ArmaPET® Insights
THERMAL INSULATION PERFORMANCE

Long-term thermal insulation performance of rigid foam boards under wet conditions

Working together with the FIW Institute (Forschungsinstitut für Wärmeschutz e.V München), we have evaluated the long-term thermal performance of PET, PU and XPS boards. The purpose of the test was to compare the thermal performance of PET with that of PU and XPS under the condition of high water contents due to absorption and adsorption as a result of water vapour diffusion to replicate real-use case performance.

MATERIALS USED FOR TESTING

For PET, **ArmaPET Eco50** was used. It has a nominal density of 50 kg/m³ and is based on 100% recycled polyethylene terephthalate (PET) foam in accordance with EAD 040179-00-1201.

For the PU Reference, a **CE-certified polyurethane** (PUR) foam with a nominal density of **30 kg/m³** was used. The manufacturer is known to Armacell.

For the XPS Reference, a **CE-certified extruded polystyrene** (XPS) foam with a nominal density of **30 kg/m³** was used. The manufacturer is known to Armacell.
All samples had a thickness of 50 mm and were provided in a dimension of 500 x 500 (length x width).

TEST PROCEDURE

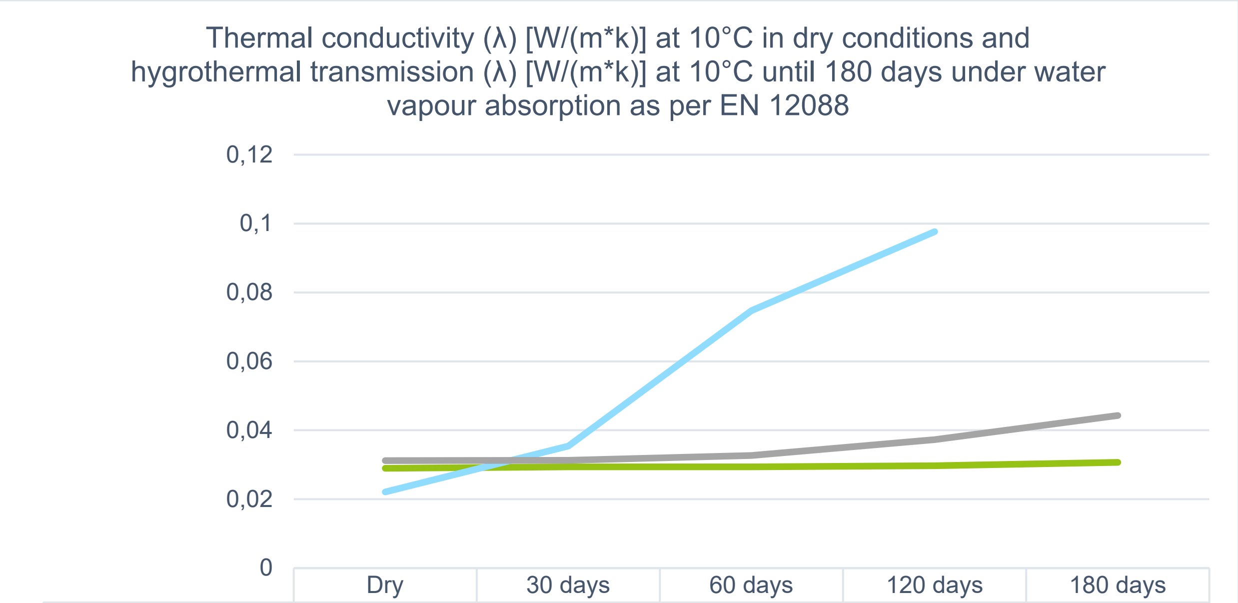
All samples were stored for 180 days under the test conditions described in EN 12088 (long-term water absorption by diffusion) between a water bath of 50°C and a cold plate of 1°C. The storage was interrupted regularly to determine the water uptake and the thermal performance of the wet specimens as per EN 12664. This evaluation was done in a dry state, after 30 days, 60 days, 120 days and 180 days of water absorption by diffusion.

Explanations on thermal conductivity tests: For standard thermal conductivity, the materials would be tested in a dry state as per EN 12667. EN 12664 is a test method for testing wet specimens with identical equipment, while the test procedure is adapted to reduce additional heat fluxes due to redistribution of the water content inside the specimen. EN 12664 determines additional physical values in addition to thermal conductivity with which the thermal performance of moist materials can be described more accurately. Both physical values are comparable with the thermal conductivity (λ) described in EN 12667, but respect the influence of moisture in wet specimens:

- Hygrothermal transmission of a material (λ) in W/(m*K), as per EN 12664 section A2.9, which "applies to moist materials during steady state conditions when moisture distribution within the material is in equilibrium and there is no moisture movement within the material (with the possible exception of moisture circulating locally or within a pore)".
- Transfer factor of a specimen T in W/(m*K) according to EN 12664 section A2.8. which "characterises a specimen in relation to moisture migration and/or the combined conduction, convention and radiation heat transfer"

The hygrothermal transmission (λ) was chosen to interpret the measurement data. Measurements were taken to minimise additional transient and misleading heat fluxes by FIW during storage and testing.

RESULTS & FINDINGS

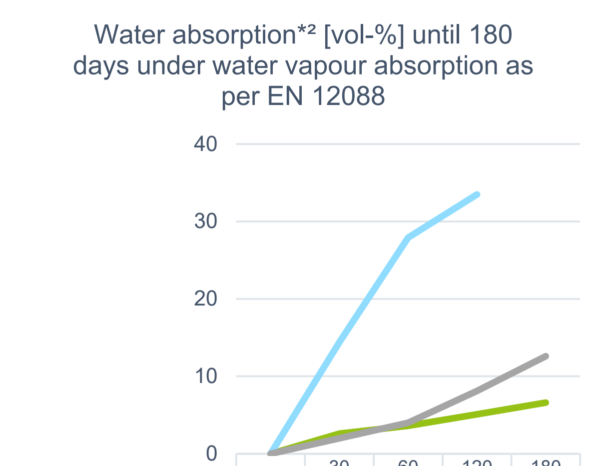


	Dry	30 days	60 days	120 days	180 days
ArmaPET Eco50	0,029	0,0294	0,0294	0,0297	0,0307
PU reference*	0,0221	0,0354	0,0747	0,0977	
XPS reference	0,0312	0,0313	0,0327	0,0373	0,0443

Table 1: based on report L1-22-042a from FIW

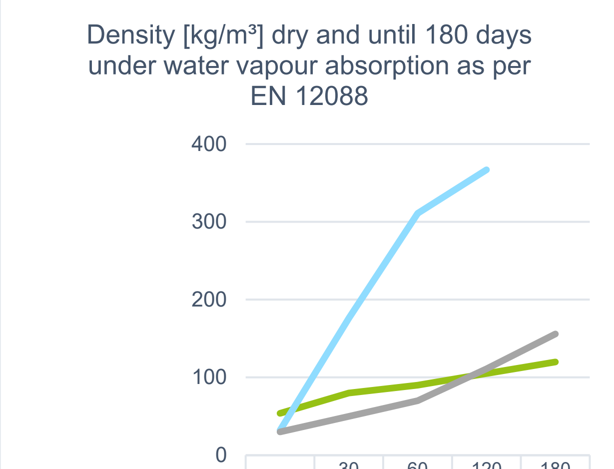
**The PU reference was stopped after 81 days of water absorption because water content reached a level at which the product was starting to be incapable of keeping all adsorbed/absorbed water inside its body.*

Regarding the PU results at 60 and 180 days: Due to high water content, it can't be excluded that latent heat fluxes contributed to the thermal transmission. Therefore, the test results represent the "transfer factor of a specimen" T.



	Dry	30 days	60 days	120 days	180 days
ArmaPET Eco50	0	2,6	3,6	5,1	6,6
PU reference*	0	14,4	27,9	33,5	
XPS reference	0	2	4	8,1	12,6

Table 2: based on report L1-22-042a from FIW



	Dry	30 days	60 days	120 days	180 days
ArmaPET Eco50	54	80	90	105	120
PU Reference*	32	176	311	367	
XPS Reference	30	50	70	111	156

Table 3: based on report L1-22-042a from FIW

**²* The levels of water content achieved were high above the hygroscopic level and also above the value typical for damage-free installation of insulation boards.*

The charts show a clear trend of high moisture absorption of the PU reference sample and a related decrease in thermal insulation performance over a short period of time. It is to say that this is likely not representative for all PUR materials and some will show less moisture intake. However, the trend of decreased thermal performance of PUR was also already proved in "New Wetting Curves for Common Roof Insulation" by Wayne Tobiasson, Alan Greatorex and Doris van Pelt in 1991, published in the International Symposium on Roofing Technology.

The same trend, while less significant, can also be found for XPS. While the starting density was lower than for PET (30 kg/m² compared to 54 kg/m³), the final increase was 420% for XPS, resulting in a higher-density specimen after 180 days than the PET one (+122% in density). While the water absorption and related thermal conductivity are still comparable in the first 60 days (Δλ 33 mW), we see a steeper increase after 120 days (Δλ76 mW) and 180 days (Δλ137 mW) in both water absorption and the resulting reduced thermal insulation behaviour. So, on overall thermal performance we see an increase of 0.0131 W/(m*K) from 0.0312 to 0.0443 W/(m*K).

For PET, we can recognise a water absorption of max. 6.6 vol-% after 180 days, which leads to a small increase in thermal conductivity of 0.0017 W/(m*K), from 0.0290 to 0.0307 W/(m*K). This strongly supports the finding that PET has a very stable insulation performance over time, even and especially under the impact of heavy moisture intake.

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