

## Cool Roofs and Radiant Barriers

Cool roofs and radiant barriers are relatively new energy code measures for residential buildings. The purpose of this guide is to explain what they do, how they work, differences between them, when they are required, and how they will be verified by building departments. The guide is intended to help designers, builders, contractors, inspectors, and anyone involved in improving comfort, lowering energy costs and improving the energy efficiency of California homes.

**The 2013 Building Energy Efficiency Standards provide the following definitions:**

1. **COOL ROOF** is a roofing material with high thermal emittance and high solar reflectance, or low thermal emittance and exceptionally high solar reflectance that reduces heat gain through the roof. Cool roofs are a prescriptive requirement for new residences in California's Climate Zone 12 (but not in 02, 03 or 04) for steep sloped roofs that are not heavy stone or tile. For alterations in Climate Zone 12, cool roofs are required in many cases, unless one of the exceptions is met.
2. **RADIANT BARRIER** is a highly reflective, low emitting material installed at the underside surface of the roof deck and the inside surface of gable ends or other exterior vertical surfaces in attics to reduce solar heat gain. Radiant barriers are a prescriptive requirement in the Bay Area for new residences, and in certain cases are also required for alterations.

## Building Science Principles

Even in new homes, much of the heat gain in summer and heat loss in winter occurs at the ceiling level. Attic insulation reduces conductive heat flow, but heat also moves by convection, or airflow, through gaps in the attic floor, and by radiant heat transfer through materials. Reducing attic heat gain during summer is especially important for homes with heating and cooling equipment and ductwork located in the attic, because ductwork contains and distributes conditioned indoor air.

### Solar Reflectance and Thermal Emittance

**Reflectivity** (or reflectance) is a measure of how much energy is reflected by a material at a given wavelength. It is expressed as a number between zero and one. The higher the reflectivity of a roofing material, the more of the sun's radiation will be reflected, and the less will be absorbed as heat.

**Emissivity** (or emittance) is the ability of an object's surface to emit absorbed heat back into air, and the object must be adjacent to an air space to do so. It also is expressed as a number between zero and one. The higher the emissivity of a material, the more readily it emits heat, and the lower the emissivity, the less heat it emits.

### Heat Transfer

**Conduction** is the transfer of heat between objects in physical contact with each other. In buildings, insulation slows conduction between solids.

**Convection** is the transfer of heat by the movement of a liquid or gas - usually air or water. In buildings, air barriers are solid materials that stop airflow between indoors and out, and must be continuous to be effective.

**Radiation** is the line-of-sight transfer of heat/energy between solid materials via electromagnetic waves.

The sun radiates heat in the form of electromagnetic energy that travels through space until it encounters solid objects, including rooftops. Radiant heat that strikes a roof is either reflected back into the air or absorbed by the roofing material, increasing its temperature. Heat absorbed at the roof's surface flows by conduction through all solid roofing materials until it encounters an air space, usually the attic. The underside of the roof sheathing, which is now hot, then radiates or emits its heat into the attic air space, where it is absorbed by solid objects in the attic, including any ductwork.

## Cool Roof and Radiant Barrier Design Elements

**Cool roof** materials have high reflectivity and emissivity. Cool roofs are available in a range of colors (including dark colors) and materials, including composite, metal and tile. The rated performance of a certified cool roof product can be obtained from the Cool Roof Rating Council's (CRRC) website: [www.coolroofs.org](http://www.coolroofs.org).

**Radiant barriers** are also highly reflective, but have low emissivity. For building construction, a reflective material such as aluminum foil is typically adhered to more durable sheet material, such as plywood or OSB sheathing, plastic, or sturdy paper. To be effective, the shiny, reflective side of the radiant barrier material must face the attic open air space; otherwise, the foil conducts heat between solids instead of stopping its flow.

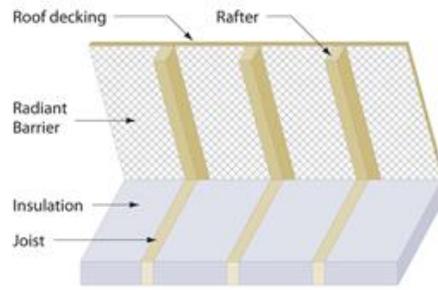
## Best Practice Design

Best practice dictates that cool roofs and radiant barriers be utilized where prescriptively required by the building code. In many cases, it is cost effective to exceed minimum code requirements, particularly in hotter climates, because they can substantially lower energy costs in buildings.

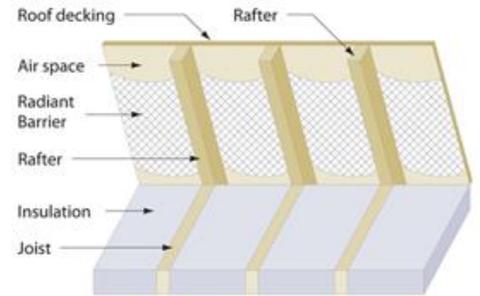
### Performance Method

- 👍 Products that are required prescriptively but perform better than the prescriptive requirements will yield a credit on the performance run, improving a building's compliance margin.
- 👎 Products that are required prescriptively and perform worse than the prescriptive requirements will yield a penalty on the performance run, decreasing a building's compliance margin.
- 👍 Products that are not required prescriptively but are included in the design in warmer climate zones will likely yield a credit on the performance run, improving a building's compliance margin.

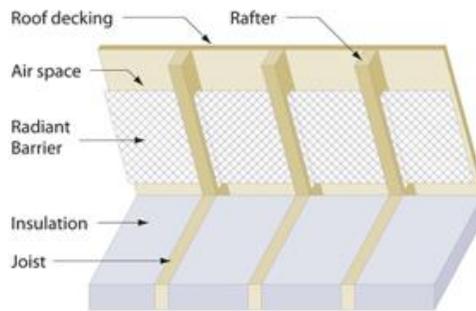
### Radiant Barrier Installation Options<sup>1</sup>



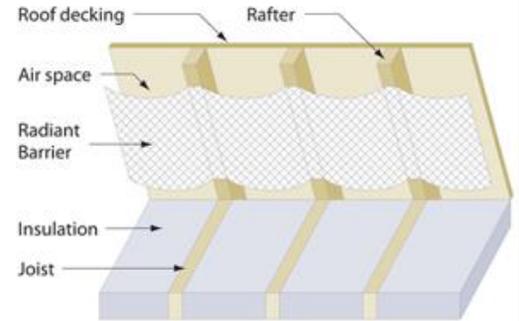
Laminated to underside of roof decking



Draped over rafters before decking is installed



Stapled to sides of rafters or truss top chords



Stapled to bottom of rafters or truss top chords

## Prescriptive Requirements for New Additions and Alterations

Cool roofs are a prescriptive requirement in Climate Zone 12 for residential buildings with steep sloped roofs (pitch > 2:12) and lightweight roofing material (< 25 lb/ft<sup>2</sup>). In these buildings, cool roofing products must have an aged solar reflectance of at least 0.20 and thermal emittance of at least 0.75, or a solar reflective index of at least 16.<sup>2</sup>

Radiant barriers are a prescriptive requirement in all new low-rise residential buildings in Climate Zones 02 through 15, which includes all Bay Area climate zones (02, 03, 04, and 12). Radiant barriers installed to meet the prescriptive requirements in California homes must have an emittance of 0.05 or less.<sup>3</sup> Radiant barriers must also cover all vertical surfaces in the attic that are adjacent to outdoors, including gable end walls. In addition, attics must meet ventilation requirements.<sup>4</sup>

## Building Department Inspections

Because cool roof materials cannot be verified by visual inspection, installers must provide inspectors with the CRRC label from the roofing material packaging. Inspectors should compare and verify that aged solar reflectance and emittance – or solar reflective index (SRI) - meet or exceed requirements; higher values are better.

When radiant barriers are required, inspectors should verify their presence, proper installation, and continuity. Radiant barriers laminated to the underside of roof decking are the easiest for building inspectors to verify by visual inspection. The continuity and air space requirements of radiant barriers draped over or stapled to trusses/rafters are more difficult to verify. Inspectors should also verify that a radiant barrier covers all vertical attic surfaces that are adjacent to outdoors.

Building inspectors will review the CF2R-ENV-04-E, Certificate of Installation. If a HERS-verified measure is used in lieu of a radiant barrier or cool roof, then the associated HERS inspection, test and registered forms must also be provided.

### Requirements for Alterations

Because of the wide variety of building permit scenarios represented in the alteration category it is best to consult the Residential Compliance Manual for specific requirements with regard to cool roofs and radiant barrier applicability. The general principle for alterations is 'if you touch it, bring it up to code'.<sup>4</sup>

1. Image source: Oak Ridge National Laboratory  
 2. 2013 Building Energy Efficiency Standards §150.1(c)11  
 3. 2013 Building Energy Efficiency Standards §150.1(c)2  
 4. Appendix RA4.2.1.1