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Research Shows Increased Building Tightness With Cellulose Insulation

Cellulose Insulation and Airtightness

The following letter is one of several we have received asking or commenting about the effect of cellulose fiber insulation on building airtightness:

To the Editor:

I have heard two claims for cellulose insulation that I would like to confirm if possible. The first is that because of its density and compactness, cellulose insulation significantly reduces air leakage through the exterior skin of a house. In other words, houses insulated with cellulose insulation are tighter than houses built with fiberglass batts. The second claim is that unlike fiberglass batts, blown cellulose does not allow convective air loops to form within the insulation layer. If these claims are true, then cellulose seems to have some distinct advantages over fiberglass batts.

Any information you have supporting or refuting these claims will be appreciated.

Cynthia Wells, Chicago.

Research has shown increased building tightness with cellulose insulation.
A 1979 study performed by Seton. Johnson and Odell for the Oregon Department of Energy found the measured air leakage of homes insulated with cellulose fiber insulation (CFI) to be 15 to 20% less than the air leakage of homes insulated with other insulation materials. Blower door tests of 71 homes found the average leakage for cellulose homes to be ID.6 air changes per hour at 50 Pa. compared to 13.0 ach for homes insulated with rockwool (Figure 1). Only limited conclusions can be drawn from these data since the houses differed in other ways in addition to insulation type. but the trend for greater tightness with cellulose is probably valid.

A more formal investigation on this topic was conducted in 1984 by David Jacobson. David Harrje. and Gautam Dutt at Princeton University. They built a simulated attic floor consisting of a test platform with intentional cracks in it. Using a controlled pressure device, air was forced through the cracks in the platform, first with no insulation on it, then successively with cellulose, fiberglass batts, fiberglass blowing wool, and finally vermiculite on it. The relative reduction in airflow caused by the various materials was measured. The results are shown in figure 2. The greatest reduction was caused by cellulose insulation.

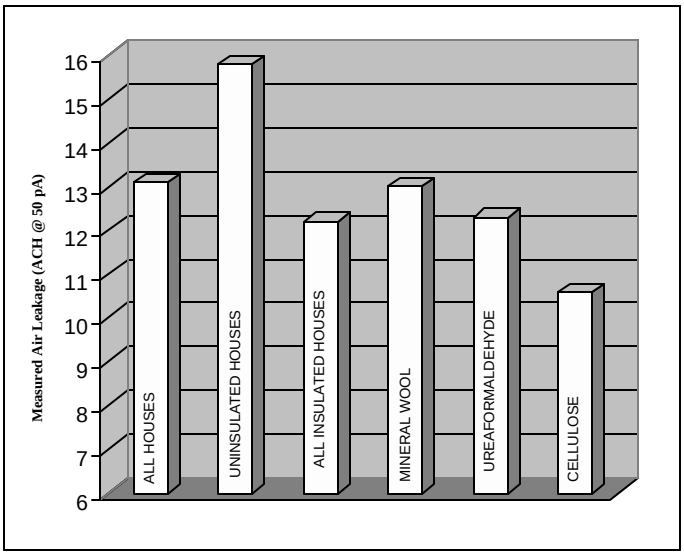

Figure 1 – Measured air leakage of homes insulated with various types of insulation. *Source: Princeton University*

The Princeton researchers also performed three field tests to measure the reduction in air leakage in houses retro-insulated with blown cellulose. Three houses were pressure tested with a blower door before and after retro-insulating the walls with cellulose. The results are shown in Figure 3. In two houses, the reduction was enormous, but in a third, the reduction was only 3.6%. [The two houses with high reductions in air leakage both had balloon framing which was probably open to the attic.]

Finally, a telling illustration of cellulose's ability to block

air leakage is described in a just-released report from the Minnesota Department of Energy and Economic Development.

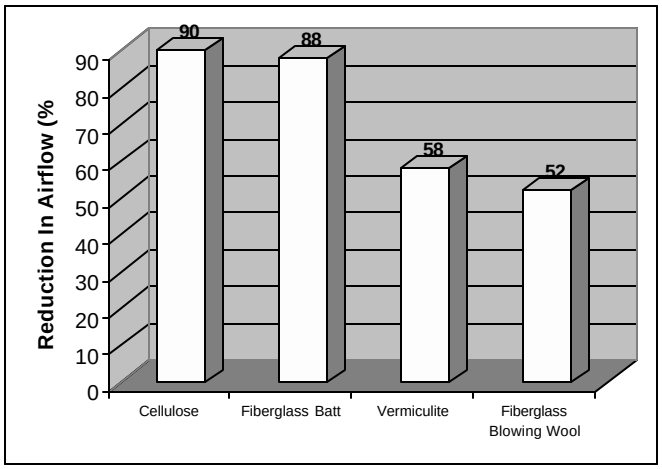

Figure 2 – Percent air leakage reduction in test chamber with various types of insulation. *Source: Princeton University.*

During inspection of a group of energy-efficient houses built under the Minnesota Energy Efficient Housing Demonstration (EEHO) program, one defect noticed in many houses was air leakage into the attic through wiring holes and other penetrations in the top plates of interior partitions. In one house, the Minnesota research team was surprised to see almost no partition wall leaks into the attic during scanning examinations with an infrared camera. The initial conclusion was that 'the builder had been careful to plug those leaks during construction. However, when the cellulose insulation in the attic was removed, holes and cracks were in fact found around the interior partitions. The cellulose was actually sealing leakage points inadvertently left open by the builder.

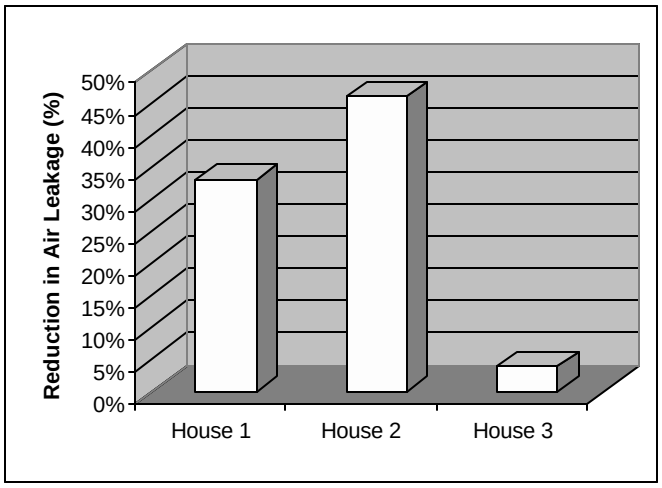

Figure 3 – Percent reduction in air leakage after cellulose wall insulation retrofit. House #1 and #2 are balloon framing and house #3 is platform framing. *Source: Princeton University*

But cellulose insulation is not an air seal.

The impressive results cited above should not be interpreted to mean that cellulose insulation can provide an effective air barrier in a building envelope. Even though it may retard air leakage, cellulose insulation still allows air to pass through and will not completely prevent heat loss or moisture damage due to air leakage. A graphic illustration of this fact is shown by the photos in Figures 4 through 7, taken by Gary Nelson as part of the Minnesota EEHD monitoring project.

Figure 4 shows a section of attic insulated with cellulose. The installation looks pretty good. but if you look closely you will see that the cellulose has settled in the area over the soffit at the top of the photograph. The cause of the settling was wetness. Also, water stains can be seen on the wood framing.

Figure 4 – Attic insulated with cellulose. Settling over soffit was caused by insulation being wetted by moist air leakage through attic floor.

Figure 5 shows the same area with some of the cellulose removed. The pencil in the photograph is sticking in a gap between a 2 x 4 and a piece of plywood The pocket knife is shown sticking into a gap between the plywood and the top plate of the exterior wall. There was apparently no attempt to seal these gaps and moisture laden air was evidently leaking up into the attic from the space below.

Figure 6 is a photo of a kitchen soffit located directly below the attic area shown in Figures 4 and 5. Figure 7 is a thermogram of the same area taken with the house depressurized. The dark spots indicate cold. The soffit is cold due to attic air leaking down from above.

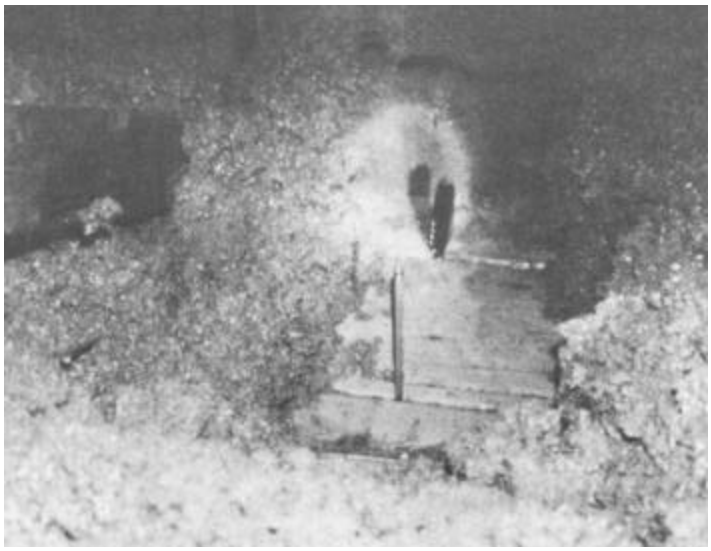

Figure 5 – Attic floor showing points of air leakage.

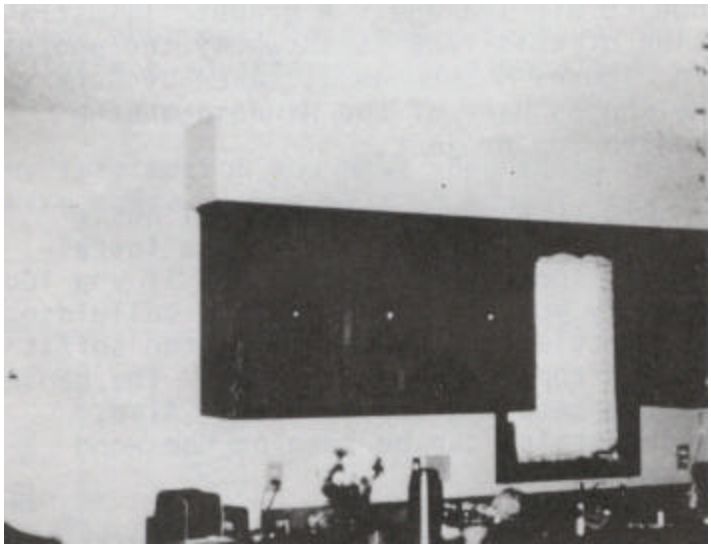

Figure 6 – Kitchen soffit below attic area shown in figures 4 and 5.

Blower door tests of this house showed it to be reasonably tight (about 3.4 air changes per hour at 50 Pa) and the cellulose insulation was probably responsible for a certain degree of that tightness. However, the defects illustrated in Figures 4 through 7 suggest that even though the insulation may suppress air leakage, it is not effective enough to serve as a good air barrier.

Wet-spray cellulose is a different story.

The most impressive air sealing effect of cellulose is seen when it is applied as a wet spray (see September 1985 EDU for a complete discussion of wet-spray insulation). We have received two reports from EDU readers about side-by-side comparisons of the air leakage characteristics of new houses built with wet-spray cellulose versus fiberglass batt insulation.

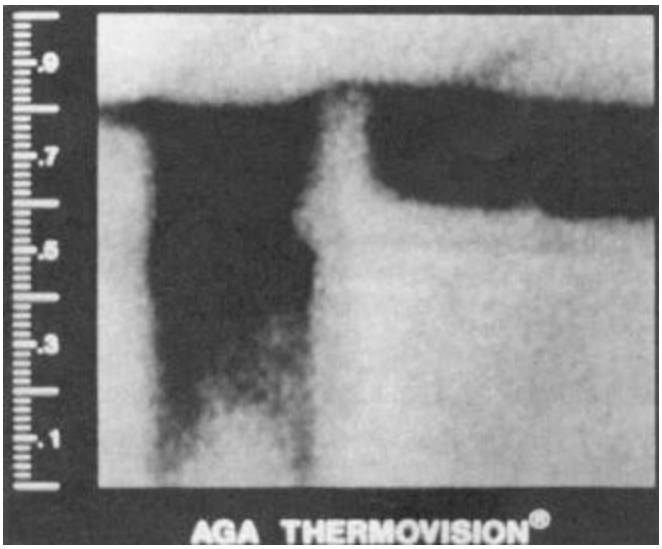

Figure 7 – Thermogram of kitchen soffit area taken with house depressurized. Dark areas indicate cold air leakage from attic.

The first case is the Leominster Housing Project for the Elderly in Leominster Massachusetts. Two of the buildings in the project have R-13 fiberglass batts in the walls and R-38 fiberglass batts in the ceilings. A third building is insulated with wet-spray cellulose in the walls and blown cellulose in the attic.

The three buildings were pressure tested with a blower door at the completion of construction. Some air sealing work was then done and the buildings were retested. Figure 8 shows the results of the tests. The effective leakage area (ELA) of the building with cellulose was 40% lower than the average ELA of the two buildings with fiberglass before the air sealing work and 27% below the fiberglass buildings after the air sealing work.

The other case study was told to us by Bill Richardson, president of Columbine Homes, in Aurora, Colorado. Richardson is a volume builder who markets his homes largely on their energy efficiency. Last year Columbine built 250 homes. Each one built was tested for air leakage with a blower door.

Richardson compared the air leakage rates of homes insulated with fiberglass batts against the air leakage rates of homes insulated with wet-spray cellulose. He found that, all else being equal, the air leakage of the houses insulated with cellulose was generally about half that of the houses insulated with batts. The Columbine formula for achieving airtightness now includes cellulose insulation as an integral component along with a system of gaskets and caulking similar to that used in the "airtight drywall approach" (ADA).

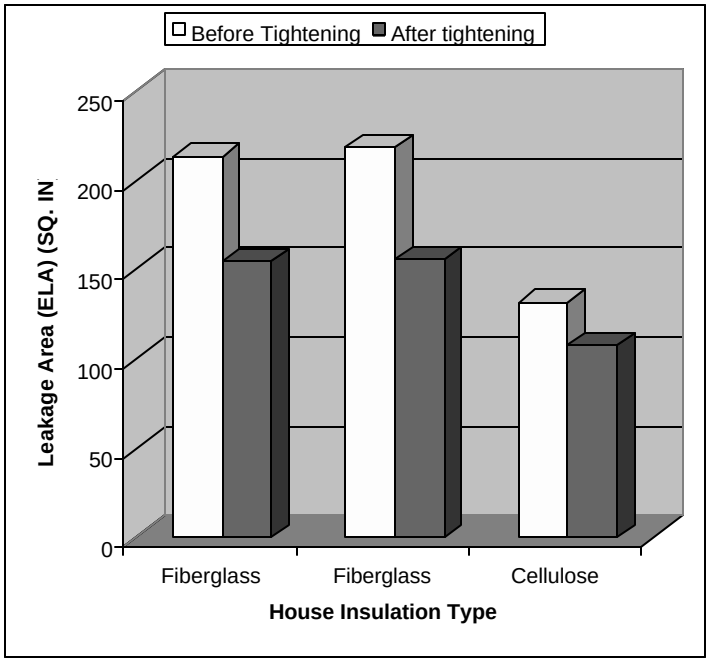

Figure 8 – Comparison of measured air leakage of buildings insulated with fiberglass and buildings insulated with cellulose.

Air circulation within insulation is unproven.

The second part of Cynthia Wells' inquiry letter, referring to the suppression of internal air movement within cellulose, is probably also true; to our knowledge, no one has demonstrated the presence of air circulation within cellulose. However, we have also not seen any discrete evidence showing the presence of air circulation within fiberglass batts either. We have seen, and have occasionally published, evidence of air circulation around and over fiberglass batts, but not within the batts. Air circulation around fiberglass batts is usually the result of gaps and spaces produced by imperfect installation. An advantage to cellulose in this respect is that gaps and spaces are less likely to occur.

Summary and Conclusion

Cellulose fiber insulation suppresses air leakage to a much greater extent than other types of insulation. In fact, when-analvzing the cost-effectiveness of cellulose retro-insulation, one should probably factor in energy savings due to infiltration reduction. In new construction, cellulose has the advantage, common to most loose-fill insulation materials, of complete filling of cavities, avoiding gaps and spaces, which can lead to convective degradation of thermal performance. It cannot, however, be relied upon to correct flaws in the house air barrier.