Attic Insulation Problems

by J. D. Ned Nisson

There is a problem with loose-fill fiberglass attic insulation in cold climates. It appears that, as attic temperature drops below a certain point, air begins to circulate into and within the insulation, forming "convective loops" that increase heat loss and decrease the effective R-value. At very cold temperatures (-20°F), the R-value may decrease by up to 50%.

The problem was first documented twelve years ago at the University of Saskatoon in Saskatchewan. Using infrared thermography, researchers observed hexagonal cold patterns on the ceiling of a house insulated with cubed loose-fill fiberglass. They suspected that the cold spots were caused by air circulation within the insulation.

In 1982, researchers at the Owens-Corning Fiberglas Research Station in Granville, Ohio, observed a measurable decrease in R-value when a full-scale ceiling assembly, insulated with loose-fill fiberglass, was subjected to very cold attic temperatures.

The most conclusive evidence came last year from Oak Ridge National Laboratory in Oak Ridge, Tenn., and the Building Research Center at the University of Illinois.

Using their "Large-Scale Climactic Simulator" (LSCS), which can test full-scale attics, Oak Ridge scientists measured the system R-value of 6 inches of cubed loose-fill fiberglass as the attic temperature was lowered from 45°F to -38°F. The results, shown in Table 1, indicate that the effective R-value decreased progressively as the attic air temperature was lowered. At -18°F, the measured R-value was only 9.2, about half the measured R-value at 45°F (R-17.8). Infrared thermograms of the insulation showed the same type of hexagonal patterns that were observed in Saskatoon — the footprint of air convection in fibrous insulation.

Some researchers speculated that the problem might be limited to cubed-type insulation, but scientists at the University of Illinois observed very similar behavior with tufted loose-fill fiberglass. The problem seems to occur with any low-density, loose-fill fibrous insulation.

Buoyant Forces Vs. Fibrous Insulation

Air convection can theoretically occur in any fibrous insulation if the temperature difference across the insulation is great enough. Loose-fill attic insulation works by trapping tiny pockets of air. As the temperature difference across the insulation increases (attic air temperature drops), so do the buoyant forces pushing trapped warm air up and out of the insulation. At some critical temperature difference, these buoyant forces overcome the holding power of the insulation fibers and convection begins (Figure 2).

The specific attic temperature at which convection begins depends on the insulation thickness, permeability, and density. In both the Oak Ridge and University of Illinois tests, convection occurred whenever the temperature drop across the attic insulation was greater than about 38°F.

Table 1
R-Value Vs. Temperature For Loose-Fill Fiberglass

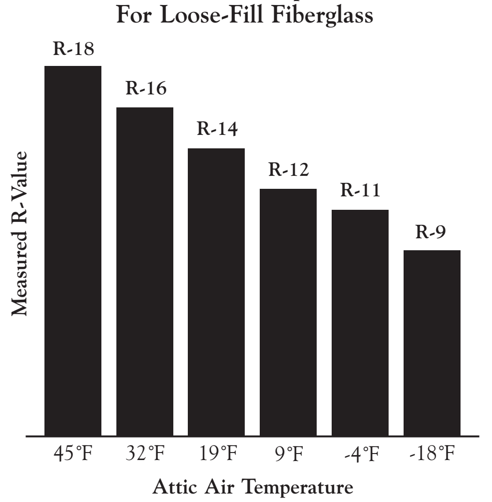

Figure 1. *In full-scale attic tests at Oak Ridge National Laboratory, the R-value of 6 inches of cubed loose-fill attic insulation progressively fell as the attic air temperature dropped. At -18°F, the R-value measured only R-9.*

Convection Losses in Loose-Fill Attic Insulation

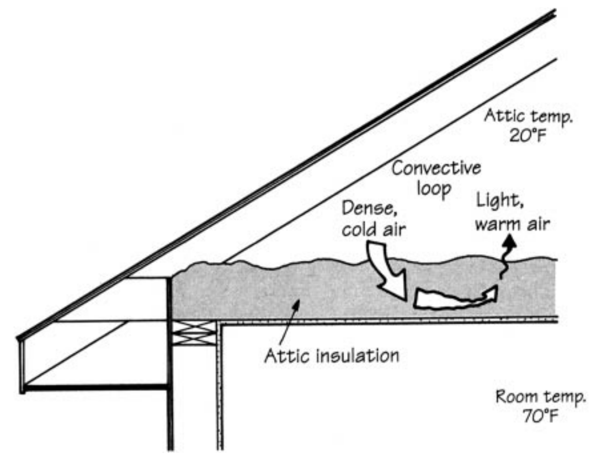

Figure 2. *At very cold temperatures, when the temperature difference across the attic insulation reaches a certain critical point, convection within the insulation can reduce R-value.*

Frigid Region Problem Only

A 50% loss of R-value sounds very serious, especially since it occurs during the coldest weather, just when you need insulation most. Not only will it cause increased fuel consumption, but the increased heat load may also strain the capacity of the heating system.

To put the problem in perspective, however, it is important to consider just how much of the time the outdoor temperature is low enough to cause significant loss of R-value. The weather data in Table 2 shows the number of hours per year that outdoor air temperature in various cities is 17°F and colder. This is the temperature range in which the Oak Ridge tests showed a 20% or greater R-value loss.

Notice that Seattle and Charlotte typically experience very few hours per year below 17°F, and convection is probably not worth worrying about in those climates. Bismark and Minneapolis, on the other hand, each have about two months worth of hours at or below 17°F. In those cities, loose-fill fiberglass is probably a poor choice for attic insulation unless it is somehow protected by a "convection blanket" (see below).

Just how much impact does R-value loss have on total winter fuel consumption? Oak Ridge scientist Ken Wilkes is planning to perform hourly computer simulations to predict its impact on total fuel consumption in various climates. Unfortunately, until those results are available, we have very little to go on.

The only field data comes from the Illinois tests in which the average heat loss through the attic during the month of January increased by about 25% due to convection. Assuming the attic accounts for about 20% of the total house heat load, the impact on total heating costs would be about 5% in January.

Strain on Heating System?

What about the possibility of straining the capacity of the heating system during extremely cold weather? At this time, could the loss of R-value in the attic increase the total heat loss to the point where the heating system could no longer handle the load?

Typically not. Even a 50% increase in heat loss through the attic translates into only a 10% increase in total load (assuming again that the attic accounts for about 20% of the total house load). Most heating systems are oversized by more than 10%.

Table 2
Total Hours of Temperatures Below 17°F

City	Hours	Days
Albany, N.Y.	686	29
Bismark, N.D.	1775	74
Charlotte, N.C.	30	1
Chicago, Ill.	497	21
Denver, Co.	479	20
Hartford, Conn.	512	21
Louisville, Ky.	179	7
Minneapolis, Minn.	1354	56
Portland, Ore.	702	29
Seattle, Wash.	23	1
Philadelphia, Pa.	141	6

Below 17°F, tests showed a 20% or greater R-value loss in loose-fill fiberglass attic insulation.

Switch Or Fight

Regardless of the severity of the problem, why spend money on insulation that doesn't work well when it's most needed? There are two ways to avoid this problem.

Use a different insulation. The easiest solution is to use a different type of insulation material. Oak Ridge scientists found that loose-fill cellulose is apparently immune to air convection, even at very low temperatures. Tests in the LSCS showed that the R-value of two-pound-density cellulose *increased* slightly at cold attic temperatures. The explanation for the superior performance of cellulose is that it is more dense and less permeable than fiberglass. Rockwool should also be immune, although that has not been demonstrated through testing.

Convection blankets. A second solution is to install a protective covering, sometimes called a "convection blanket," over the loose-fill fiberglass. Oak Ridge scientists looked at various convection blankets. Perforated poly sheeting, originally marketed to reduce convection through attic insulation, turned out to offer little help, probably because air leaked through the perforations. Exterior housewrap, without perforations, helped somewhat, improving the 6-inch ceiling insulation R-value from R-10.6 to R-13.2 (at 4°F). The best performance, however, came from "pillows" made of high-density fiberglass wrapped in perforated metallized plastic.

The product tested was developed by Attic Seal (3321 Pines Rd., Shreveport, LA 71119; 318/636-0946). When laid over the loose fill, the Attic Seal Pillows not only stopped the convection through the blown insulation, they also improved the R-value in two other ways: First the pillows add R-4 worth of fiberglass to the attic. Second, they improve the R-value of the blown insulation by warming it, thereby reducing convection at temperatures as low as -18°F.

One last solution might be to blow in cellulose over the fiberglass. This would be particularly practical for retrofit projects and would probably be less expensive than the Attic Seal Product. ■

J. D. Ned Nisson is editor of Energy Design Update *of Arlington, Massachusetts, a monthly technical newsletter on energy-efficient building design and construction.*

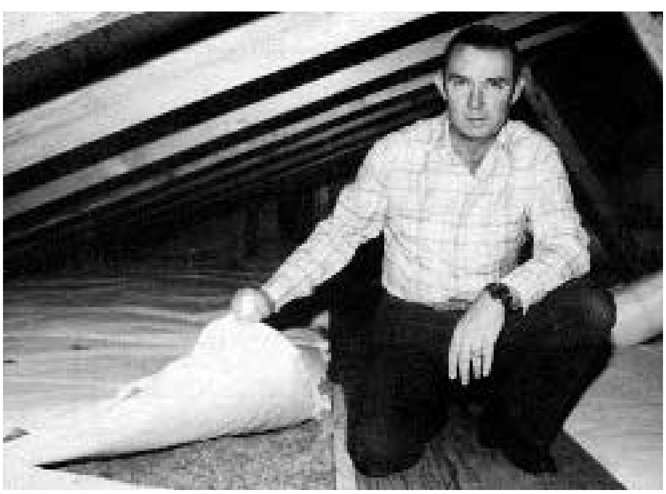

Figure 3. *One way to suppress convection in loose-fill fiberglass is to cover the insulation with a convection blanket, such as these pillows manufactured by Attic Seal Inc.*