# Moisture properties of vapor open roofing underlays in winter conditions


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## INTRODUCTION

Vapor open roofing underlay`s mounted according to the acknowledged guidelines in Norway have in the past cold winters experienced problems with rim and melt water on the interior side of the products. When the temperature is below zero, diffusion of water vapor leads to accumulation of rime/ice on the underside of the roofing underlay. This can, when the outdoor temperature quickly rises above zero degrees, lead to dripping from the roofing underlay, experienced as a water leakage through the ceiling for users of the building. This water can cause short-and long term damages to the building elements such as window frames, ceiling plates, gypsum boards in both walls and roofs etc.

## OBJECTIVES

An extensive laboratory experiment was conducted in 2010-2011 at SINTEF Building and Infrastructure, Trondheim, Norway. The objective was to investigate the water vapor resistance in vapor open roofing underlays in temperatures below zero, with potential for rime/ice on the underside of the products. The water vapor permeance is the roofing underlays ability to transport water vapor from one side of the product to the other. The purpose of the experiment was to investigate if and how the vapor permeance of the material changes when rime/ice is formed on the interior side of the product. The research question was to investigate if the potential for further accumulation of rime/ice increase when there is ice on the product?

## Method and apparatus

The experiment was going to simulate winter conditions in thermal insulated wooden roof structures with a high level of build in moisture. Ten vapor open roofing underlay`s was tested in an advanced and further developed version of the cup-method described in NS-EN ISO 12572. Each underlay represented the top lid of a plastic box that contained 200 mm insulation with water in the bottom. The water in the bottom of the box was held at a constant temperature of +23 ˚ C. The temperature on the outside of the box was -4 ˚ C when testing in sub-zero conditions. The respectively $s_d$-values was calculated by registering the weight loss for each product as the experiment progressed. In addition, the condensation uptake for each product was measured, using an additional box with removable lids made of the respective roofing underlays. The apparatus is shown in Figure 1.

Figure 1 Overview of the experiment apparatus in the laboratory

Each product replaced the original lids on two separate boxes. Boxes closest in the left row in the picture were used to measure the water vapor diffusion resistance, and the lid was sealed with butyl tape. Sensors for measuring the relative humidity were mounted inside the box, close to the interior side of the roofing underlay. Two sensors were also mounted inside the room, tracking the temperature and relative humidity in the room. Thermo elements were mounted on both exterior and interior side of the roofing underlays, and were detached at each weighing of the boxes. The boxes in the row to the right in the picture had a detachable lid, making it possible to investigate how much rime/ice that was attached to the specimen.

## Results and discussion

The results for a total of 10 products are shown in Figure 2. The vapor diffusion resistance is presented as the $s_d$-value. The products are anonymous and called A-J.

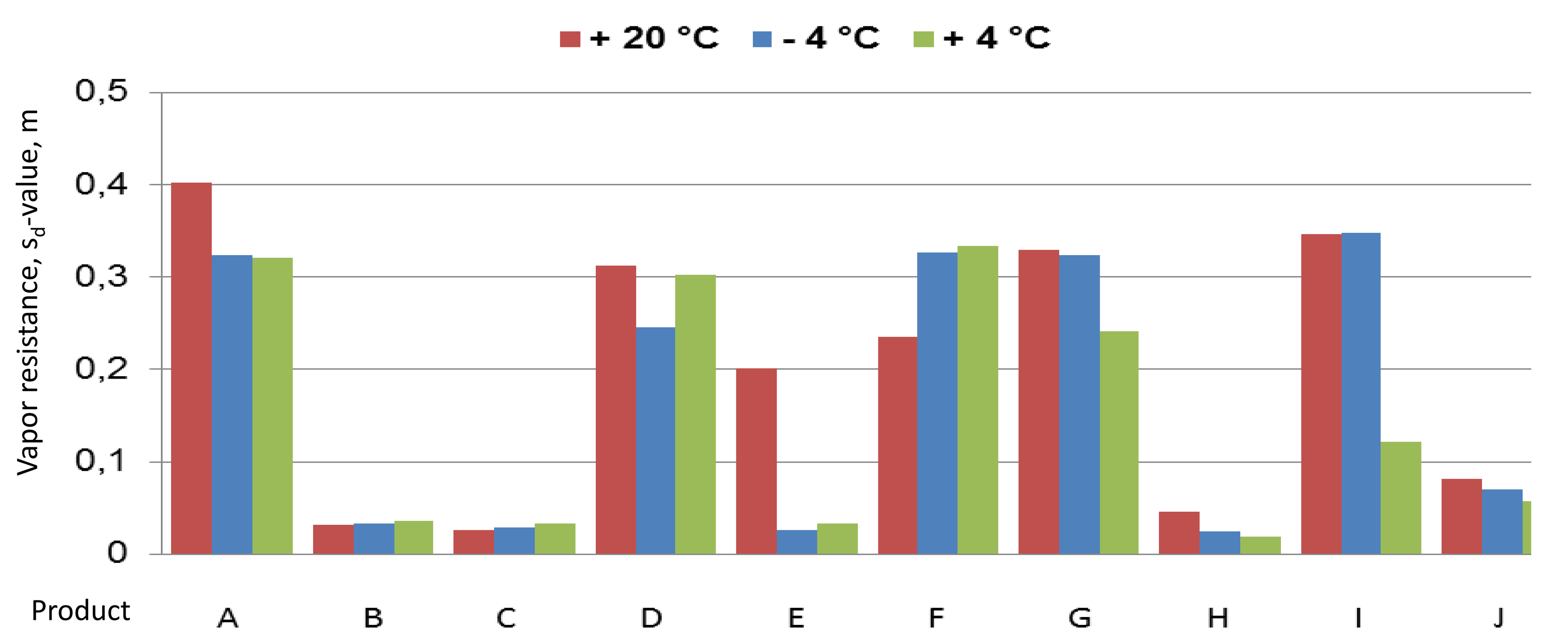


Figure 2 The $s_d$-values for the ten products A-J at the respective temperatures

The results show that six of the ten roofing underlays have approximately the same vapor resistance in temperatures below zero as in room temperatures. Product F had a significant increase in the vapor resistance (+40 %). Product E had a severe decrease in water vapor diffusion resistance in cold temperatures (-85 %).

The moisture flow (moisture transport + moisture uptake) is highest at +20 ˚C. In winter conditions the moisture uptake is the main part of the moisture flow for several products. Even if the $s_d$-value in sub-zero temperatures is approximately the same at +20 ˚C, the total amount of water vapor that is diffusing thorough the material at -4 ˚C is remarkably lower. This is due to the fact that the moisture transport via diffusion through the material is dependent on the $s_d$-value of the product and the water vapor pressure difference through the samples. The water vapor pressure differences across the samples are lower in sub-zero temperatures, thus the total water vapor flow through the samples will be lower in sub-zero temperatures.

Figure 3 shows three examples of roofing underlays with ice on the interior surface. All the three products was participating in the experiment.


Figure 3 Three examples of roofing underlays with ice on the interior side during the experiment (-4 ˚C)

## Conclusion

The results show that to avoid condensation on roofing underlays the most crucial property of the roofing underlay is a low water vapor diffusion resistance ($s_d$-value). The capability to temporarily store water might compensate for a somewhat lower capability to transfer moisture. It is important though, that the stored moisture is dried out before the temperature in the spring reaches above approximately +5 ˚C, preventing the possibility for mold growth to start.

The level of build in moisture in the structure is also important. The risk of ice underneath the roofing underlay can be further reduced by having an air tight structure, and having a roofing underlay with the ability to store water without letting it fall down from its surface.

The results and conclusions in this article are only valid for the product included in the experiments and can not automatically be transferred to other roofing underlay products.

## ACKNOWLEDGEMENTS


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