van vet en stof

opmerking:
- Vochtige of niet geheel gebonden ondergronden kunnen leiden tot beschadigingen zoals bv. blaasvorming, of scheuren in de volgende lagen.

Voorbereidingen

1. Aanwezige verflagen op draagkracht en hechting controleren.
2. Niet draagkrachtige lagen verwijderen.
3. Evt. de ondergrond reinigen.

D Technical data: Mineral strips

sto

Technisch informatieblad

Sto-Steenstrips

Gevelbekleding met metselwerk uiterlijk

Kenmerk	
Toepassing	• buiten • als gevelbekleding • op buitengevelisolatiesystemen en voorgehangen, geventileerde gevelsystemen en massieve ondergronden
Eigenschappen	• hoogste stootvastheid • hoogste slagvastheid
Formaat	• Lengte x hoogte, vermelding in mm: • Strips: 210 x 50, ca. 72 st/m² 155 x 50, ca. 97 st/m² Op aanvraag • Kop (EK):(Enter)100 x 50 (EK), ca. 144 st/m² Op aanvraag
Optiek	• steenoptiek: natuurlijke look door handmatige productie • veel vormgevingsmogelijkheden: kleuren, structuren, formaten
Bijzonderheden/opmerkingen	• de standaardkleuren Celle, Husum, Lübeck, Rügen, Verden en Xanten zijn een mengsel van verschillende kleuren

Technische gegevens

Criterium	Norm/ testvoorschrift	Waarde/ Eenheid	Opmerkingen
Dichtheid	EN ISO 2811	1,6 - 1,8 g/cm³	
Diffusie-equivalente luchtlaagdikte	EN ISO 7783	0,49 - 0,58 m	V2 gemiddeld

sto

Technisch informatieblad
Sto-Steenstrips

Waterdoorlaatbaarheid w	EN 1062-1	< 0,1 kg/(m²h$^{0.5}$)	W3 laag
Waterdampdiffusieweerstand µ	EN ISO 7783	110	gemiddelde waarde
Droge laagdikte	EN 1062-1	4.850 µm	E5 > 400
Korrelgrootte	EN 1062-1	< 1.500 µm	S3 grof
Massastroomdichtheid V	EN ISO 7783	middel	

Bij de opgave van de specificaties betreft het gemiddelde waarden resp. ca.-waarden. Vanwege het gebruik van natuurlijke grondstoffen in onze producten kunnen de opgegeven waarden per levering iets afwijken, zonder dat de geschiktheid van het product wordt beïnvloed.

Ondergrond

Eisen

Ondergrond algemeen:
- Vast, droog, schoon, draagkrachtig
- Vrij van sinterhuid, uitbloedingen en onthechtende substanties

Minerale ondergronden:
- De ondergrond met Sto-Putzgrund gronderen.

In de houtskeletbouw:
- Een bouwfysische berekening is vereist.
- Alternatieve tussencoating: StoPrep Miral

Minerale lichtgewicht onderpleister:
- Uitsluitend na overleg met Sto SE & Co.KGaA gebruiken.

Verwerking

Verwerkingstemperatuur

ondergrond- en luchttemperatuur:
Minimale temperatuur: +5°C

Verbruik

Toepassingssoort	Ca. verbruik
De verbruikswaarden worden gespecificeerd onder Kenmerken van het formaat .	

De opgegeven verbruikswaarden kunnen alleen worden gebruikt ter oriëntatie. Exacte verbruikswaarden moeten eventueel op het object worden bepaald.

Laagopbouw

1.verlijmen: Sto-Lijm- en voegmortel
2.bekleding: Sto-Eckverblender, Sto-Steenstrips Hoekstrip of Sto-Steenstrips Lateistrip

E Technical data: EPS

High-quality insulation panels MultiPro EPS for uncompromisingly high-grade, long-term insulation.

blaugelb Insulation Panel MultiPro EPS
For long-lasting insulation.

- Tongue and groove connection for unlimited extension
- 100 % recyclable
- 100 % HCFC, HFC and HBCD-free
- Enables sustainable construction thanks to reversibility of window sealing and fastening when renovating
- Low weight, high pressure resistance and high screw withdrawal values
- Does not produce fine dust harmful to the lungs when being processed (e.g. compared with mineral wool)
- Insensitive to moisture

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blaugelb Insulation Panel MultiPro EPS

For long-lasting insulation.

blaugelb

Product features:

The blaugelb Insulation Panel MultiPro EPS is made from a highly compacted EPS (expanded polystyrene) and offers the best possible heat and moisture protection in the vicinity of windows and façades. A major area of application of the blaugelb Insulation Panel MultiPro EPS is meeting the high requirements placed on passive houses, low-energy houses/thermal rehabilitation. The blaugelb insulation panels allow consistent and homogeneous insulation to be achieved, ensuring that no valuable heating energy is lost. This external insulation keeps the heat inside the room. Insulating the outside ensures that heat is retained in the masonry, exploiting the storage capacity of the blaugelb Insulation Panel MultiPro EPS material. The existing tongue and groove connection facilitates precise work, especially over large areas, as the panels can be slid into one another with precision and the resulting insulation surface presents a homogeneous picture.

The blaugelb Insulation Panel MultiPro can be fastened mechanically. To eliminate thermal bridges, the panels can be mounted on a steel girder using the blaugelb Hybrid Polymer Power Fix, among others. The blaugelb Insulation Panels MultiPro EPS are absolutely insensitive to moisture, so houses insulated with blaugelb Insulation Panels MultiPro EPS are not at risk from mould. The more a house is insulated, the greater is the surface temperature on the inside of the outer walls and the less is the danger of condensation and mould forming. The high-density EPS material does not provide a growth medium for mould fungi, does not rot and retains its properties over the long term.

Applications:

- In the vicinity of windows and facades with high requirements on strength, pressure resistance and insulating properties
- Insulation of windows and door connections (e.g. steel girders, concrete supports)
- Insulation of critical areas (e.g. in wood-aluminium, aluminium and PVC systems)
- Floor recess profile for special structures with high load transfer (e.g. doors and lift-and-slide systems)
- Insulation of panels
- Load-transferring jamb extension for the mounting of sealing systems for proper window connections with the positive insulation properties and increased compressive strength so that the connection materials can function
- Cladding substructures of heavy lift-and-slide door systems
- Roller shutter, Venetian blind and external blind construction

Product benefits:

- Tongue and groove connection for unlimited extension
- 100 % recyclable
- 100 % HCFC, HFC and HBCD-free
- High-density (expanded) polystyrene
- High ductility
- Enables sustainable construction thanks to reversibility of window sealing and fastening when renovating
- blaugelb insulation panels are easy to machine/saw with a jigsaw or mitre saw (coarse longitudinal-cut blade)
- Can be cut to size precisely with little dust
- Low weight, high pressure resistance and high screw withdrawal values
- High inherent stability and flexural strength
- Does not produce fine dust harmful to the lungs when being processed (e.g. compared with mineral wool)
- Dimensionally stable
- Easy to process
- Insensitive to moisture

Technical data:

Material:	high-density EPS (expanded polystyrene), high ductility
Colour:	grey
Load transfer:	> 200 kg/m
Fire behaviour: **DIN EN 13501-1**	class E
Thermal conductivity nominal value λ_D: **DIN EN 12667**	λ = 0.040 W/m°K
Water vapour diffusion resistance: **DIN EN ISO 12572**	380 – 550 µ
Airborne sound insulation: **DIN EN ISO 717-1** (with an area of 0.8 m²)	30 mm: R_w 28.0 dB ± 1.2 dB 40 mm: R_w 28.5 dB ± 1.2 dB 60 mm: R_w 31.9 dB ± 1.2 dB 80 mm: R_w 33.9 dB ± 1.2 dB
Air permeability: **EN 12207**	Class 4
Bending strength: **DIN EN 12089**	≥ 650 kPa
Compression stress (10 %) compression: **DIN EN 13163:2015-04**	≥ 2,500 kPa
Compression stress (2%) compression: **DIN EN 13163:2015-04**	≥ 1,100 kPa
Shear strength: **DIN EN ISO 14130**	0.217 N/mm²
Dimensional strength: **DIN ISO 75-1**	short-term up to +95 °C long-term up to +85 °C
Dimensional stability: **DIN EN 13163:2015-04**	very high, including outdoor weathering
Water absorption after 28 days under water: **DIN 12087**	≤ 1.5 vol. %
Compatibility with conventional building materials:	compatible, except for solvents, solvent-bearing materials and materials that are not polystyrene-compatible
Ageing resistance:	mould-proof, does not rot
Waste code:	code no. 170604 code no. 170904

Product name	PU/pallet	Item no.
blaugelb Insulation Panel MultiPro EPS 30 x 1200 x 1200 mm	30 piece	9049338
blaugelb Insulation Panel MultiPro EPS 35 x 1200 x 1200 mm	27 piece	9049339
blaugelb Insulation Panel MultiPro EPS 40 x 1200 x 1200 mm	24 piece	9049340
blaugelb Insulation Panel MultiPro EPS 45 x 1200 x 1200 mm	22 piece	9066610
blaugelb Insulation Panel MultiPro EPS 50 x 1200 x 1200 mm	20 piece	9049341
blaugelb Insulation Panel MultiPro EPS 55 x 1200 x 1200 mm	18 piece	9049342
blaugelb Insulation Panel MultiPro EPS 60 x 1200 x 1200 mm	17 piece	9049343
blaugelb Insulation Panel MultiPro EPS 65 x 1200 x 1200 mm	16 piece	9049354

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