# Radiant Barrier System

## Introduction

A radiant barrier system (RBS) is comprised of a sheet of reflective foil placed next to an air space, the combination of which discourages radiant heat transfer.

In a hot climate, an RBS properly installed beneath a roof blocks up to 95% of the heat transfer from the roof to the attic insulation, resulting in a cooler living space and less cooling load. Reflective foil can either be stapled to the bottom of the roof rafters as in Figure 1 or purchased pre-laminated to the underside of the roof decking as in Figure 2. Walls facing direct sun can also benefit from inclusion of an RBS.

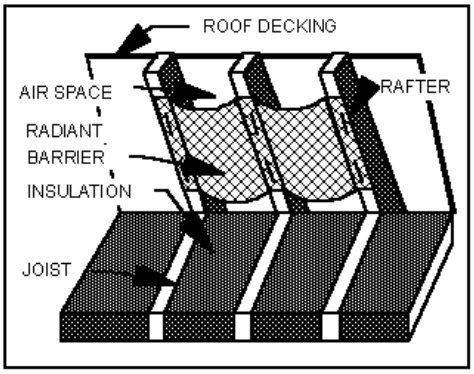


**Figure 1:** Radiant barrier foil stapled to bottom of rafters (courtesy of Oak Ridge National Laboratory)

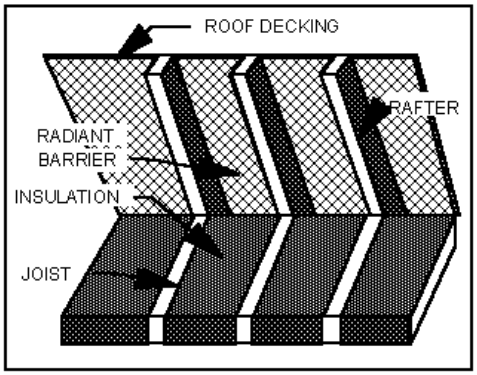


**Figure 2:** Radiant barrier laminated to roof decking (courtesy of Oak Ridge National Laboratory)

## Green Building Benefits

### Energy Savings and Improved Comfort

An RBS is installed primarily to improve comfort and reduce energy use for mechanical cooling in hot climates. During a hot, sunny day with outside temperatures at 100º, attic temperatures can reach 130 – 160 ºF. Such temperatures overpower the ceiling insulation and heat the rooms below through radiation. Radiant heat--what one feels near a fire or hot surface, for example--can move in all directions (from hot to cold). First, the 130 - 160º air moves by convection through the insulation to the rooms below. Second, the shingles and roof decking capture and radiate the sun's heat into and through the attic and ceiling insulation to rooms below. An RBS can prevent up to 95% of such heating, absorbing heat but not re-radiating it into the attic space. The effect is attic temperatures lowered to within 5 - 10º above the outdoor temperature. An RBS helps in spring and fall, too, when strong sun makes roof temperatures very hot even though the outside air temperature is moderate. No energy penalty is paid in winter/heating climates since most upward heat movement occurs by convection and because the radiant barrier will reflect some heat back down into the attic.

If the HVAC ductwork is located in the attic (the worst possible but common location), benefits from an RBS are substantially increased. Duct insulation is only R-8 at best (typically much lower), and thus quite susceptible to the negative effect of much warmer surrounding air. An attic made cooler by an RBS prevents the conditioned duct air from being warmed as much while passing through the attic, resulting in greater occupant comfort and HVAC system efficiency. An additional benefit is that stored items won't degrade as readily in a cooler attic.

Energy bill savings resulting from an RBS will vary depending on the installation quality, occupant lifestyle, local climate, roof type and color, attic insulation levels, ductwork location, amount and quality of attic ventilation, extent of home shading, quality of RBS installation, and other factors. Given such variables, studies do show that typical savings are between 8-12% of annual cooling costs. A very small heating savings may be realized as well.

 

An RBS is a low-cost way to achieve significant benefits. The product is inexpensive, requires only low-skill labor to install, and continues to work passively without maintenance.

## How Radiant Barrier Systems Work

How can a thin piece of aluminum foil can be so effective in "blocking" heat? It works well because it is a good heat reflector and a bad heat radiator. Think of your Thanksgiving turkey--when you take it out of the oven and cover it loosely with foil, it stays hot. The foil reflects heat back to the turkey while not emitting much heat to the cooler air around it.

### Airspace

Space is the operative word when we're talking about radiant heat. *Radiant* heat moves in straight lines through a space from hotter objects to any cooler object it can "see." This is different than *convective* heat, which travels through moving air. Nor do we mean the *conduction* of heat, which would occur if there were no space but instead direct contact between the radiant barrier and the insulation. Aluminum foil is a good conductor but a poor radiator—an air space prevents conduction while not affecting its low radiating capacity.

### E-value and R-value

Insulation effectiveness is measured by R-value (resistance of a material to conducting heat): the higher the number the better the insulation. Radiant barrier effectiveness is measured by E-value, an emissivity rating (ability of a material to emit heat): the lower the number the better (0.05 or less on a scale of 0.0 to 1.0). A thin metal coating on the interior pane of "low-e" windows performs the same useful function, absorbing heat from the sun while not re-radiating it into the interior conditioned space.

Aluminum foil by itself does not have insulative value. Advertising claims of R-value are most likely false (unless the foil is attached to insulation or constructed in multiple layers with airspaces). Both insulation and radiant barriers, properly installed, function to reduce heat flow--they simply do so by different means. Together they form two lines of defense--one at the roof deck and one at the ceiling.

## Selection and Installation

### Products

A radiant barrier is available in various forms; the most common being reinforced single or double-sided foil. The foil can be perforated so as not to act as a vapor barrier.

Radiant barrier/insulation combinations are available but probably not worth the expense. If a home needs more insulation, it is usually cheaper to install it separately from the radiant barrier.

Roof decking manufactured with radiant barrier factory-glued to it is recommended for new construction. Radiant-barrier paint can be used for retrofits in attics in which foil radiant barrier would be too difficult to install. Such paint's emissivity rating is typically higher than foil (0.22-0.49), but it will still help cool the attic.

### Placement

A roof radiant barrier should be installed at the top of the attic (against the rafters or truss members), shiny surface facing down. It should not be placed on the floor of the attic because it will get dusty there and cease to be effective. Placement of the radiant barrier at the roof may increase roof temperature by 2 - 5º, but this a very low percentage of the roof's overall temperature and not enough to cause additional roofing degradation.

**In new construction** it is easiest to use roof decking with the radiant barrier already glued to the underside. No additional labor is required and radiant heat is blocked from ever entering the attic space (see in Figure1).

If the ceiling is vaulted, it can be tricky to get the necessary airspace (1" minimum) between the radiant barrier and the insulation installed between the rafters. Parallel cord or scissor trusses solve this problem as they make the attic cathedral cavity larger.

If a radiant barrier wall is constructed, the shiny side of the radiant barrier faces outward to an air space behind the siding. An air space can be formed by nailing 1x4 boards, spaced as needed, to the structural wall sheathing. Proper installation of brick and stone veneer provides an air space.

 

**In retrofits** the radiant barrier should be draped from rafter to rafter and stapled to their underside (as in Figure 2). A handy homeowner can do this job. Note that a radiant barrier does not need to be a continuous, gap-free system as insulation does, but more coverage does offer more benefit. A radiant barrier will help cool the house wherever it's installed. But if not all corners of the attic are feasible or accessible for RBS installation, the integrity of the radiant barrier that is installed will not be compromised.

For installation, choose a cool day and wear protective clothing, including a dust mask to protect against contact with or inhalation of insulation fibers and particles. Heavy-duty scissors or a utility knife should be adequate to cut the radiant barrier. Use a slap-hammer stapler, not a manual compression staple gun, or your hand will tire quickly. Place boards or pieces of plywood across the ceiling joists for walking in order to avoid accidentally stepping through the ceiling.

### Attic Ventilation

RBS performance is enhanced by good attic ventilation. Continuous soffit and ridge vents provide the most effective ventilation system--outside air can enter the attic under the entire soffit, evenly bathe the entire underside of the roof deck, and exhaust fully out of the highest part of the attic (see Figure 3). This system operates passively, dependent on physics rather than wind or electricity.

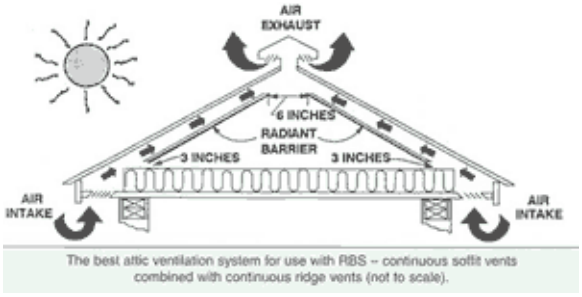


**Figure 3:** Attic ventilation above the radiant barrier (courtesy of Austin Energy)

## Operation and Maintenance

A properly installed radiant barrier needs no maintenance. Once it is in place, it is effective for the life of the home.

## For More Information

Radiant barrier products are available from almost every retail hardware outlet.

- Search Build It Green's **AccessGreen Directory** to find local suppliers and services: www.builditgreen.org
- **Oak Ridge National Laboratory** has developed a lengthy radiant barrier fact sheet showing the results of detailed field testing in numerous cities and various climates: www.ornl.gov/sci/roofs+walls/radiant/rb_02.html
- For more information about Build It Green, visit our web site at www.BuildItGreen.org or call us at 510-845-0472.