Radiant Barriers
Do they make sense in Pennsylvania?

Presented by
Bryan Heitzmann, Training & Edu. Dev. Specialist
&
Mike Turns, Associate Director PHRC

www.engr.psu.edu/phrc

Outline

• Introduction

• Radiant Barrier Background

• Areas & Methods of Application

• Summary & Conclusion
Introduction

Purpose –
To provide an overview of radiant barriers and how they apply to energy savings in residential construction.

Discussion will include:
- How they work
- Types of radiant barriers
- Whether or not the application methods make sense
- Whether or not the application methods make sense in PA

Background

What are radiant barriers?

- A thin layer of reflective material
- Reflects heat rather than absorbs it
- Have low emissivity

- RB is applied to one or both sides of a building material
  - Cardboard
  - Plywood
  - Paper
  - Bubble packs
  - OSB
  - Plastic
Background

Heat travels from warm to cold by a combination of:

- **Conduction**
  - Heat flow through a substance or material by direct contact

- **Convection**
  - Transfer of heat through air (for building enclosures)

- **Radiation**
  - Transfer of heat through electromagnetic waves traveling in a gas or vacuum

Background

**Reflectivity**
- A measure of how much radiant heat is reflected by a material. It is measured by a number between 1 and 0, or as a percentage. The higher the number or percentage, the greater the reflectivity.

**Emissivity**
- The relative ability of a surface to emit energy (heat) by radiation. It is expressed as a number between 1 and 0 or as a percentage. The higher the number or percentage, the more radiation is emitted.
The radiant barrier is designed to block radiant heat flow between a:

* If radiant barrier is installed next to an air space, the overall assembly can provide an R-Value equivalency for the adjacent space.

A radiant barrier is designed to have a low emissivity (0.1 or less) to reduce thermal radiation and a high reflectivity (0.9 or higher) so heat is reflected away.

– Emissivity + Reflectivity = 1.0
How They Work

- The sun’s radiant energy makes the roof hot
- Heat then conducts through the roofing materials to the inside of the attic
- The hot roofing materials then radiate their gained heat onto cooler attic surfaces

How They Work

Radiant energy transfer is greatest when:
- Temperatures are high
- Temperature difference is high
- Emissivity is high
- Reflectivity is low
How They Work

• The airspace facing the reflective surface is of primary importance
  – Prevents conductive heat transfer
  – Must have an air space of at least 3/4 of an inch on one or both sides to be effective at blocking radiant heat

• Reflective surfaces become conductive when in contact with a solid surface

Radiant Heat Transfer

Radiant heat transfer is proportional to:

1. The **absolute temperature** of the surfaces
   – Higher temps means more radiant heat transfer

2. The **temperature difference** (ΔT) between two surfaces
   – A greater ΔT means more radiant heat transfer
Radiant Heat Flux

Radiant Heat Flux (W/m²) = Radiant HT Coef x (T_h - T_c)

Radiant HT Coef = Emissivity x Stefan-Boltzmann Constant x \left[ \left( \frac{T_h^2 + T_c^2}{T_h + T_c} \right) \right]

\[ \text{Hot roof (summer): } \]
\[ T_h = 170 ^\circ F = 630 \text{ Rankine} \]
\[ T_c = 70 ^\circ F = 530 \text{ Rankine} \]
\[ \text{RHF}_{\text{hot}} = 134 \text{ (W/m}^2\text{)} \]

\[ \text{Cold wall (winter): } \]
\[ T_h = 70 ^\circ F = 530 \text{ Rankine} \]
\[ T_c = 20 ^\circ F = 480 \text{ Rankine} \]
\[ \text{RHF}_{\text{cold}} = 44 \text{ (W/m}^2\text{)} \]

\[ \frac{134}{44} = 3.0 \]

Thus, radiant heat transfer is 3X more important in the hot roof example.

Types of Radiant Barriers
Types of Radiant Barriers

Single-sided foil

• Aluminum foil

• May have a different material backing, such as craft paper or polypropylene

• May be strengthened with a fiber webbing to increase strength and resist tearing

Types of Radiant Barriers

Double sided foil

• Reflective foil surface on two sides of a material, such as kraft paper or mesh

• Reinforced by a webbing or weave to increase durability
Types of Radiant Barriers

**Bubble products**
- Bubble material laminated between two layers of foil
- The bubble pack in the center provides a thermal break
- Claim to help control condensation and moisture

**Foil faced products**
- Building materials such as OSB, fiberglass batt insulation, foam, with radiant barrier foil attached
R-Value Claims

• Measure of thermal resistance
  – higher R-Value represents a greater insulating effectiveness

• How can a product as thin as a radiant barrier have such a high R-Value?
  – It Can’t
  – Refers to the overall assembly R-Value
    • Includes adjacent building material
    • Includes airspace
R-Value Claims

• The IRC and the IECC reference the FTC R-Value rule requirements for rating the R-Value of insulation materials
  – Includes airspaces with reflective materials
  – Must comply with CFR Title 16 Part 460.5

  • Meet ASHRAE ideal space requirements or
  • Perform ASTM C1363 test

Areas of Application in Residential Construction
&
Do They Make Sense in PA?
Annual Heating / Cooling Loads in PA

Source: Sampling of Manual J reports, courtesy of Comfort Home Corp.

Areas of Application

Attic Radiant Barriers
Attic Radiant Barriers

Most residential roof systems provide some type of attic airspace to incorporate radiant barrier installation

- Most common application method
- Fairly easy to install
- Can be applied during construction or retrofit of an existing home

Attic Radiant Barriers

- There are two truss applications that can be considered when applying radiant barriers in attics
  - Below the truss chords
  - Draped above truss chords

- Deck applied radiant barriers consist of radiant barrier material applied directly to the roof decking
Attic Radiant Barrier

Horizontal radiant barriers
- installed on the top of attic floor insulation
- reflective side must face up towards roof
- perforated to allow moisture to pass through
- allows for dust accumulation and may require maintenance
- cannot use attic for storage
Attic Radiant Barrier

Do They Make Sense In PA?

- Radiant Barriers with Ducts in Attic
- Radiant Barrier vs adding insulation
- Does dust effect Radiant barrier performance?
  - Yes, radiant barrier must remain shiny to work
  - Attic floor application may require maintenance
Climate Zones In PA

Do They Make Sense In PA?

- Original Attic Conditions:
  - Add RB, improve ducts, add insulation
  - Add RB, improve ducts
  - Add RB, add insulation
  - Add RB
  - Add RB, improve ducts
  - Add RB
  - Add RB, add insulation
  - Add RB
  - Add RB
  - Add RB, add insulation
  - Add RB
  - Add RB

- Uninsulated Ducts
  - R19
  - Code

- Insulated Ducts
  - R19
  - Code

- No Ducts
  - R19
  - Code

- Costs:
  - $0
  - $400
  - $800
  - $1,200
  - $1,600

- Zone Labels:
  - Miami (Zone 1)
  - Austin (Zone 2)
  - Atlanta (Zone 3)
  - Baltimore (Zone 4)
  - Chicago (Zone 5)
  - Minneapolis (Zone 6)
  - Fargo (Zone 7)
  - Fairbanks (Zone 8)
### Do They Make Sense In PA?

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<th>Attic system modification</th>
<th>Insulated and well-sealed ducts</th>
<th>Code-level Attic Insulation</th>
<th>No ducts</th>
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<td>Code-level Attic Insulation</td>
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### Areas Of Application

#### Radiant Barrier House Wrap
Radiant Barrier House Wrap

• The intent of Radiant Barrier House wrap is to manage radiant heat flow through walls

• They also:
  – Can be vapor permeable to allow drying
  – Add a reflective barrier to the exterior
  – Seal up cracks and gaps in the exterior

Radiant Barrier House Wrap

SUMMER

Inside Condition
70 °F

Heat Conducting Through wall

Outside Condition
80 °F

Air gap
Brick Veneer
Solar Radiation

Gypsum board
Plywood
Stud bay – R-21
Radiant Barrier House Wrap

**SUMMER**

Inside Condition
70 °F

Outside Condition
80 °F

**WINTER**

Inside Condition
70 °F

Outside Condition
20 °F

Version 2
3/13/2012

19
Radiant Barrier House Wrap

Furring strips added for siding

• Use on a wall system with a ¾ inch gap between wall and siding create an R-value equal to R-0.66
  - May keep sheathing temperature higher reducing condensation risk
  - Low emissivity reduces radiant heat flow through wall
Do They Make Sense In PA?

• Must be installed with an air gap
  – Need to use furring strips with siding
  – If no air gap, heat will conduct through wall
  – Requires precise installment

• Creates improved R-Value in airspace
  - Small improvement
  - Claims of R-2?

Do They Make Sense In PA?

• Potential moisture problems
  - Acts as effective air barrier
  - Perforated to allow moisture to escape and dry out

• Work more effectively in warmer climate zones
  – Conductive heat gain in winter can be beneficial
  – Daytime solar heat gains in cold climates
Areas of Application

Foil Faced Bubble Wrap

Foil Faced Bubble Wrap - Ducts

- Metal HVAC ducts provide no insulation value
- Heat loss from ducts in unconditioned space can be significant
- IRC requirements –
  - Supply ducts in attics minimum R-8
  - All other ducts minimum R-6

Outside the thermal envelope
Foil Faced Bubble Wrap – Ducts

• Radiant barrier insulation will assist in stopping the transfer (loss or gain) of radiant heat into or out of your ducts

• Ducts are still required to be sealed and system must be substantially airtight

• Pressure testing of duct system is still required

Foil Faced Bubble Wrap – Ducts

• Reflective bubble duct insulation may offer an R-4 to R-8 insulation equivalency depending on the depth of spacer and number of layers

• It is theoretically possible to meet 2009 IRC code requirements for HVAC duct insulation

• Can also be installed around R-4 duct board to increase the R-value and achieve code compliance

Compare with fiberglass duct wrap
Do They Make Sense In PA

• Installation is the key to performance
  – Must incorporate air gap to obtain R-Value
  – Bubble wrap cannot be in contact with the duct
  – Spacers must be used
  – Labor intensive
  – Extra cost
  – Realistic?

Do They Make Sense In PA

• R-Value represents complete assembly
  – Not just bubble wrap

• Condensation problems?
Methods of Application

Under Slab

- Aluminum foil surfaces with flexible foam or bubble pack core
  - often used with radiant heating tubes

- Placed over gravel & apply concrete on top
  - system does not incorporate an air gap

- Must provide a **Class 1** vapor retarder: less than 0.1 perm

- Claim to increase the thermal efficiency
  - Provides only a slight thermal break
Under Slab

Radiant Barrier being used with radiant floor heating system
Do They Make Sense In Pa

- No airspace when installed under concrete
  - Radiant barrier acts as a conductor, not an insulator
  - Core acts only as a slight thermal break (R-1?)

- Radiant Barrier price **vs** code level vapor retarder

- When used with radiant floor heating tubes, claims exist that foil facing will reflect heat
  - **Not true.** Only reflects heat if airspace exists

Summary & Conclusions

- The radiant barrier is designed to block radiant heat flow between a heat radiating surface and a heat absorbing surface
  - Numerous applications for residential housing

- Must have one air space of at least 3/4 of an inch on one or both sides to be effective at blocking radiant heat

- Be cautious of R-Value claims by manufacturers
The use of radiant barriers does help to save energy costs, however:

- Depends on application method
- Depends on climate
- Requires precise installment to be effective
- Need to determine if the cost of installation is worth it in long-term
- Minimal savings in Pennsylvania