# Reduce Solar Heat Gain by Improving Thermal Resistance Performance

Installing a  Roof provides an excellent opportunity for a homeowner or building owner to significantly reduce solar heat gain on their interior conditioned space. This action will, in turn, reduce the building's overall cooling expense. To quantify this Roof insulation advantage, we contracted with R&D Engineering, Cookeville, TN* to calculate thermal resistance performance (expressed as the R-Value) for each of our DECRA Metal Roof panel styles used in an installed roof system. R&D Engineering is an internationally recognized lab focused on thermal resistance research for building products.

**Reference Report RD19798 –* ***Technical Report: Thermal Resistance and U-Values for Six DECRA Roof Panels;*** *conducted by David W. Yarbrough, PhD, PE – September 25, 2019*

## Below are the results of the R&D Engineering thermal resistance analysis:

A Metal Roof panel provides an enclosed insulating air space between the roof panel and the roof deck. This advantage factors in the positive thermal emittance property provided by the Metal Roof panel underside surface. This enclosed air space is further enhanced for roof panels that install on a batten system. Thermal resistance performance is calculated across the entire roof assembly. A roof assembly includes:

- Roofing Material
- Roof Deck Sheathing (7/16” oriented strand board (OSB) or 1/2” CDX plywood)
- Roofing Underlayment
- Air Film (on both the exterior and interior roof system surfaces)
- If using a batten system: includes the portion of the roof covered by Wood Battens

First, let's establish a competitive roof “base case” by calculating the R-Value thermal resistance performance of a 3-tab asphalt shingle roof assembly:

| Material | R-Value |
|---|---|
| 3-tab asphalt roof shingles | 0.44 |
| ½” sheathing | 0.68 |
| 15 lb asphalt roof felt | 0.15 |
| Air film – exterior/interior | 1.01 |
| **Total Assembly R-Value:** | **2.28** |

Metal Roof assembly R-Value calculations, *using the same roof materials as the 3-tab asphalt shingle roof assembly* ***with 15 lb asphalt felt underlayment***:

| Material | Install Method | R-Value | % Improvement vs. 3-Tab Asphalt Roof Assembly |
|---|---|---|---|
| Shake XD | direct | 2.71 | + 18.9% |
| Shingle XD | direct | 2.47 | + 8.3% |
| Villa Tile | direct | 2.61 | + 14.5% |
| Villa Tile | on 1x4 battens | 3.14 | + 37.7% |
| Tile | on 2x2 battens | 3.39 | + 48.7% |
| Shake | on 2x2 battens | 3.37 | + 47.8% |
| Shingle Plus | direct | 2.76 | + 21.1% |
| Shingle Plus | on 2x2 battens | 3.39 | + 48.7% |

The roof assembly provides optimal thermal resistance performance when a radiant barrier roof underlayment material is used in place of 15 lb asphalt roof felt. A radiant barrier roof underlayment is only effective at reducing solar heat gain (improving thermal performance) IF the roofing material provides an enclosed air space between the underside of the roof panel and the roof deck. Metal Roof panels, formed with an integral airspace molded into the panel profile, provide the perfect scenario to leverage radiant barrier roof underlayment performance.

roof assembly R-Value calculations, substituting 15 lb asphalt roof felt underlayment ***with a radiant barrier underlayment*** consisting of a synthetic fabric underlayment bonded with an aluminum foil-faced reflective surface:

| Material | Install Method | R-Value | % Improvement vs. the 3-Tab Asphalt Roof Assembly |
|---|---|---|---|
| Shake XD | direct | 2.97 | + 30.3% |
| Shingle XD | direct | 2.69 | + 18.0% |
| Villa Tile | direct | 2.97 | + 30.3% |
| Villa Tile | on 1x4 battens | 4.85 | + 112.7% |
| Tile | on 2x2 battens | 6.15 | + 169.7% |
| Shake | on 2x2 battens | 6.06 | + 165.8% |
| Shingle Plus | direct | 2.88 | + 26.3% |
| Shingle Plus | on 2x2 battens | 5.63 | + 146.9% |

| Material | Install Method | % Improvement Comparing DECRA with Radiant Barrier Underlayment vs. DECRA with 15 lb Asphalt Felt Underlayment |
|---|---|---|
| Shake XD | direct | + 9.6% |
| Shingle XD | direct | + 8.9% |
| Villa Tile | direct | + 13.8% |
| Villa Tile | on 1x4 battens | + 54.5% |
| Tile | on 2x2 battens | + 81.4% |

| | | |
|---|---|---|
| Shake | on 2x2 battens | + 79.8% |
| Shingle Plus | direct | + 4.4% |
| Shingle Plus | on 2x2 battens | + 66.1% |

## Why Use a Radiant Barrier Roof Underlayment:

A radiant barrier blocks radiant heat energy, unlike traditional insulation products that are designed to slow down heat transfer by absorbing it. A radiant barrier can also reduce heat transfer through the roof assembly by blocking convective air flow.

## How Does a Radiant Barrier Work?

An aluminum-faced radiant barrier roof underlayment uses two physical properties to reduce radiant heat transfer through a roof assembly:

1. **Reflectivity:** The natural reflective property of a reflective surface facing a heat source across an air space allows the aluminum surface to reflect radiant heat back to the direction from which it came.
2. **Emissivity:** All materials have an emissivity rating from 0% - 100%. The lower the emittance percentage, the lower the amount of radiant heat radiated from its surface. The naturally low emissivity property of a reflective surface – facing an air space – results in very low emittance of heat from itself. It radiates very little of its own heat.

A radiant barrier reflects radiant heat that strikes its surface across an open air space from a heat source. Conversely, it emits very little radiant heat from its surface across an air space opposite a heat source.

## Why Is An Air Space Required for a Radiant Barrier to Perform?

For a radiant barrier roof underlayment to perform, it must have an air space of at least ¾” to be effective at blocking radiant heat. All Metal Roof panels provide that minimum average air space – allowing a radiant barrier roof underlayment to perform. The purpose of the air space is to prevent conductive heat transfer through the roof assembly. The existence of an air space eliminates, almost entirely, the pass-through of radiant heat.

If the minimum air space requirement is not met, heat will conduct from the surface touching the radiant barrier, through the radiant barrier, and then transfer to the next surface touching the radiant barrier on the opposite side – thus providing no protection against the heat you intend to block. That is why a radiant barrier roof underlayment is not effective when used in conjunction with an asphalt roof assembly. In the absence of the air space requirement between the roofing material and the roof deck, a radiant barrier cannot function to protect against the heat you intend to block.

## How Conventional Insulation Works

Traditional insulating materials such as fiberglass, foam board, rock wool – absorb or slow down convective and conductive heat transfers, thus insulating a building. These insulation types do not block heat – only slow it down. Thus, after a period of time, 100% of the heat absorbed would eventually transfer through the insulation. The rate in which this heat eventually transfers through an insulation material is the material’s R-Value. Insulation products, such as spun fiberglass batts, are manufactured with air spaces within the material that reduce heat conduction through the insulation. They also restrict heat transfer by convection by trapping air flows and lowering air circulation.

## ADDENDUM 1: Installing a foil-faced radiant barrier insulated roof underlayment

Through the research conducted by R&D Engineering*, we have compiled R-Value improvements to a Roof System installation using radiant barrier roof underlayment products that also provide an insulating layer via closed-cell foam or fiberglass woven mat construction.

Two insulating radiant barrier roof underlayment products were tested in a roof assembly:

1. **Low-E Therma Sheet** roof underlayment – manufactured by **Environmentally Safe Products, Inc**.
2. **Sol-R-Skin Thermal Underlayment** – manufactured by **International Insulation Products, LLC**

Here are the results:

**Assembly 1:** *Uses Low-E Therma Sheet with 1/8" closed cell foam core & radiant barrier skin*

| Material | Install Method | R-Value | % Improvement vs. the 3-Tab Asphalt Roof Assembly | % Improvement vs. DECRA w/ 15 lb Asphalt Felt Roof |
|---|---|---|---|---|
| Shake XD | direct | 3.66 | + 60.5% | + 35.1% |
| Shingle XD | direct | 2.91 | + 27.6% | + 17.8% |
| Villa Tile | direct | 3.66 | + 60.5% | + 40.2% |
| Villa Tile | on 1x4 battens | 5.54 | + 143.0% | + 76.4% |
| Tile | on 2x2 battens | 6.69 | + 193.4% | + 97.3% |
| Shake | on 2x2 battens | 6.64 | + 191.2% | + 97.0% |
| Shingle Plus | direct | 3.56 | + 56.1% | + 29.0% |
| Shingle Plus | on 2x2 battens | 6.18 | + 171.1% | + 82.3% |

**Assembly 2:** *Uses Low-E Therma Sheet with 5/16" closed cell foam core & radiant barrier skin*

| Material | Install Method | R-Value | % Improvement vs. the 3-Tab Asphalt Roof Assembly | % Improvement vs. DECRA w/ 15 lb Asphalt Felt Roof |
|---|---|---|---|---|
| Shake XD | direct | 4.11 | + 80.3% | + 51.7% |
| Shingle XD | direct | 3.11 | + 36.4% | + 25.9% |
| Villa Tile | direct | 4.11 | + 80.3% | + 57.5% |
| Villa Tile | on 1x4 battens | 6.02 | + 164.0% | + 91.7% |
| Tile | on 2x2 battens | 7.08 | + 210.5% | + 108.9% |
| Shake | on 2x2 battens | 7.05 | + 209.2% | + 109.2% |
| Shingle Plus | direct | 4.00 | + 75.4% | + 44.9% |
| Shingle Plus | on 2x2 battens | 6.58 | +188.6% | + 94.1% |

**Assembly 3:** *Uses Sol-R-Skin Thermal Underlayment with fiberglass mat core & radiant barrier skin*

| Material | Install Method | R-Value | % Improvement vs. the 3-Tab Asphalt Roof Assembly | % Improvement vs. DECRA w/ 15 lb Asphalt Felt Roof |
|---|---|---|---|---|
| Shake XD | direct | 4.65 | + 103.9% | + 71.6% |
| Shingle XD | direct | 3.34 | + 46.5% | + 35.2% |
| Villa Tile | direct | 4.64 | + 103.5% | + 77.8% |

| | | | | |
|---|---|---|---|---|
| Villa Tile | on 1x4 battens | 6.38 | + 179.8% | + 103.2% |
| Tile | on 2x2 battens | 7.25 | + 218.0% | + 113.9% |
| Shake | on 2x2 battens | 7.22 | + 216.7% | + 114.2% |
| Shingle Plus | direct | 6.76 | + 99.6% | + 64.9% |
| Shingle Plus | on 2x2 battens | 5.63 | + 196.5% | + 99.4% |