



NATIONAL FIBER
CEL-PAK INSULATION

Professional Cellulose for Cellulose Professionals

The Hygroscopic Properties of Cellulose Insulation and its Relevance in Superinsulated Buildings

Many of our common insulating materials (fiberglass, mineral fiber and foam) are hydrophobic, meaning they don't interact with moisture. Unfortunately, this property can also allow diffusional and airborne moisture to accumulate and linger on surrounding wood and steel building materials, resulting in damage.

Cellulose insulation is made from wood fibers and is hygroscopic, responding much differently to moisture than hydrophobic materials. As moisture levels fluctuate, hygroscopic materials will slowly take on or release moisture as a function of their sorption/desorption curve. Hygroscopic properties also help to distribute moisture evenly throughout the material. The mass of cellulose also allows it to temporarily store moisture and act as a hygric buffer in response to moisture fluctuation. These properties are protective to both the cellulose and adjacent surfaces, by denying damaging organisms the water they need to replicate.

The issue for superinsulated building cavities is that, in the winter, the extra insulation allows the exterior sheathing to get much colder than in conventionally insulated buildings. This can be a problem for fibrous, hydrophobic materials like fiberglass and mineral fiber, since outward diffusional and airborne moisture flows readily pass through these materials. If this moisture cools below its dew point on its way outward, it can condense and/or freeze on the interior side of the building's exterior sheathing. This is problematic since these materials don't interact with water, thus allowing the possibility of mold and rot to develop over time. Very careful detailing of vapor barriers, combined with airtight drywall, is critical with these insulation materials to try to prevent durability issues.

In cellulose-filled superinsulated building cavities, the rate of the inward hygroscopic moisture dispersion is faster than the diffusional moisture drive outward, never allowing the moisture levels to reach dew point. Moisture measurements of 12 inch, dense pack cellulose filled walls at the end of the winter in VT and MA has shown the moisture content of the exterior sheathing typically ranging within 2% of the interior drywall. In buildings with a 50% interior relative humidity, this equates to an approximately 8% moisture content on the interior drywall and 10% moisture content of the exterior sheathing. The ability of cellulose to disperse moisture to the interior, combined with its high installed density of over 3.5 lbs/cuft, makes vapor barriers and airtight drywall unnecessary and, in fact, counterproductive, with dense pack cellulose insulation. This has been borne out by the more than thirty years of experience we have with the first generation of superinsulated cellulose buildings that were constructed in the early 1980's.

These same building science principles are applied when using dense pack cellulose in unvented roof assemblies. The key to their long term performance and durability lies in the installed density being high enough to allow the cellulose to remain in contact with, and protect, the exterior roof sheathing. In a twelve-inch deep rafter bay, an installed density of 3.7 lbs/cuft is required, while in an eighteen-inch rafter bay, an installed density of 4.0 lbs/cuft is necessary. This high density will require several passes, both horizontally and vertically within the rafter bay, to achieve a consistent installed density. The expanded bag coverage chart is used, along with an actual bag count, to allow the installer to verify that the appropriate self-supporting density has been achieved for the rafter depth being insulated.

Moisture modeling software such as dew models and WUFI can be useful in modeling relatively simple single or two-way dimensional moisture flows through hydrophobic materials. These models, however, do not have the mathematical sophistication necessary to model the much more complex moisture flows and hygric buffering that occurs in hygroscopic materials like cellulose insulation.



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If you have any questions or would like to discuss this further, please contact our Technical Manager, Bill Hulstrunk at technical@nationalfiber.com.