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Saving energy with radiant barriers and HVAC ductwork

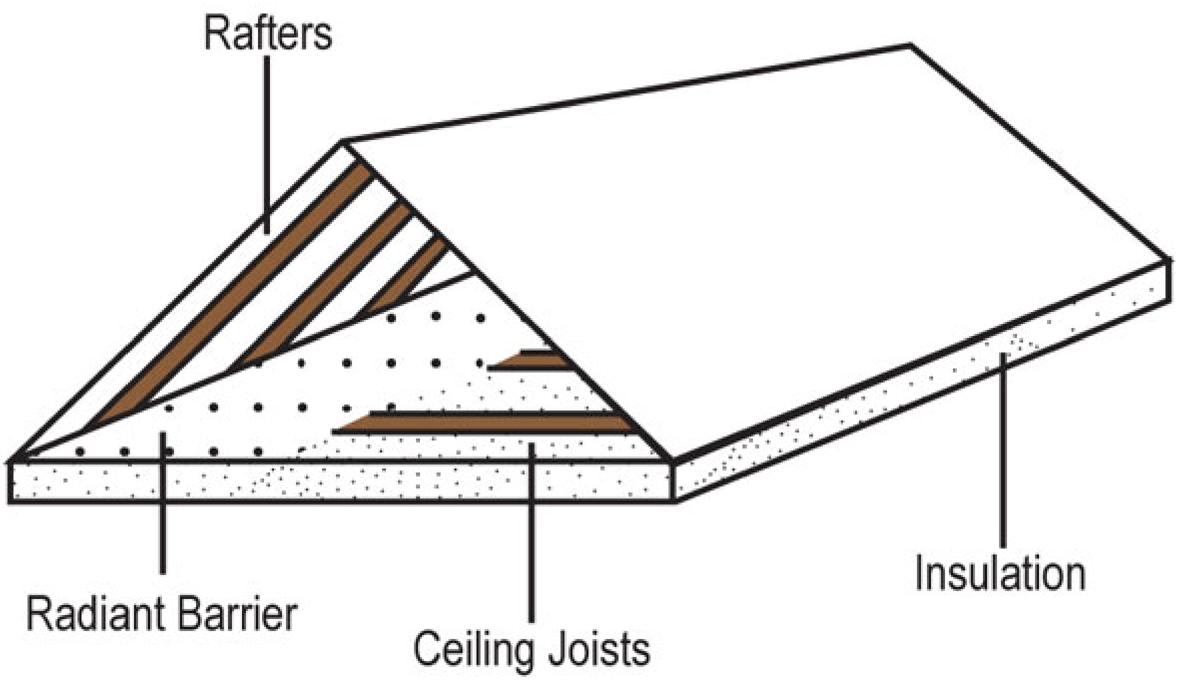
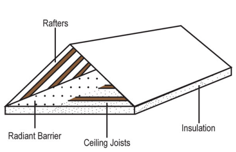
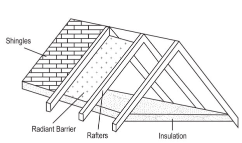
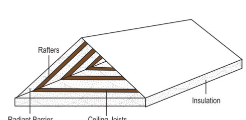
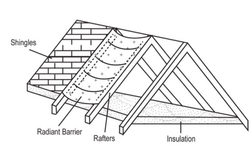
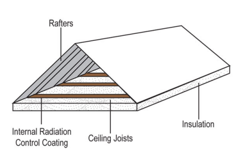
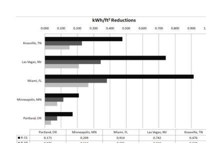


Figure 1. With a horizontal radiant barrier, the radiant barrier is on top of the ceiling insulation.

PREV

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June 10, 2013

Attic radiant barriers and interior radiation control coatings are proven technologies that significantly reduce the flow of radiant heat across attic spaces.

This reduction in radiant heat lowers heat flows across the ceilings of buildings. Lower heat flows across the ceilings of buildings potentially translates into smaller cooling and heating systems, and building operation cost savings. The energy savings increase when the HVAC ducts are located in attic spaces outfitted with the above-mentioned technologies.

As a direct consequence of increased pressure for reducing energy use and decreasing the electrical peak demand that result from building operations, the use and sometimes the excessive use of insulation has been encouraged. Although most forms of building insulation — fiberglass, mineral fibers, cellulose, cellular plastic, etc. — have played an essential role in making buildings more energy-efficient and in reducing electrical peak demand, the amount of insulation that can be added to a wall or to an attic space is limited by the physical dimensions of the wall frames and ceiling frames.

Attic radiant barriers and interior radiation control coatings present a different way of increasing the thermal performance of existing or to-be-installed insulation within the space between roofs and ceilings of buildings. Radiant barriers are aluminum foil laminates or aluminum-added synthetic films sheets. The foils are laminated to paper, most commonly to kraft paper, synthetic films, to oriented strand board or plywood. For the aluminized synthetic films, a thin layer of aluminum particles are deposited on the films through a vacuum process. These laminates and films are characterized by having at least one low emittance surface of 0.1 or less. IRCCs are low-emittance coatings or paints that when applied (sprayed or painted) to building surfaces such as OSB, plywood, metal siding or plasterboard that decrease the emittance of these surfaces to 0.25 or less.

Both RBs and IRCCs have received considerable attention because of their potential to reduce the radiant heat transfer across vented spaces between roofs and attic spaces in residential buildings.

Radiant barriers are commonly installed in one of four configurations. The “horizontal radiant barrier,” shown in Figure 1, places the radiant barrier on top of the ceiling insulation.

The “truss radiant barrier” configuration (Figure 2) consists of a radiant barrier fastened to the rafters that support the roof deck. Under this configuration an extra air space is formed between the radiant barrier and the roof deck.

The “deck-applied radiant barrier” in Figure 3 bonds the aluminum foil to the oriented strand board or plywood boards that make up the roof deck.

The “draped radiant barrier” (Figure 4) attaches the radiant barrier to the roof deck or to the top of the roof trusses where the barrier is allowed to form a “drapelike” configuration, which in turn forms a narrow air space between the deck and the radiant barrier.

Interior radiation control coatings are normally sprayed on the interior surfaces that enclose the attic space. Figure 5 shows the configuration of an applied IRCC.

A number of simulated results were compiled for this article and are presented in Table 1. These results are from simulated space cooling load reductions produced by radiant barriers.

In the first part of Table 1 the programs AtticSim and Micropas were run using weather data files from five representative cities. The cities were Miami (U.S. Department of Energy-classified Climatic Zone No. 1); Las Vegas (Climatic Zone No. 3); Knoxville, Tenn. (Climatic Zone No. 4), Portland, Ore. (Zone No. 4); and Minneapolis (Zone No. 6).

According to AtticSim, for attics with an insulation level of R-11, the space cooling load reductions produced by horizontal radiant barriers ranged from 11 percent to 25 percent, with the average being 16 percent. The simulations assumed that the air-handling ducts were not located in the attic.

For the same cities and conditions, Micropas predicted reductions from truss radiant barriers in the range of 13 percent to 35 percent. The average value was 20 percent. For the case of an assumed attic insulation level of R-19, while all other conditions remained the same as above, AtticSim predicted an average reduction from HRBs of 9 percent and Micropas predicted an average reduction from TRBs of 15 percent.

For an assumed attic insulation level of R-30, the average reductions produced by both programs were 6 percent for HRBs using AtticSim and 8 percent for TRBs using Micropas.

There was a clear correlation between percent reduction in space cooling load and the geographical location of the buildings. However, because of the manner in which percentages are calculated, the lowest values corresponded to the cities with higher cooling degree-days and the highest saving percentages corresponded to the cities with milder climates. This was true for both programs.

Data from running Micropas under the same conditions but assuming that the air-handling ducts were placed in the attic, predicted average percent reductions in space cooling load of 22 percent for an insulation level of R-11, 16 percent for an insulation level of R-19, and 9 percent for an insulation level of R-30, all for a TRB configuration. The simulated results show a clear correlation in load reductions when the ducts are placed in the attics. The percent reductions increased by 2 percent, 1 percent and 1 percent for assumed insulation levels of R-11, R-19, and R-30, respectively.

Comparable data from running the Texas A&M Energy Systems Laboratory model and EnergyGauge USA for Houston with an assumed insulation level of R-19, and with the assumption that the ducts were placed in the attic, predicted reductions from TRBs of 9 percent (ESL model) and 5 percent (EnergyGauge). The ESL model predicted higher reductions in space cooling loads when the insulation level of the ducts decreased. Both programs predicted similar trends in that the installation of radiant barriers produces higher reductions in space-cooling load as the leakage rate in the return ducts was increased.

Similarly, both programs predicted larger space cooling load reductions for lower values of attic insulation. The University of Nevada-Reno’s Resheat software was also used to simulate reductions in space cooling loads. It predicted reductions of 7 percent and 18 percent for attics with R-19 insulation for Phoenix and Tampa, Fla., respectively. For the same two cities, in attics with insulation level of R-30, the predictions were 4 percent for Phoenix and 16 percent for Tampa.

Figures six through eight depict the cooling load reductions in kilowatt hours per square foot as predicted by AtticSim (Figure 6), Micropas (Figure 7), and Micropas when the HVAC ducts are located in the attic space (Figure 8).

All the simulations confirmed the experimental findings that radiant barriers and IRCCs play a significant role in reducing ceiling heat transfer flows in attics when compared to similar attics without RBs and IRCCs. For radiant barriers, the percent reductions in space cooling load varied from 11 to 35 percent in cases when the attics were insulated with R-11, 5 to 25 percent when the levels of insulation were R-19, and 3 to 10 percent when the insulation levels were R-30. The percent reductions in space cooling load when the air-handling ducts were placed in the attic space ranged from 21 percent to 36 percent in cases when the attics were insulated with R-11, 3 percent to 27 percent when the levels of insulation were R-19, and 1 percent to 26 percent when the insulation level was R-30.

From the simulations it was clear that larger reductions in space cooling loads are produced when the HVAC ducts are placed in attic spaces. In addition, at higher leakage rates from and to the ducts, the radiant barriers produced even larger reductions.

This article and its images were supplied by the Reflective Insulation Manufacturers Association International. Author Mario A. Medina, Ph.D., P.E., is an associate professor at the University of Kansas' Civil, Environmental and Architectural Engineering Department and director of its Building Thermal and Material Sciences Laboratory.