Radiant Barriers

Do they make sense in Pennsylvania?

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Outline

- Introduction
- Radiant Barrier Background
- Areas & Methods of Application
- Summary & Conclusion

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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
- areas of installation
- features/benefits
- Whether or not the application methods make sense
- Whether or not the application methods make sense in PA

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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

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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

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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.

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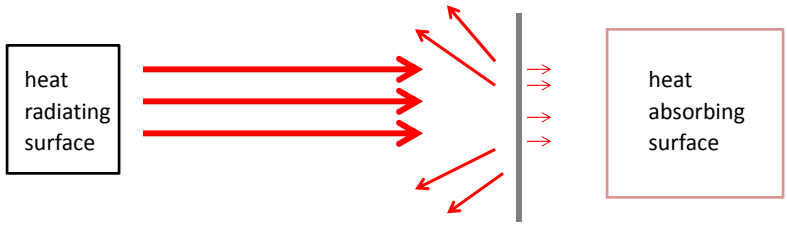
Background

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.

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Background

- 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

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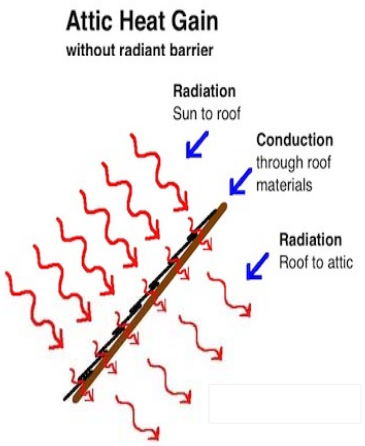
How They Work

- 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



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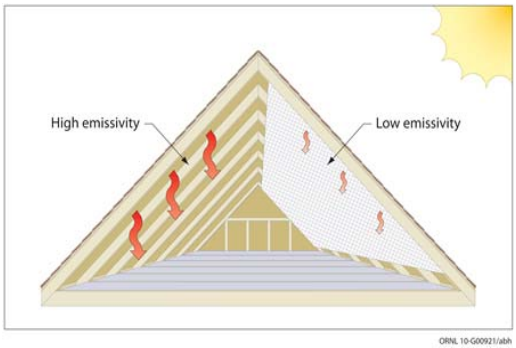
How They Work

Radiant energy transfer is greatest when:

- Temperatures are high
- Temperature difference is high
- Emissivity is high
- Reflectivity is low



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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

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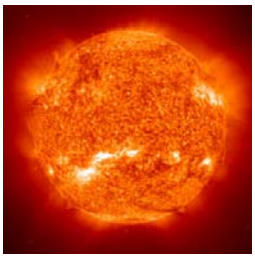
Radiant Heat Transfer

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/m^2) = Radiant HT Coef x ($T_h - T_c$)

Radiant HT Coef = Emissivity x Stefan-Boltzmann Constant x $[(T_h^2 + T_c^2)(T_h + T_c)]$

(0.1714×10^{-8} Btu/hr-ft^2-R^4)

T_h = Temperature of radiating surface

T_c = Temperature of absorbing surface

Hot roof (summer):
T_h = 170 °F = 630 Rankine
T_c = 70 °F = 530 Rankine

RHF_{hot} = 134 (W/m^2)

Cold wall (winter):
T_h = 70 °F = 530 Rankine
T_c = 20 °F = 480 Rankine

RHF_{cold} = 44 (W/m^2)

134 / 44 = 3.0

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

Types of Radiant Barriers

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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

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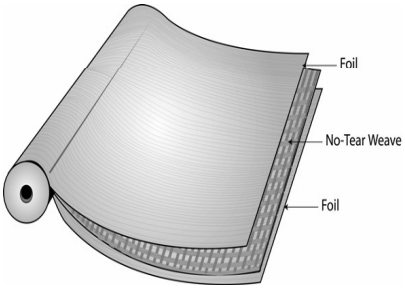
Types of Radiant Barriers

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



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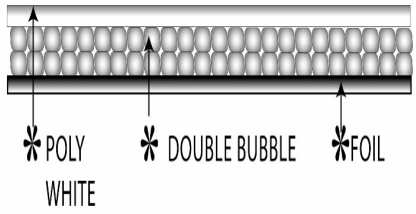
Types of Radiant Barriers

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



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Types of Radiant Barriers

Foil faced products

- Building materials such as OSB, fiberglass batt insulation, foam, with radiant barrier foil attached

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R-Value Claims

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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

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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

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Areas of Application in Residential Construction & Do They Make Sense in PA?

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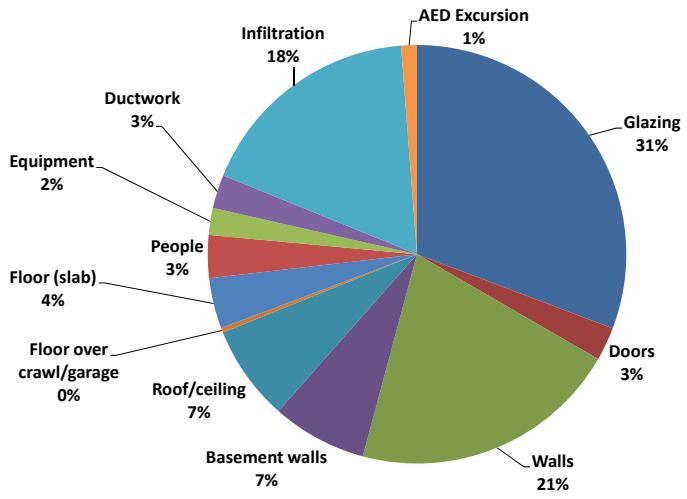
Annual Heating / Cooling Loads in PA



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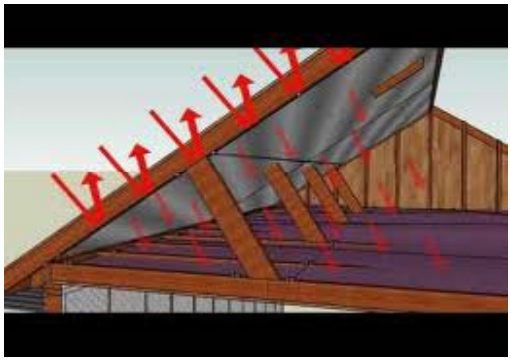
Source: Sampling of Manual J reports, courtesy of Comfort Home Corp.

Areas of Application

Attic Radiant Barriers



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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

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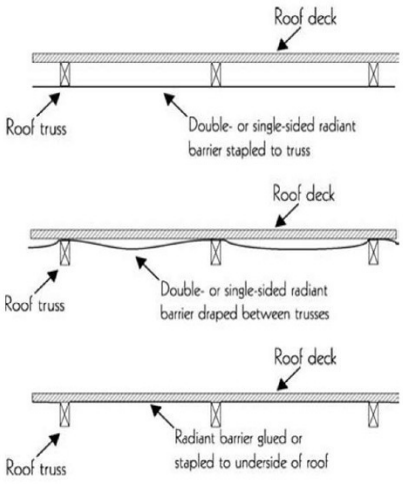
Attic Radiant Barriers

- 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



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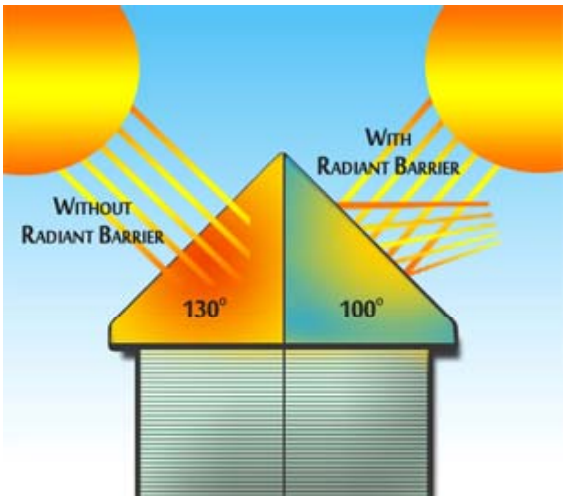
Attic Radiant Barrier



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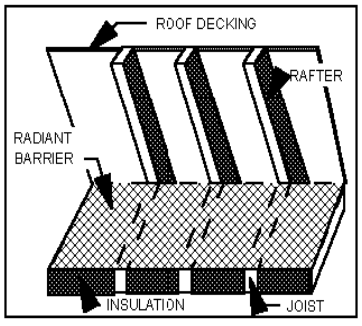
Attic Radiant Barriers

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



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Attic Radiant Barrier

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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

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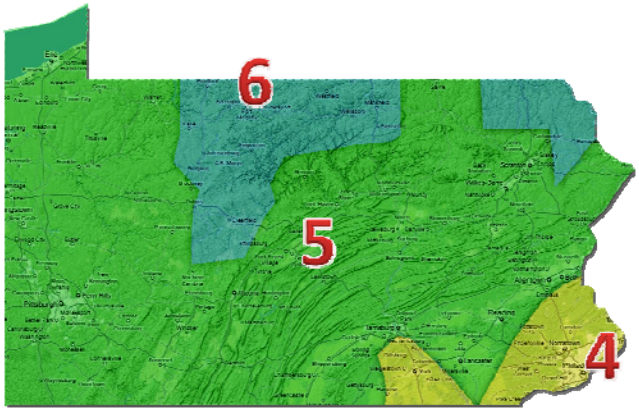
Climate Zones In PA



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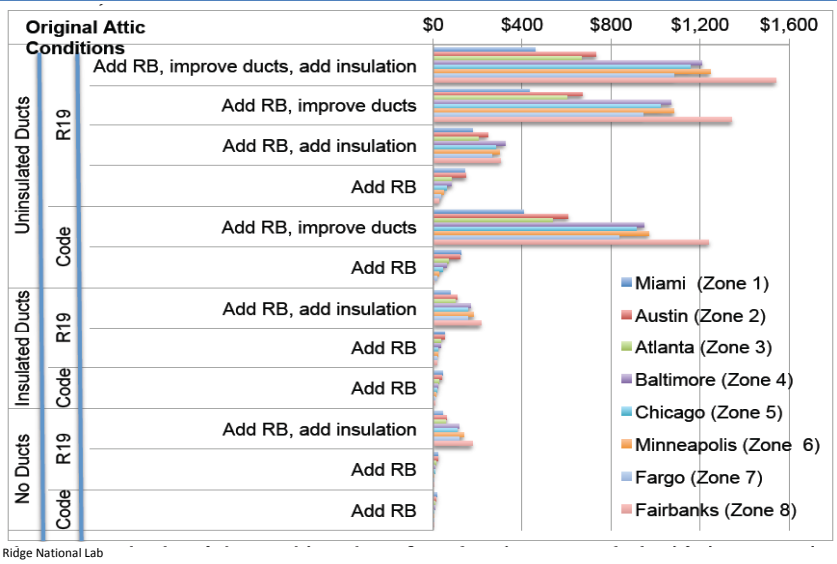
Do They Make Sense In PA?



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Do They Make Sense In PA?

Original attic condition	Insulated and well-sealed ducts			No ducts		
	R19 Attic Insulation		Code-level Attic Insulation	R19 Attic Insulation		Code-level Attic Insulation
Attic system modification	*Add RB, add insulation*	*Add RB*	*Add RB*	*Add RB, add insulation*	*Add RB*	*Add RB*
Miami (1)	$75	$50	$40	$40	$20	$15
Austin (2)	$110	$50	$40	$60	$20	$15
Atlanta (3)	$100	$30	$25	$55	$15	$10
Baltimore (4)	$170	$30	$20	$120	$10	$5
Chicago (5)	$150	$20	$15	$110	$5	$5
Minneapolis (6)	$180	$20	$10	$140	$5	$0
Fargo (7)	$150	$15	$10	$120	$0	$0
Fairbanks (8)	$210	$15	$10	$180	$5	$0

Oak Ridge National Lab

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Areas Of Application

Radiant Barrier House Wrap

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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

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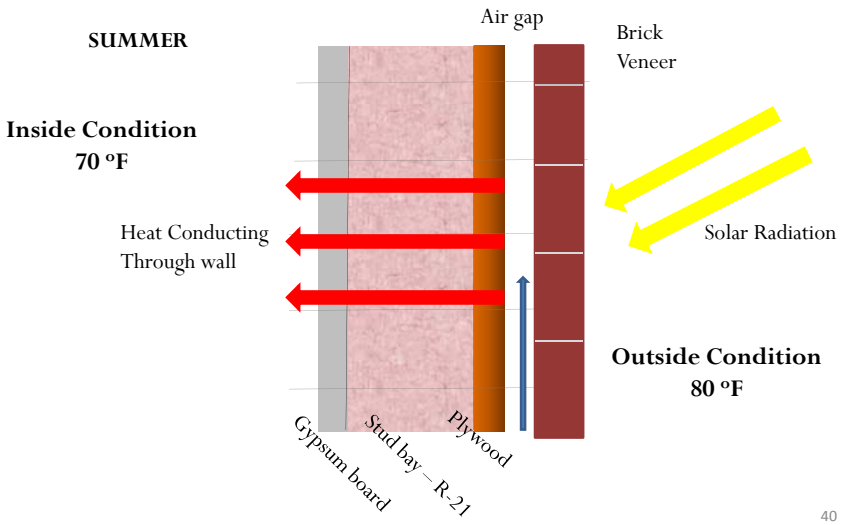
Radiant Barrier House Wrap



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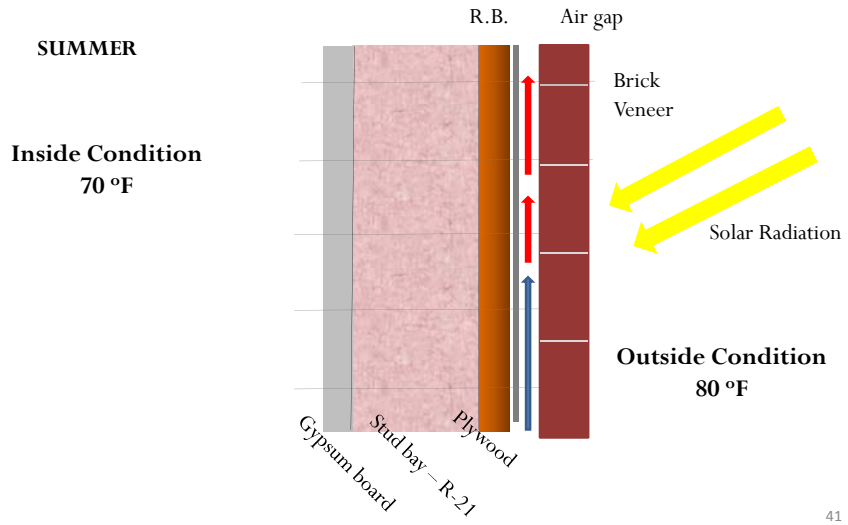
Radiant Barrier House Wrap



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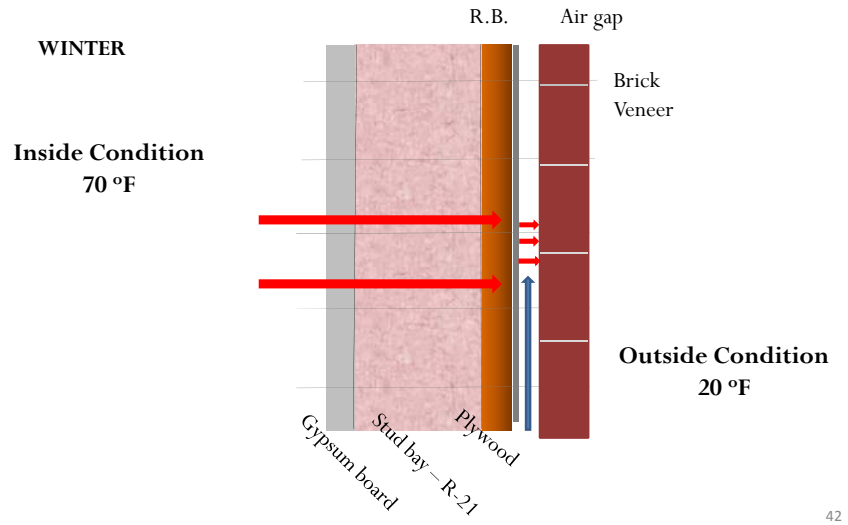
Radiant Barrier House Wrap



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Radiant Barrier House Wrap

Furring strips added for siding

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Radiant Barrier House Wrap

- 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

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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?

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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

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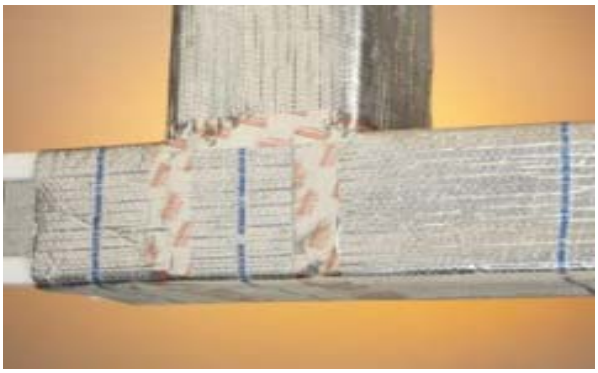
Areas of Application

Foil Faced Bubble Wrap



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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

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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

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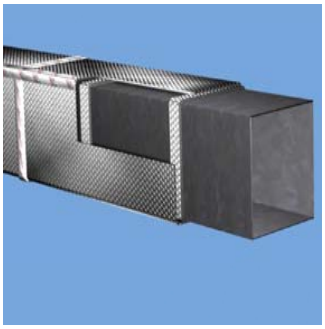
Foil Faced Bubble Wrap – Ducts

- 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

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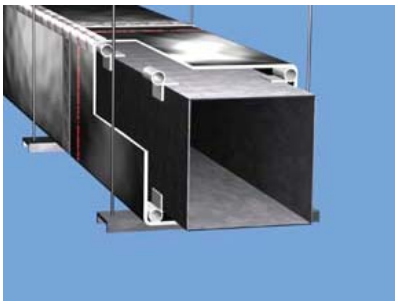
Do They Make Sense In PA

- 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?



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Do They Make Sense In PA

- R-Value represents complete assembly
  - Not just bubble wrap
- Condensation problems?

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Methods of Application

Under Slab

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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

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Under Slab

Radiant Barrier being used with radiant floor heating system

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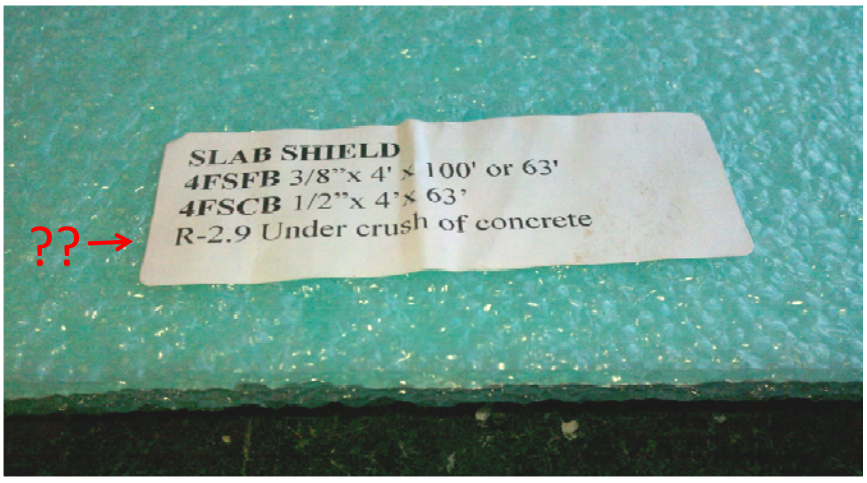
Under Slab



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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

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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

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Summary & Conclusions

- 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

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