FRSA TECHNICAL ADVISORY ON SEALED ATTICS

It has come to FRSA's attention that the combination of roofing materials and unvented, spray foam sealed attics has become a source of significant concern for the Florida roofing industry. The potential for long term accumulation of moisture in the roof system may result in costly and potentially hazardous structural deterioration. Based on contractor feedback, technical bulletins from the Asphalt Roofing Manufacturers Association (ARMA), the American Plywood Association (APA) and several shingle and self-adhered underlayment manufacturers, we concur with the sentiment that spray foam insulation applied directly to the bottom side of the deck, without an effective means of providing airflow directly below the decking, is not recommended.

References:
All reference documents can be found on the FRSA website, www.floridaroof.com

- American Plywood Association (APA) Technical Bulletin TT-111
- Asphalt Roofing Manufacturers Association (ARMA) Form No. 211-RR-94 Revised May 2008
- ARMA – Fast Facts – Ventilation
- Atlas Roofing Technical Bulletin – Proper Attic Ventilation
- Atlas Roofing Technical Bulletin – Balanced Ventilation is Critical
- Atlas Roofing Technical Bulletin – Spray Foam – Sealed Attics
- Atlas Roofing – Spray Foam – What's the Big Concern for the Roof Deck?
- Building Science – PA-1101: A Crash Course in Roof Venting
- Building Science – RR-9081: Vented and Sealed Attics in Hot Climates
- CertainTeed Symphony 2016 Limited Warranty
- GAF Residential Technical Bulleting – Deck Sprayed-In-Place Foam Insulation
- Interim Florida Building Commission Report on FRSA website
- NEI – Sprayed Foam – Sealed Attics
- Owens Corning Technical Bulletin
- Owens Corning and ORNL Collaborative Study Unvented Attics
- TAMKO Building Products Technical Bulletin – Use of Below Deck Spray
- Tarco Technical Bulletin – Foam Insulation

A Publication of the FRSA ◆ Florida's Association of Roofing Professionals

ROOFING FLORIDA

Research Remains to Be Conducted on Effects of Sealed Attics on Roofing Systems in Florida's Climate

By John Hellein, RFM Editor – Redistributed with Permision

According to comments at FRSA's April committee meetings, the use of sealed attics as a residential insulation solution has become widespread in Florida. Some member contractors expressed concern about possible negative effects caused when attics are sealed and ventilation that allows for the entry and egress of air in the attic is eliminated. At the same time, members recognized that sufficient scientific research, specific to Florida's high temperature, high humidity climate has yet to be conducted.

A primary concern about sealed attics is the possibility that the lack of air movement into and out of the attic might result in moisture that permeates from the living space below being trapped. The trapped moisture could encourage the growth of mold in the insulation or trusses. Also, it is possible that the higher humidity could weaken the wood in the trusses or roof deck.

Both the *American Plywood Association* (APA) and the *Asphalt Roofing Manufacturers Association* (ARMA) have issued statements expressing concern on this topic. In a paragraph entitled "Unvented Attics", in *Technical Topics TT-111A*, the APA, writes:

> Notwithstanding the acceptance of unvented attics by the International Building Code (IBC) and International Residential Code (IRC) in IBC 1203.3.2 and IRC R806.4, there has been a general concern about possible detrimental effects resulting from recently popularized practice of applying insulation directly to the underside of roof sheathing. Should the roof (or other) system become wet due, for example, to misinstalled or failed weather barriers, flashing, or systems that have not been properly maintained, the direct application of some insulation materials may limit the ability of wood structural panel sheathing to dry. **The use of insulation materials that inhibit the drying of wood structural panel roof sheathing, such as some direct applied insulation on the underside of the sheathing, could lead to structural panel performance issues such as buckling and other moisture-induced problems. When such insulation materials are used in combination with an impermeable layer on top of the roof sheathing, such as some adhered shingle underlayment materials, the risk of moisture problems due to reduced drying potential of the system will increase substantially.** This could lead to potential long-term accumulation of moisture in the roof system resulting in costly and potentially hazardous structural deterioration as well as possible health risks.

ARMA's *Technical Bulletin (Form No. 211-RR-94)* references "Shingle Application Directly Over Insulated Decks" and states:

> This type of application is not recommended unless an adequate free-flow ventilation space is created between the top of any insulation and the underside of a nailable deck. Proper ventilation must be provided to dissipate heat and humidity build-up under the roof top. (See ARMA Bulletin 209-RR-86 entitled "Ventilation and Moisture Control for Residential Roofing.")
>
> In addition to affecting roof performance, direct applications of asphalt shingles over insulated decks without providing proper ventilation may void the shingle manufacturer's warranty. Individual manufacturers should be consulted to determine possible effects on their product warranties when such applications are utilized.

For instance, looking at the installation instructions for *Atlas Roofing Corporation's* Pinnacle 35 asphalt shingles reveals "Spray foam insulation applied directly to the bottom of the decking will void the warranty."

More Research Needed

FRSA recognizes the need for research on the effects of sealed attics in the Florida climate and may commission the *FRSA Educational and Research Foundation* to study the issue. At the committee meetings, Tim Graboski of *Tim Graboski Roofing Inc* of Delray Beach mentioned sealed attic research that is currently being conducted by the *Department of Energy's* Dr. William Miller at the *Oak Ridge National Laboratory*. For now, the real-world research being conducted on the homes of Florida citizens will continue with the installation of every sealed attic: results pending.

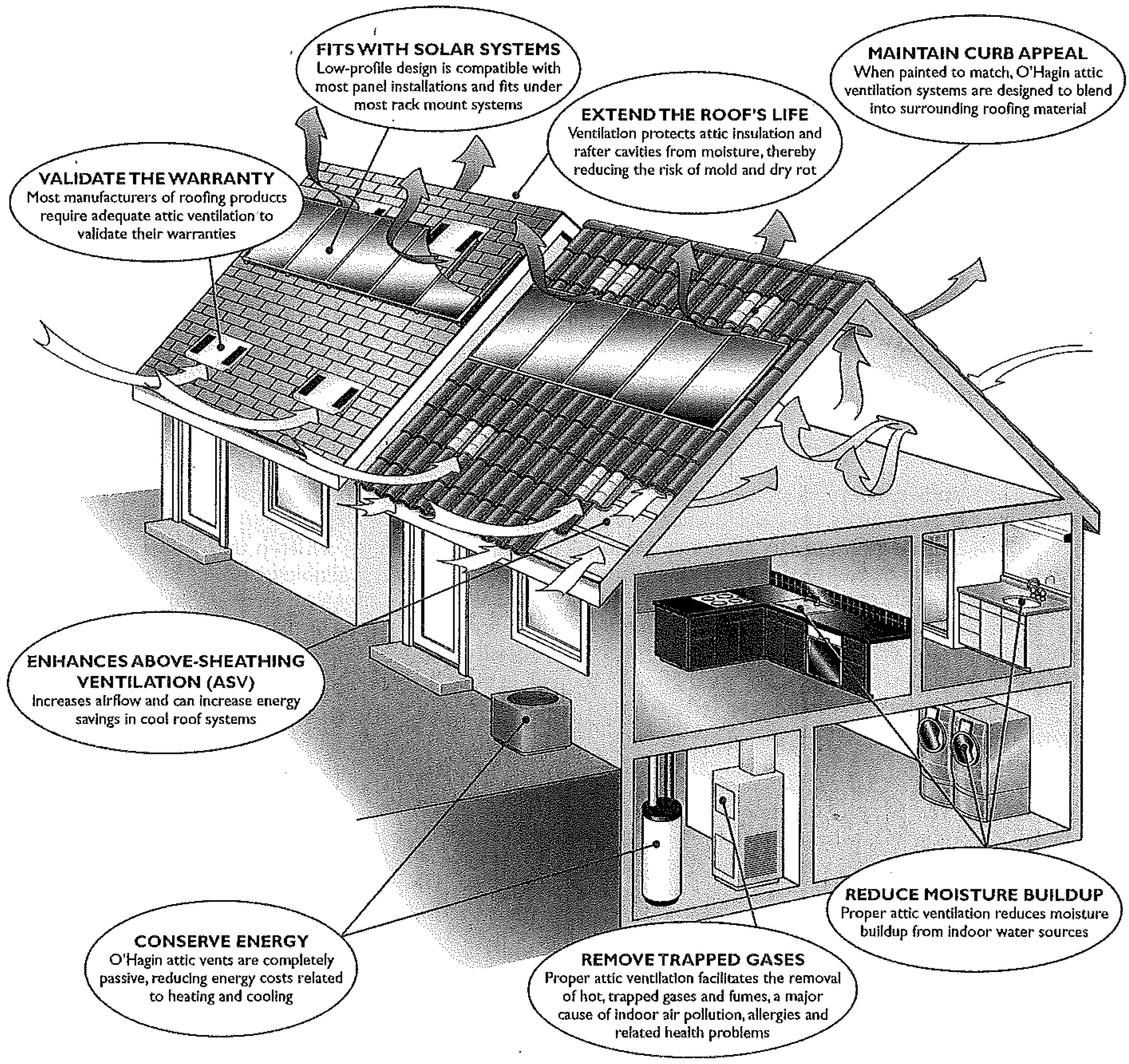
–RFM–

2017 Sixth Edition Florida Building Code Ventilation

Mike Fulton, National Manager of Technical Training and Compliance, O'Hagin

Attic ventilation is an important tool in the creation of optimal environmental conditions in any residence or structure. Properly venting the attic space helps ensure a healthier environment as well as conserve energy. Attic ventilation may also reduce the build-up of ice dams in cold areas and play an important role in prolonging the life of the roof. Ventilation requires the free flow of air, which may be achieved through the use of different methods and products. A proper ventilation system encourages superior air movement by exhausting air from the upper vents (exhaust) causing a natural vacuum effect that draws air in through the lower vents or soffit (intake).

Attic ventilation has been a standard in building construction and living envelope air quality for years. Although the language in the code has changed slightly over the years, the intent is still the same – to furnish adequate cross ventilation to all rafter and/or truss spaces



with ventilators located at or near the ridge and at the eave or cornice creating intake and exhaust.

As building designs changed from roofs with gable ends to hip roof designs, balance has been ignored.

Florida Building Codes

The Florida Building Code (FBC) Residential Code (R806) uses the 1/150 rule where one square feet of ventilation is required for every 150 square feet of attic floor space. It can be reduced to 1/300 provided 50 percent of the ventilators are located at or near the ridge with the remaining ventilators at the eave or cornice. The 1/300 rule provides the cross ventilation in buildings where the distance between the attic floor and the bottom of the ridge board is greater than three feet. At and above this distance natural convection can occur. Where the distance is less than three feet, the 1/150 should be used with ventilators on one plane, usually at the soffit. Unfortunately, there are builders that use only the 1/150 rule with attic spaces that are much higher than three feet, but technically "meet the code." This allows superheated air to accumulate in the upper portion of the attic space where air conditioning ducts are located. Since the "R" value of most AC ducts is less than "R8" a tremendous amount of heat can radiate into the ducts, greatly decreasing the efficiency of the AC system and increase cooling costs.

The FBC Ventilation Section 1203 references only the 1/300 rule requiring both intake and exhaust. Most non-residential structures do not meet the criteria for the low slope, bungalow type buildings that the 1/150 rule was created for.

Ventilators also need to have either a Miami-Dade Product Approval or a State of Florida Product Approval. Impostors are an invitation to leaks and/or wind damage such as blow-offs.

Independent studies where existing structures have utilized approved ventilators that encourage nonrestrictive airflow in conjunction with a balanced intake or soffit have shown decreased attic temperatures. Lowering attic temperatures decreases the radiant heat transfer to not only the living envelope but to heat gain in the AC ducts. Also, air handlers that are installed in the attic have even greater heat gain, adding insult to injury. In some cases, by decreasing attic temperatures, homeowners have experienced between 10-20 percent decreases in utility costs. However, due to building design, one size does not necessarily fit all.

Many vent manufacturers have tools and or resources to help both roofing contractors and homeowners achieve lower energy costs and encourage it. Most have ventilation calculators that not only help with number of vents that are required by code but can also prevent any possible future litigation due to "guessing".

Sealed Attics

Sealed attics systems have been a hot bed of discussions over the past few years. They show initial signs of success with energy savings but we don't know what the long-term consequences may be. Where there's an undetectable roof leak, water build up after time in the plywood substrate and or OSB, shows signs of premature rotting of the organic material, resulting in possible catastrophic failures. Studies done at Oak Ridge Labs and by GAF show that there's a tremendous amount of vapor transmission during the day when the sun is highest in the sky. Humidity levels soar and then lower as the sun goes down. This vapor transmission over a period of time can and will saturate the sheathing, and possibly even trusses. Early failures have happened due to an undetectable roof leak and water is trapped between the spray foam insulation and the sheathing. This is what I consider accelerated aging.

We have seen cases in South Florida where roofers actually stepped through the roof due to this premature failure. This not only becomes a structural issue over time, but a possible life safety issue. It is allowed in the code but must be designed by a Florida licensed architect or engineer. Ideally there would be an air space between the sheathing and the foam insulation. This rarely happens. It is just sprayed directly to the bottom side of the sheathing by a crew that may or may not be certified for the application. If the foam is applied too heavily, off gassing by the foam as it cures can occur and become a health issue. It's also been noted that it is very difficult, if not impossible, to completely seal the attic space, therefore allowing more vapor into the attic space.

As I've mentioned in earlier articles, the jury is still out on this matter. Only time will tell if this will become another Chinese drywall situation. Until then, we urge roofing contractors to use a disclaimer in their contract stating that they won't be responsible for structural damage in a sealed attic due to an undetectable roof leak. This may or may not protect the roofing contractor totally, but at least gives them a chance if a future structural failure goes to litigation. FRSA members can access the disclaimer written by FRSA Legal Counsel Trent Cotney, P.A., available on the FRSA website, www.floridaroof.com, under the member login section.

In conclusion, attic ventilation done properly with a balanced system that promotes unrestricted airflow, will reduce attic temperatures, humidity levels and energy costs. Others will disagree.

FRM

Mike has worked with O'Hagin for 20 years and has been the National Manager of Technical Training and Compliance for the past 12 years. He is a member of FRSA Roof Tile and Codes and Regulatory Compliance Committees as well as the TRI Southeast Technical Committee.

ASPHALT ROOFING™
MANUFACTURERS ASSOCIATION

FAST FACTS

Ventilation

DID YOU KNOW?

Why is ventilation important?

Proper ventilation reduces moisture build-up in your home

- The average family of four generates approximately 2 to 4 gallons of water vapor each day through activities such as breathing, perspiration, showering, cooking and dishwashing.
- When moisture vapor remains in a colder/dryer attic, it can potentially condense damaging your roof deck and insulation.
  - In cold weather climates, ice dams can form along your eave edge increasing the chance of a roof leak and damage to your gutters.
  - Excess moisture may also lead to moisture build-up in your insulation, which can lessen the insulating value over time, and even lead to mold build-up in your attic

Proper ventilated spaces reduce the Stack Effect by pushing warm, moist air out of the attic space. In addition to moisture build-up, proper ventilation also reduces heat build-up in your attic.

- Improper ventilation can lead to premature deterioration of your shingles and roof deck.
- Proper ventilation means your attic stays cooler, reducing load on your air conditioning units. The less your AC unit works, the longer it will last, likely resulting in lower cooling bills.

DID YOU KNOW?

How much ventilation do I need?

- A **balanced ventilation system** is best. A balanced system is where intake ventilation at the eave areas is equaled at or near the ridge area.
- Minimum ventilation requirements are 1 sq. ft. unobstructed or **net free area** of ventilation for every 300 sq. ft. of attic space.
- The preferred ration is 1 sq. ft. of net free area of ventilation to every 150 feet of attic space. In order to qualify for a FHA loan, ventilation must meet the 1/150 rule. Many calculators to help you plan the right amount of ventilation for your home and the ventilation system you select are available.
- There are different styles of **ventilation systems available**; many are 100% green, utilizing no electrical power.

DID YOU KNOW?

Can I over ventilate?

If the system is not balanced at the top or ridge area, or if there were gable end vents with ridge vents, without adequate soffit ventilation you may actually pull moisture into the home during a heavy rain or snow storm.

The exception to the balance rule is at the soffit in passive systems. Since the air that enters at the soffit acts to push out moisture and warm air, having extra soffit ventilation will not create an off-balance system.

Additional information:

Still have questions? For more information, please visit www.asphaltroofing.org to see ARMA's MAT Releases, Case Studies and Videos.

ATLAS® ROOFING CORPORATION

Technical Bulletin:

Re: "Spray Foam" – Sealed Attics

Atlas Roofing Corporation only accepts the installation of asphalt shingles and/or self-adhered underlayments over highly insulated roof decks insulated with any type of foam insulation when an effective means of providing air flow directly below the nailing surface is permanently installed. The provided air flow must be continuous from the eaves area through to the highest point of the roof area.

Spray foam insulation applied directly to the bottom of the roof decking material is not acceptable to Atlas Roofing Corporation regarding warranty claims on either self-adhered underlayments or asphalt shingles.

The "Open Cell" and the "Closed Cell" foam types can contribute to a decrease in the expected life of asphalt-based roof covering and the decking materials, due to the inability of the finished roof system to properly dissipate heat and/or moisture from the system.

There are commercially available, economical and easily installed, ducting/baffle products which provide for continuous soffit to ridge air flow, directly below the decking material. The baffles are to be installed between the rafter/truss components to provide continuous air paths from the intake at the soffit areas through to the ridge vent exhaust openings at the ridge. The continuous baffles shall be installed, full cavity width, in all rafter cavities of the roof assembly. These baffle type products will alleviate the ventilation concerns noted above and will maintain the Atlas Roofing Corporation Shingle, Limited Warranty coverage when properly installed.

Ed Todd
Director of Product Management
Atlas Roofing Corporation

TECHNICAL BULLETIN

Last Revision: January 2016

Subject: **Proper Attic Ventilation - Net Free Area Design Criteria**

Proper attic ventilation is critical in the life expectancy and durability of an asphalt roof system. Proper attic ventilation can help ensure the maximum service life of roof assembly materials, and can improve heating and cooling efficiency. Ventilation is a system of intake and exhaust that creates a flow of air. Solar heat is transmitted through the roofing material and radiated to the ceiling insulation. As both the roof and insulation warm up, the attic air also becomes heated. Continual heat buildup can cause premature shingle deterioration and roof system component failure.

Shingles start to deteriorate at a faster rate when the temperature of the roof sheathing they are attached to is continually elevated. This can significantly shorten the life of a shingle. An overheated attic, combined with moisture, can cause a number of problems, including damage to roof decking and roof shingles, ice dam formation in cold weather and moisture accumulation in the deck and/or building insulation. This can lead to deck and shingle distortion and premature deterioration.

Atlas Roofing Corporation requires the attic ventilation installation to at least meet or exceed the FHA minimum requirements of at least one square foot of net free unrestricted air flow for each 150 square feet of attic floor space. While some model codes include an allowance for reduced vent area when the system is properly balanced, an unbalanced system may result in performance and durability issues.

The best approach is to employ the right amount of vent area, installed as part of a balanced system. It may be possible to reduce the minimum Net Free Ventilation Area ratio to as little as one square foot per 300 square feet of attic floor space with an approximately equally balanced system between the intake (lower) and the exhaust (upper). Always provide at least 50 percent, but no more than 60 percent, of the total required ventilation at the eaves or lowest portion of the roof if possible.

If possible, exceeding these requirements will benefit the life expectancy of the roof system.

The installation of this amount of ventilation in the described locations will maintain the requirements of the Atlas Roofing Limited Shingle Warranty.

Check with the vent device manufacturer for the Net Free Area design capacity of specific vents.

Paul Casseri, Product Manager, Residential Roofing Products | PCasseri@AtlasRoofing.com

TECHNICAL BULLETIN

Last Revision: January 2016

Subject: **Under Deck Sprayed-In-Place Foam Insulation**

Will Sprayed-In-Place Foam Insulation Void My Atlas Limited Shingle Warranty?	Spray foam insulation or other insulation materials which are applied directly to the bottom of the roof decking material does not allow for eave to ridge airflow will void the warranty. It is the responsibility of the asphalt shingle installer and/or design professional to insure that adequate ventilation is present and meets warranty requirements and local codes.
Is There An Acceptable Method Of Applying Spray-In-Place Foam Insulation That Would Not Void	Spray-In-Place Foam Insulation that is installed in a manner that provides continuous adequate air flow directly below the shingle nailing surface and is permanently installed. The provided air flow must be continuous from the eaves unimpeded through to the highest point of the roof area (ridge), available directly below the decking to which the underlayment and shingles are attached.
Warranty Provision Compliances	• In order for the Atlas Limited Shingle warranty be in effect, full compliance to the minimum stated ventilation requirements, fastening requirements, as well as the entire installation requirements, as stated on the product packaging, must be provided. Unrestricted, flow through ventilation from the soffit area to the ridge area must be incorporated into the roof assembly to maintain the warranty provisions. This flow through ventilation must occur directly below the decking and must be able to support the minimum roof ventilation, per local code requirements, or, the standard Atlas ventilation requirements as printed on the product packaging, whichever is greater. • Atlas Roofing Corporation shall not have liability for: 1. Damage to Atlas Singles caused by movement, distortion, settlement, deterioration, cracking failure of the roof deck or framing members of the roof assembly, 2. Failure of, damage to, or defects attributable to radiant barrier type materials used in the deck assembly, such as excessive blistering, cracking and/or excessive granule loss, 3. Premature failure of, or damage to, Atlas asphalt shingles not applied in strict compliance with the installation instructions stated on the packaging or as dictated by local building codes. 4. Any damage to the shingles attributed to using sprayed-in-place insulation directly applied to the roof deck or lack ventilation as outlined in the printed Atlas shingle installation instructions is excluded from Atlas's responsibility under the terms of our limited warranty.

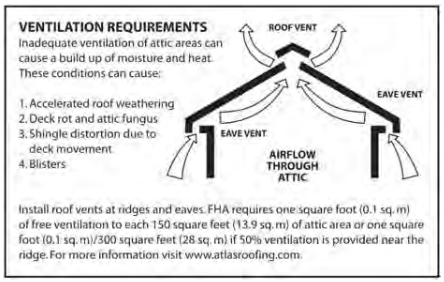
Paul Casseri, Product Manager, Residential Roofing Products | PCasseri@AtlasRoofing.com

Issue Date: September 1, 2016

Atlas ProForce

Technical & Product Update

Balanced Ventilation is Critical



The Key to Proper Attic Ventilation: More is Not Better.

The general consensus among building scientists is that the amount of ventilation a roof needs can be determined by its size. Recognized by builders throughout the industry, the Federal Housing Administration (FHA) standard for static ventilation, as found in U.S. Department of Housing and Urban Development (HUD) requirements for proper ventilation, is a ratio of 1:150 or 1:300. This means that one square foot of ventilation for every 300 square feet of attic.

The International Code Council (ICC), the U.S. Department of Housing and Urban Development (HUD) and ASHRAE have set standards for roof ventilation. Most shingle manufacturers have adopted these standards as minimum acceptable ventilation conditions in their shingle warranties. The standards require a minimum of 1 square foot of net-free ventilation area for every 150 square feet of attic floor space. However, if approximately half of the open ventilation area is in the upper portion of the roof, such as at the ridge, and half is in the lower area, such as at the soffits or eaves, the standard reduces to 1 square foot of net-free ventilation for every 300 square feet of attic floor space. A balanced system allows a less restricted, even flow of air throughout the attic space. Many states have adopted different versions of the ICC construction codes, including the International Building Code (IBC) and International Residential Code (IRC). Specific language addressing cross ventilation requirements in enclosed attic or rafter spaces is available in the 2012 IBC Section 1203.2 VENTILATION – Attic spaces.

The most important factor in roof ventilation is the need for a “balanced system.” This means that for every inch of air exhausted, the amount of air intake at the eaves must be the same or greater – 50% of the vents at the eave and 50% of the upper portion of the roof. (In cases where a 50:50 balance cannot be achieved, always provide more than 50% of the ventilation at the eave).

Try this: Breathe out. Hold it and breathe out again. And again. You can’t do this more than a couple of times before you have to breathe in again. An attic works the same way. Any air that is exhausted has to come from somewhere. In a properly vented attic, it comes from outside and low on the roof. Then, it is exhausted out at the warmer, higher parts of the roof.

If an attic has a properly balanced system the airflow will move from the bottom of the attic to the top, pushing heat and moisture in a natural flow using air pressure, thermal effect and diffusion. If the Net Free Area (NFA) at the ridge (top third of the attic) is higher than at the eave, a reverse airflow can occur.

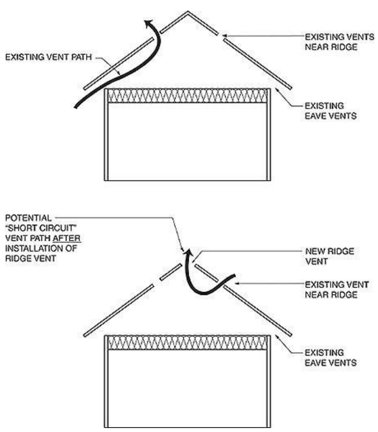
Poor Ventilation – The Potential Problems

With poor ventilation, summer sunshine can cause a massive buildup of heat in the attic space. In a building with poor ventilation, the temperature in the attic may eventually reach 140°F on a 90°F day. An overheated attic, combined with moisture, can cause a number of problems, including damage to roof decking and roofing shingles, which can become distorted and deteriorate prematurely. Heat that's absorbed in the attic can also radiate into the living space causing air conditioners, fans, refrigerators and other appliances to work harder. As a result, energy bills can increase.

In the winter, moist, warm air from the lower portions of a building will tend to rise through the ceiling into the attic, especially through bypasses where electrical and plumbing fixtures are installed. In a cold attic, the warm, moist air condenses on the cold surfaces of the rafters, the nails and other metal, and the attic side of the deck. This excess water can create several problems including ice dams.

First, the condensation can cause the deck to swell, resulting in waviness and buckling of both the deck and the shingles. Second, the water can rot the roof deck, destroying its ability to carry loads and its nail-holding capability. Third, severe condensation can drip onto the insulation, reducing its effectiveness and possibly seeping through to the ceiling below. Damp insulation causes wood rot, mold, and mildew, leading to poor indoor air quality in the rest of the home.

Too Much Ventilation – Short Circuiting



Short circuits occur when air is caused to go around and away from its original and intended path resulting in areas of the attic being bypassed (skipped). Air flows the path of least resistance. In a properly designed and installed attic ventilation system, the air will flow from intake vents to exhaust vents flushing out the warm, moist air along the entire underside of the roof.

The most common example of short circuiting ventilation is when more than one type of exhaust vent system is installed such as ridge vents and roof louvers. One of these two exhaust-type vents would act as an intake vent, leaving large areas of the attic unventilated and increasing the potential for weather infiltration problems.

If two or more different types of exhaust vents are in place, the secondary exhaust vent interrupts the flow of air and may actually become an intake vent for the primary exhaust vent – diverting air away from a ridge vent – and leaving large chunks of attic space incorrectly vented.

Note: It's okay to mix or combine two or more types of intake vents without fear of possible short circuiting because unlike the exhaust vents described above, the intake vents will all be in the same wind pressure zone.

- ❏ **More Info:**
    - ❏ Importance of Proper Ventilation
    - ❏ Ventilation Short Circuiting
    - ❏ Net Free Area Calculator
    - ❏ Ventilated Roof System Calculator
    - ❏ ARMA Ventilation Fast Facts
    - ❏ Atlas Technical Bulletin - Attic Ventilation

REMEMBER: *When a claim is inspected and/or submitted, the proper ventilation information must be filled out on the Inspection/Lab Report. The warranty requirement is a minimum of 1 sq. ft. of net free attic vent area for every 150 sq. ft. of attic floor space, or 1 sq. ft. of net free attic vent for every 300 sq. ft. of attic floor space.*

Breathable Underlayment – Does it Really Work?

The real answer is "No". Owens Corning commissioned a study with leading Building Science Experts and published their results titled Vapor Permeability Provides NO PERFORMANCE BENEFITS FOR ROOFING UNDERLAYMENTS in vented attics. The following is a summary paraphrased from the research study.

The research performed indicates that non-breathable underlayments show comparable or better moisture performance than products marketed as breathable. Incorporating a permeable underlayment into the roof system does not improve the system breathability of the roofing system.

When asphalt shingles are installed to manufactures recommendations, it creates a non-permeable structure which means that no air or moisture from inside the roof attic will escape through the roofing assembly. It is suggested that breathable underlayment may perform negatively in the assembly versus non-breathable underlayment. The more breathable the product, the more water, moisture and air is allowed to penetrate the underlayment.

Proper balanced ventilation is stressed by all asphalt shingle manufactures to achieve the most efficient moisture transfer from the attic.

- ❏ **More Info:**
    - ❏ Underlayment Breathability Study

- ❏ **How To Use This Info:**

- ❏ Have an open conversation with your contractors about underlayment breathability. Help them understand that once shingles are installed on the roof the system becomes closed. Please read the study and get a basic understanding of the research results.

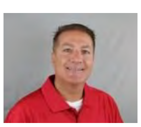
OSHA Update – Major Fine Increases

Safety should always be the top priority of the contractor and their roofing crew. The Occupational Safety and Health Act of 1970 (OSHA) was established "To assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health..."

Falls are the leading cause of death in the construction industry. Falls from roofs accounted for 34% of all fall deaths between 2001 and 2013. Safety should not be compromised or ignored. OSHA just released an increase in penalties that will take effect August 1, 2016. OSHA fines to Jump 78% effective August 1st. It's important as a sales professional to relay this information to your contractors. A steep fine can cause heartache for any business and the cheapest solution is to keep everyone safe.

- ❏ **More Info:**
  - ❏ OSHA – Protecting Roofing Workers
  - ❏ OSHA Fines to Jump 78% Effective August 1, 2016

Keep In Touch!



Questions, comments, concerns?

Paul Casseri - Product Manager - Roof Shingles & Underlayments
e: pcasseri@atlasroofing.com
p: 678-402-9632
m: 770-312-6608

A Crash Course in Roof Venting

Understand when to vent your roof, when not to, and how to execute each approach successfully

BY JOSEPH LSTIBUREK

ROOF VENTING 101

Vent the attic space

To ensure that a vented attic performs at its best, you need to get the details right. Here are **five rules** that are critical to the success of this simple roof design. These rules must guide design and construction no matter where the roof is being built.

So much information has been devoted to the subject of roof venting that it's easy to become confused and to lose focus. So I'll start by saying something that might sound controversial, but really isn't: A vented attic, where insulation is placed on an air-sealed attic floor, is one of the most underappreciated building assemblies that we have in the history of building science. It's hard to screw up this approach. A vented attic works in hot climates, mixed climates, and cold climates. It works in the Arctic and in the Amazon. It works absolutely everywhere—when executed properly.

Unfortunately, we manage to screw it up again and again, and a poorly constructed attic or roof assembly can lead to excessive energy losses, ice dams, mold, rot, and lots of unnecessary homeowner angst.

Here, I'll explain how to construct a vented attic properly. I'll also explain when it makes sense to move the thermal, moisture, and air-control layers to the roof plane, and how to detail vented and unvented roofs correctly.

Theory behind venting

The intent of roof venting varies depending on climate, but it is the same if you're venting the entire attic or if you're venting only the roof deck.

In a cold climate, the primary purpose of ventilation is to maintain a cold roof temperature to avoid ice dams created by melting snow and to vent any moisture that moves from the conditioned living space to the attic. (See "Energy Smart Details" in *FHB* #218 for more on ice dams.)

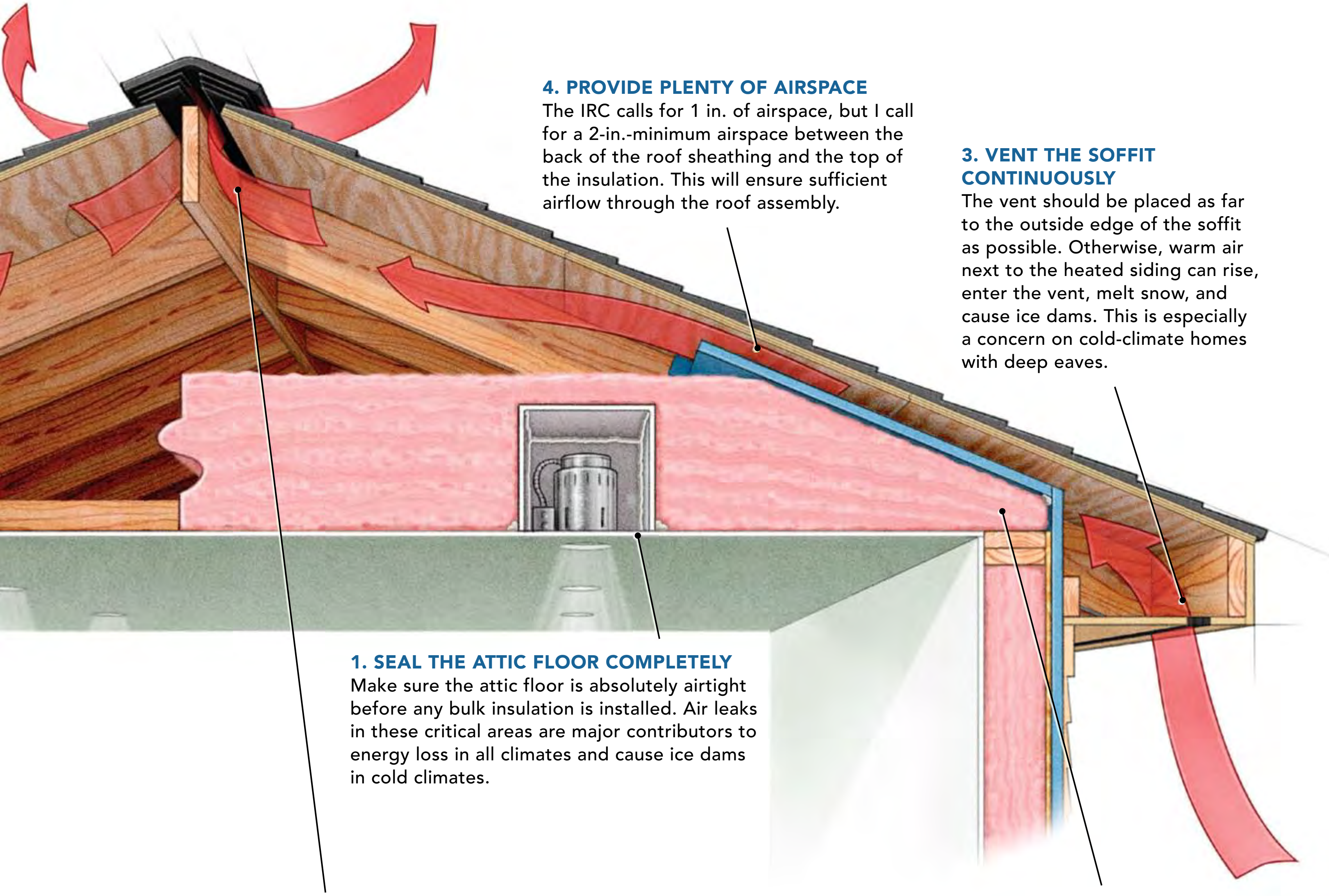
In a hot climate, the primary purpose of ventilation is to expel solar-heated hot air from the attic or roof to reduce the building's cooling load and to relieve the strain on air-conditioning systems. In mixed climates, ventilation serves either role, depending on the season.

Vent the attic

A key benefit of venting the attic is that the approach is the same regardless of how creative your architect got with the roof. Because the roof isn't in play here, it doesn't matter how many hips, valleys, dormers, or gables there are. It's also easier and often less expensive to pile on fiberglass or cellulose insulation at the attic floor to hit target R-values than it is to achieve a comparable R-value in the roof plane.

The success of this approach hinges on the ceiling of the top level of the house being absolutely airtight before any insulation is installed. (See "Attic-Insulation Upgrade" in *FHB* #200.) It's also important to ensure that there isn't anything in the attic except lots of insulation and air—not the Christmas decorations, not the tuxedo you wore on your wedding day, nothing. Attic space can be used for storage, but only if you build an elevated platform above the insulation. Otherwise, the insulation gets compressed or kicked around, which diminishes its R-value. Also, attic-access hatches are notoriously leaky. You can build an airtight entry to the

Drawings: John Hartman



4. PROVIDE PLENTY OF AIRSPACE
The IRC calls for 1 in. of airspace, but I call for a 2-in.-minimum airspace between the back of the roof sheathing and the top of the insulation. This will ensure sufficient airflow through the roof assembly.

3. VENT THE SOFFIT CONTINUOUSLY
The vent should be placed as far to the outside edge of the soffit as possible. Otherwise, warm air next to the heated siding can rise, enter the vent, melt snow, and cause ice dams. This is especially a concern on cold-climate homes with deep eaves.

1. SEAL THE ATTIC FLOOR COMPLETELY
Make sure the attic floor is absolutely airtight before any bulk insulation is installed. Air leaks in these critical areas are major contributors to energy loss in all climates and cause ice dams in cold climates.

2. BULK UP THE INSULATION ABOVE THE TOP PLATE
Make sure the amount of insulation (typically fiberglass or cellulose) above the top plate is equal to or greater than the R-value of the wall assembly, never less.

5. SLIGHTLY PRESSURIZE THE ATTIC
Building codes suggest balancing the intake and exhaust ventilation. The code, however, is wrong, and I'm working hard to get it changed. More ventilation at the eaves than at the ridge will slightly pressurize the attic. A depressurized attic can suck conditioned air out of the living space, and losing that conditioned air wastes money.

For best results, provide between 50% and 75% of the ventilation space at the eaves; a 60/40 split is a good sweet spot. The code specifies 1 sq. ft. of net free-vent area (NFVA) for every 300 sq. ft. of attic space. (Keep in mind that different vent products have different NFVA ratings.) Here's how to do the math for a 1200-sq.-ft. attic.

STEP 1

Calculate how much NFVA you need.

1200 sq. ft.
÷ 300 sq. ft.
= 4 sq. ft. of NFVA

STEP 2

Convert that to inches.

4 sq. ft. of NFVA
x 144 (in. per sq. ft.)
= 576 sq. in. of NFVA

STEP 3

Divide it up between the soffit and the ridge.

60% of 576 sq. in. =
345.6 sq. in. (soffit vents)

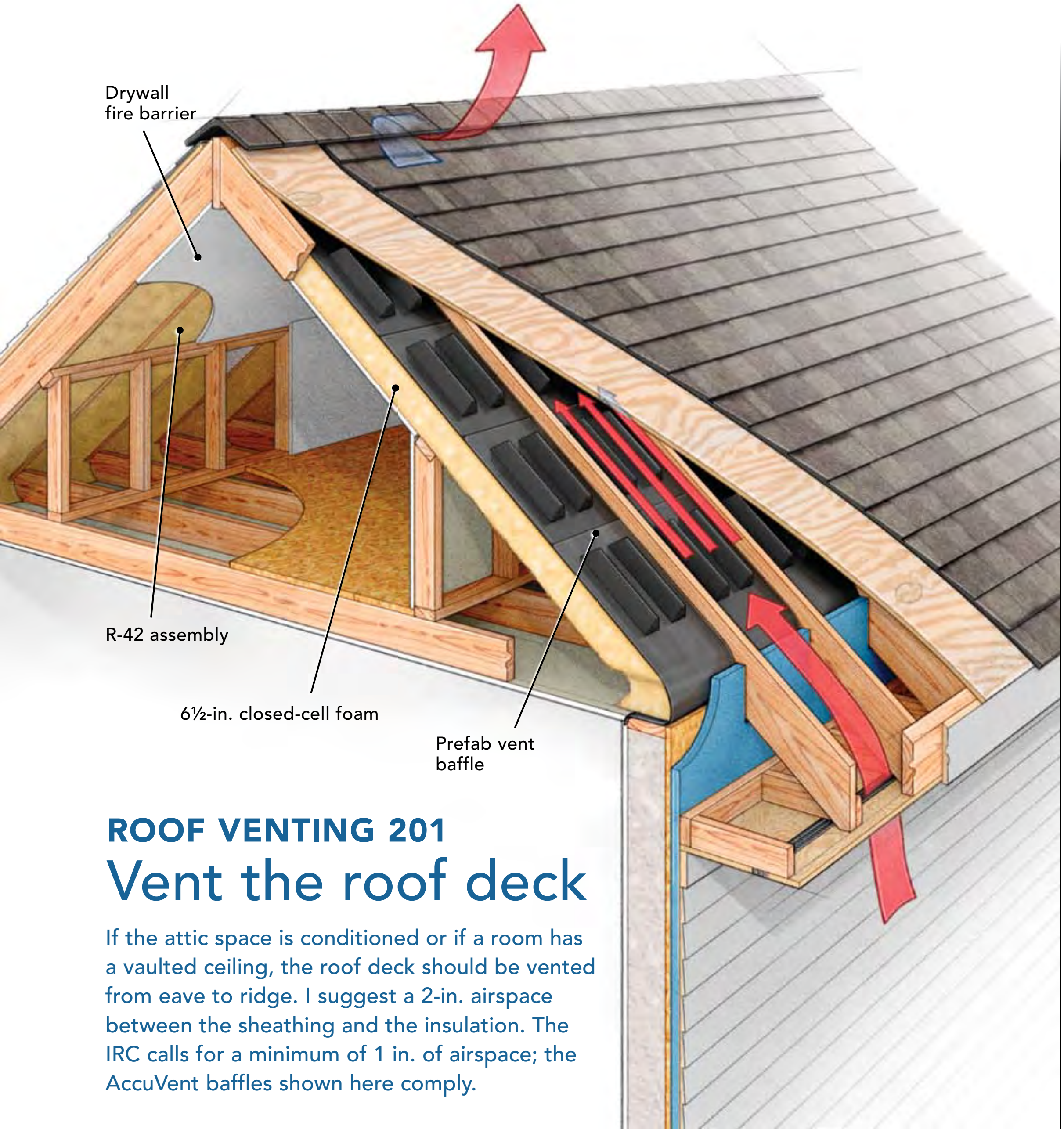
40% of 576 sq. in. =
230.4 sq. in. (ridge vents)

STEP 4

Apply it to the particular soffit and ridge vents that you are using.

Soffit vents
345.6 sq. in. ÷ 9 (NFVA-per-ft. rating of vent)
= 38.4 lin. ft. of intake, or
= 19.2 ft. of intake per side of roof

Ridge vents
230.4 sq. in. ÷ 9
= 25.6 lin. ft. of exhaust



ROOF VENTING 201

Vent the roof deck

If the attic space is conditioned or if a room has a vaulted ceiling, the roof deck should be vented from eave to ridge. I suggest a 2-in. airspace between the sheathing and the insulation. The IRC calls for a minimum of 1 in. of airspace; the AccuVent baffles shown here comply.

attic, but you should know that the more it is used, the leakier it gets.

How do people get this simple approach wrong? They don't follow the rules. They punch a bunch of holes in the ceiling, they fill the holes with recessed lights that leak air, and they stuff mechanical systems with air handlers and a serpentine array of ductwork in the attic. The air leakage from these holes and systems is a major cause of ice dams in cold climates and a major cause of humidity problems in hot climates. It's also an unbelievable energy waste no matter where you live.

Don't think you can get away with putting ductwork in an unconditioned attic just because you sealed and insulated it. Duct-sealing is faith-based work. You can only hope you're doing a good-enough job. Even when you're really diligent about air-sealing, you can take a system with 20% leakage and bring it down to maybe 5% leakage, and that's still not good enough.

With regard to recessed lights and other ceiling penetrations, it would be great if we could rely on the builder to air-seal all these areas. Unfortunately, we can't be sure the builder will air-seal well or even air-seal at all. So we have to take some of the responsibility out of the builder's hands and think of other options.

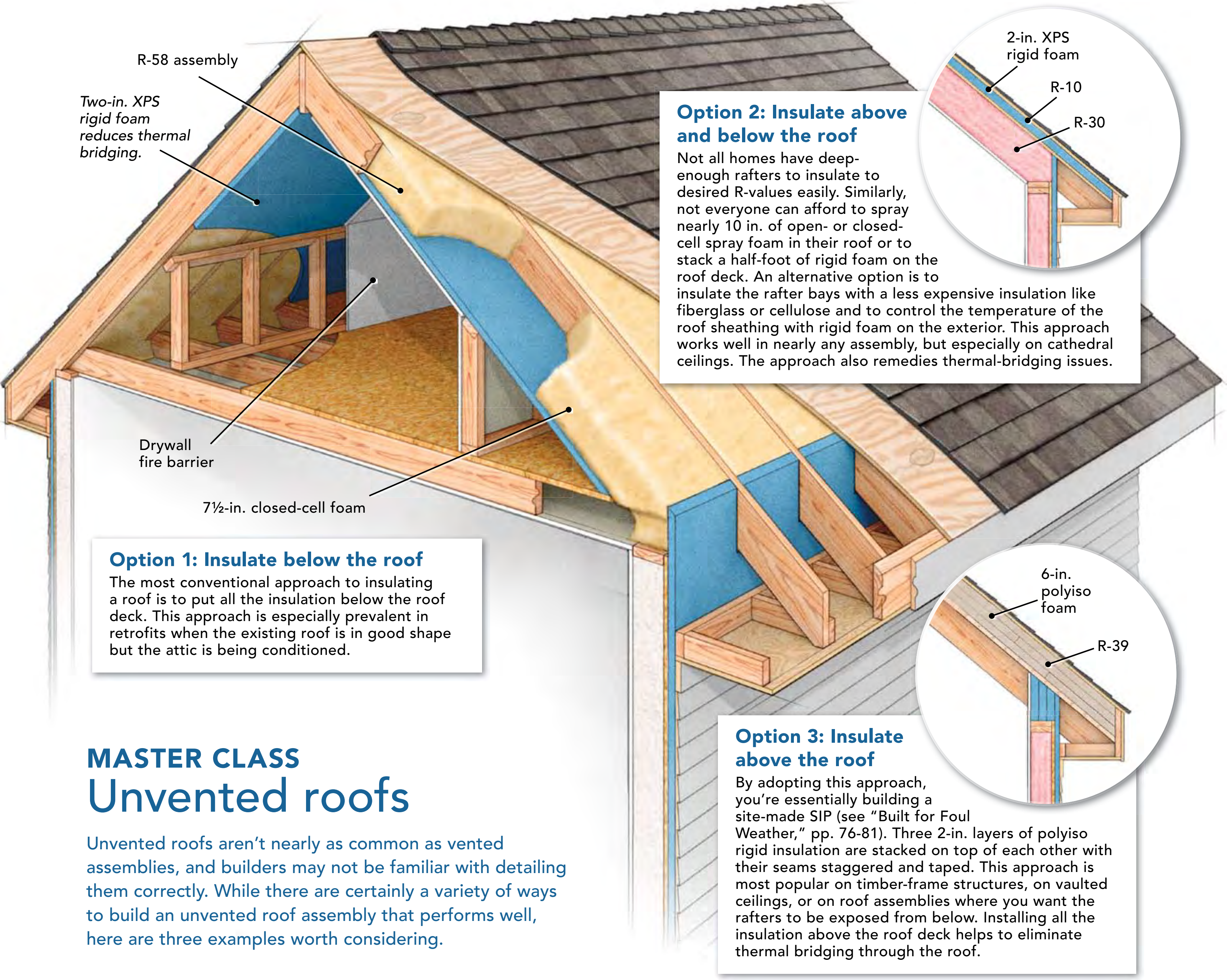
In a situation where mechanical systems or ductwork has to be in the attic space or when there are lots of penetrations in the ceiling below the attic, it's best to bring the entire attic area inside the thermal envelope. This way, it's not as big a deal if the ceiling leaks air or if the ducts are leaky and uninsulated.

Vent the roof deck

If the attic space is going to be conditioned, either for living or mechanical purposes, or if a home design calls for a vaulted ceiling, provision R806.3 in the International Residential Code calls for the roof deck above the space to be vented continuously from the eave to the ridge. This is easy to accomplish in simply constructed roofs and difficult, if not impossible, to accomplish in roofs that have hips, valleys, dormers, or skylights that interrupt the rafter bays.

If you choose to vent the roof deck, then be serious about it and really vent it. The code calls for a minimum of 1 in. of airspace between the top of the insulation and the back of the roof sheathing. That's not enough. For best performance, the airspace in the vent chute should be a minimum of 2 in. deep. Unless you're bulk-filling rafter bays between 2x10 or 2x8 rafters with closed-cell spray foam, this approach will likely require you to fur out the rafters to accommodate additional insulation to achieve desired R-values. That can be a pain, but you won't run into the problems associated with having too little air circulating under the roof. To be sure your roof is getting enough ventilation, there are simple calculations that you can follow (sidebar p. 69)

Beyond the decreased capacity for insulation when venting the roof deck, venting the roof deck or the attic has some other drawbacks worth considering. In cold climates, snow can enter the soffit and ridge vents, melt, and potentially cause rot. Similarly, in coastal environments or in regions with lots of rain and wind, moisture can be forced into the vents and into the roof assembly. In hurricane-prone zones with frequent high-wind events, vented-soffit collapse can pressurize a building, which can cause windows to blow out and the roof to be blown off. Finally, in wildfire zones, floating embers can enter the vents and cause roof fires. If any of these



MASTER CLASS

Unvented roofs

Unvented roofs aren't nearly as common as vented assemblies, and builders may not be familiar with detailing them correctly. While there are certainly a variety of ways to build an unvented roof assembly that performs well, here are three examples worth considering.

Option 1: Insulate below the roof

The most conventional approach to insulating a roof is to put all the insulation below the roof deck. This approach is especially prevalent in retrofits when the existing roof is in good shape but the attic is being conditioned.

Option 2: Insulate above and below the roof

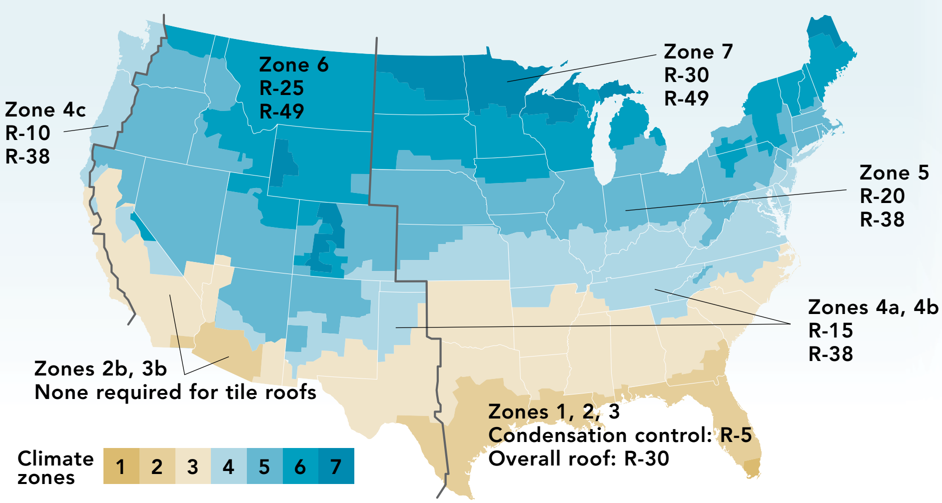
Not all homes have deep-enough rafters to insulate to desired R-values easily. Similarly, not everyone can afford to spray nearly 10 in. of open- or closed-cell spray foam in their roof or to stack a half-foot of rigid foam on the roof deck. An alternative option is to insulate the rafter bays with a less expensive insulation like fiberglass or cellulose and to control the temperature of the roof sheathing with rigid foam on the exterior. This approach works well in nearly any assembly, but especially on cathedral ceilings. The approach also remedies thermal-bridging issues.

Option 3: Insulate above the roof

By adopting this approach, you're essentially building a site-made SIP (see "Built for Foul Weather," pp. 76-81). Three 2-in. layers of polyiso rigid insulation are stacked on top of each other with their seams staggered and taped. This approach is most popular on timber-frame structures, on vaulted ceilings, or on roof assemblies where you want the rafters to be exposed from below. Installing all the insulation above the roof deck helps to eliminate thermal bridging through the roof.

PREVENT CONDENSATION WITH THE RIGHT AMOUNT OF INSULATION

An unvented roof assembly is possible only if you keep the roof sheathing warm enough to prevent conditioned air from condensing against it. The map at right, which is based on table R806.4 of the IRC, lists the minimum R-values required to prevent condensation in unvented assemblies in various climate zones. The thickness of the insulation will vary depending on the type. These R-value requirements are intended only to prevent condensation and don't supersede the code-required R-values for energy efficiency, which are also listed.



EXTRA CREDIT

Site-built or prefab baffles?

The success of a vented attic or roof deck relies on its airtightness. The space above the top plate of exterior walls—at the bottom of each rafter bay—is especially important. Baffles placed in this area channel intake air into either the attic space or vent chutes, and also prevent insulation from falling into the soffit and blocking airflow.

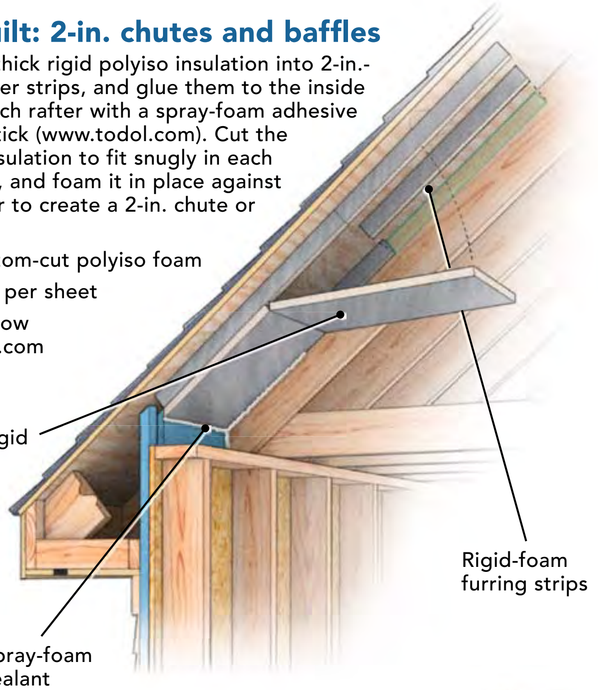
Site-built: 2-in. chutes and baffles

Cut 1-in.-thick rigid polyiso insulation into 2-in.-wide spacer strips, and glue them to the inside face of each rafter with a spray-foam adhesive like Pur Stick (www.todol.com). Cut the polyiso insulation to fit snugly in each rafter bay, and foam it in place against the spacer to create a 2-in. chute or baffle.

Size: Custom-cut polyiso foam

Cost: $23 per sheet

Source: Dow www.dow.com



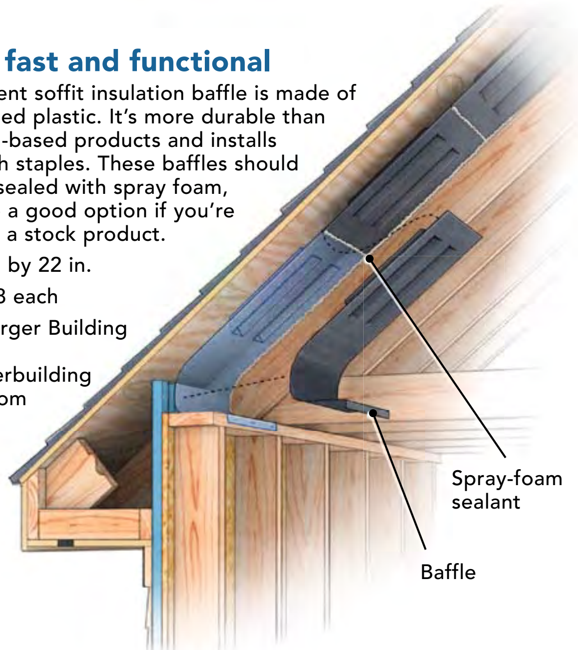
Prefab: fast and functional

The AccuVent soffit insulation baffle is made of rigid recycled plastic. It's more durable than other foam-based products and installs quickly with staples. These baffles should still be air-sealed with spray foam, but they're a good option if you're looking for a stock product.

Size: 41 in. by 22 in.

Cost: $1.68 each

Source: Berger Building Products www.bergerbuildingproducts.com



Go to **FineHomebuilding.com** for a video of Joseph Lstiburek speaking about roof venting.

issues are of concern, there is another option.

Create an unvented roof

Through provision R806.4, the IRC also allows you to build an unvented roof assembly. Unvented assemblies work particularly well on complex roofs that would be difficult or impossible to vent properly or on roofs where it would be difficult to insulate properly if the roof were vented.

It should be noted, however, that in high-snow-load areas, you still need a vented over-roof to deal with ice damming. In essence, you're creating a hybrid vented/unvented roof system.

The goal in an unvented roof is to keep the roof deck—the principal condensing surface in roof assemblies—sufficiently warm through the year to prevent condensation from occurring. In most climates, builders have to insulate the roof sheathing to prevent condensation from occurring within the assembly. The exception is hot-dry climates such as in Phoenix, where condensation isn't as big an issue.

Condensation control is most often accomplished by installing rigid foam above the roof deck or by installing air-impermeable spray-foam insulation directly against the underside of the roof deck. The code also allows for air-permeable insulation, such as fiberglass or cellulose, to be used under the roof deck as long as rigid foam is used above the roof sheathing. Flash-and-batt (or flash-fill) assemblies are also allowed. Any of these approaches can adequately prevent condensation from occurring within the roof when the rigid foam or spray foam is installed at the appropriate thickness (chart p. 71).

If you're spraying foam on the underside of the roof deck, be sure you're using the right product. Closed-cell spray foam works in all climates, but especially well in climate zones 5 through 8, where high R-values are desired and where air-impermeable insulation also must be a vapor retarder. Low-density, open-cell foam is permissible, but in climate zones 5 and above, it has to be covered with a vapor-retarder coating, like rigid foam or painted drywall.

Also pay attention to roofing materials. Asphalt shingles require special attention when installed on unvented roof assemblies in hot-humid, mixed-humid, and marine climates due to inward vapor drive. To keep moisture out of the roof assembly, a roofing underlayment with 1 perm or less (class-II vapor retarder) must be installed under the shingles. Also, check to be sure that you are in compliance with the manufacturer warranties when installing shingles over an unvented roof in all climates. Some manufacturers don't warranty or offer only a limited warranty when their products are used over an unvented roof assembly.

Shingles that are installed on unvented roof assemblies operate at slightly higher temperatures, roughly 2°F to 3°F warmer than shingles on vented assemblies. This can reduce their service life by roughly 10%. You can vent the roof cladding, which will increase its longevity, but the expense of fastening battens over the roof sheathing, then adding another layer of plywood over the battens as a nail base for the shingles, may not be worth the expense. After all, the shingle color and the roof orientation are much more significant concerns when it comes to shingle life. □

This article was excerpted from a class taught by Joseph Lstiburek, Ph.D., P.Eng., of Building Science Corp. in Westford, Mass.

building science.com

Vented and Sealed Attics in Hot Climates

Research Report - 0981

1998

Armin Rudd and Joseph Lstiburek

Abstract:

Sealed attic construction, by excluding vents to the exterior, can be a good way to exclude moisture-laden outside air from attic and may offer a more easily constructed alternative for air leakage control at the top of residential buildings. However, the space conditioning energy use and roof temperature implications of this approach have not been extensively studied. A computer modeling study (Rudd 1996) was performed to determine the effects of sealed residential attics in hot climates on space conditioning energy use and roof temperatures. The one-dimensional, finite element computer model (FSEC 1992) contained an attic model developed and validated by Parker et al. (1991). Empirical modifications were made to the attic model to provide better alignment with measured ceiling heat flux reductions of ventilated attics with respect to sealed attics for summer peak days from three roof research facilities (Beal et al. 1995; Rose 1996; Fairey 1986). Annual and peak cooling day simulations were made for the Orlando, Florida, and Las Vegas, Nevada, climates, using a 139 m^2 (1500 ft^2) slab-on-grade ranch style house with wood frame construction. Results showed that, when compared to typically vented attics with the air distribution ducts present, sealed "cathedralized" attics (i.e., sealed attic with the air barrier and thermal barrier [insulation] at the sloped roof plane) can be constructed without an associated energy penalty in hot climates.

TO-98-20-3

Vented and Sealed Attics In Hot Climates

Armin F. Rudd

Joseph W. Lstiburek, P.Eng.
Member ASHRAE

ABSTRACT

Sealed attic construction, by excluding vents to the exterior, can be a good way to exclude moisture-laden outside air from attics and may offer a more easily constructed alternative for air leakage control at the top of residential buildings. However, the space conditioning energy use and roof temperature implications of this approach have not been extensively studied. A computer modeling study (Rudd 1996) was performed to determine the effects of sealed residential attics in hot climates on space conditioning energy use and roof temperatures. The one-dimensional, finite element computer model (FSEC 1992) contained an attic model developed and validated by Parker et al. (1991). Empirical modifications were made to the attic model to provide better alignment with measured ceiling heat flux reductions of ventilated attics with respect to sealed attics for summer peak days from three roof research facilities (Beal et al. 1995; Rose 1996; Fairey 1986). Annual and peak cooing day simulations were made for the Orlando, Florida, and Las Vegas, Nevada, climates, using a 139 m² (1500 ft²) slab-on-grade ranch style house with wood frame construction. Results showed that, when compared to typically vented attics with the air distribution ducts present, sealed "cathedralized" attics (i.e., sealed attic with the air barrier and thermal barrier [insulation] at the sloped roof plane) can be constructed without an associated energy penalty in hot climates.

INTRODUCTION

The rationale behind this attic ventilation study was primarily twofold:

1. The need to solve problems related to the entry of moisture-laden outside air in hot-humid climates (ASHRAE 1997), such as condensation on cooling ducts and interior mold.
2. The need to obtain a tight air infiltration barrier at the top of residential buildings in hot climates to reduce energy consumption.

Ventilation is one of the most effective ways to deal with humidity problems in heating climates, but ventilation can be one of the major causes of humidity problems in southern humid climates (Lstiburek 1993). The problem of condensation in attics in hot-humid climates is caused by humid outdoor air coming in contact with cold surfaces in the attic. Although worse in coastal areas, this problem is not confined to them. The most offending cold surfaces are usually supply ducts, but they can be ceiling drywall and metallic penetrations through the ceiling if low interior setpoints are maintained. In much of Florida, it is not uncommon to have an outdoor air dew point of 24°C (75°F) and an attic air dew point of 29°C (85°F). When an attic surface temperature is lower than the attic air dew point, condensation will occur.

The attic air dew point can be higher than the outdoor air dew point because moisture stored in the wood roof framing at night is released during the day. This moisture adsorption-desorption process is driven by the relative humidity gradient between surfaces and the air in contact with those surfaces. Relative humidity of air at a surface is that of air in equilibrium with the surface moisture content of the material. The result of this attic moisture adsorption-desorption mechanism is summarized as follows:

Nighttime:

High attic air relative humidity due to air exchange with outdoors

- Lower air relative humidity at the surface of wood framing materials resulting in moisture being adsorbed by the wood framing materials
- Attic air dew-point temperature similar to outdoors

Armin F. Rudd is a senior research engineer at the Florida Solar Energy Center, Cocoa, Fla. **Joseph W. Lstiburek** is a principal with Building Science Corporation, Westford, Mass.

Daytime:

- Lower attic air relative humidity due to sensible heat gain by solar
- Higher air relative humidity at the surface of wood framing materials resulting in moisture being desorbed by the attic framing materials
- Attic air dew-point temperature elevated above outdoors

The greatest problem with attic condensation will occur during the daytime when the air-conditioning (cooling) system operates for long periods, causing supply ducts, supply diffusers, and ceiling areas near supply diffusers to remain cold. With normal supply temperatures between 10°C and 13°C (50°F and 55°F), and attic air dew-point temperatures up to 29°C (85°F), it is easy to see how condensation can occur. Obviously, duct insulation, with the proper thermal resistance and surface emittance and properly installed to avoid insulation compression, can minimize condensation potential on ducts. However, the ducts must not only be insulated but also sealed against air leakage. Cold air leaking from supply ducts, creating cold surfaces in the moist attic environment, can also cause condensation-related problems.

Moving the entire air distribution system out of the attic and into conditioned space is good but is often impractical or impossible due to design and cost constraints. In the hot-humid climate, the best solution to eliminate the potential for moisture condensation in attics may be to keep the moisture out of the attic altogether by sealing the attic to the outdoors. TenWolde and Burch (1993) recommended that the roof cavities of manufactured homes not be ventilated in hot-humid climates due to conditions that could be conducive to mold and mildew growth (monthly mean surface relative humidity above 80%). A later report by Burch et al. (1996) came to the same conclusion, stating that their computer modeling results for Miami, Florida, "indicate that ceiling vapor retarders and roof cavity vents should not be installed in homes exposed to hot and humid climates." In many cases, roofing layers that provide rain-proofing can also provide air sealing, and if stucco is used for the exterior wall finish, it can be easy to seal the fascia, soffit, and rake areas with stucco also. This would provide an attic that was sealed from outdoor air exchange, effectively excluding the moisture-laden air.

Another attic condensation problem, separate from the one discussed above but still related to outside moisture entering the attic through attic vents, sometimes occurs with metal roofing and an attic radiant barrier. In this case, condensation forms at night on the underside of metal roofing or radiant barrier exposed to humid attic air. Due to night sky radiation, the metal roof or radiant barrier temperature can be depressed below the attic air dew-point temperature, allowing condensation and possible water damage to ceiling materials to occur. In predominantly hot-humid climates, attics sealed to outside air exchange would correct this problem.

In modern residences, the challenge of achieving a continuous air infiltration barrier and thermal insulation barrier at the interior ceiling level is especially difficult. The air barrier, used to isolate the living space from the attic, is usually the taped drywall, while the thermal barrier is the insulation placed on top of the drywall. Typically, the ceiling is not a single horizontal plane but a series of horizontal planes, vertical planes (knee walls), and sloped planes, all intersecting to create the ceiling. Field inspections repeatedly show how the continuity of the air barrier and thermal barrier is compromised at knee walls, coffered ceilings, dropped ceilings, framed soffits or mechanical chases, recessed canister lights, fireplace flues or chimneys, and penetrations for plumbing, electrical, and space conditioning, etc. In reality, it is often impractical to try to maintain air and thermal barrier continuity at all of these locations. Airtight recessed cannister lights rated for insulation contact, foam sealing of penetrations, and full-depth blown insulation to cover the variations in ceiling plane can help to alleviate the problems, but at significant added cost.

The most cost-effective location to both air seal and insulate the attic may be at the roof plane rather than the interior ceiling plane. Where attic insulation is placed along the underside of the roof sheathing, this has been referred to as "cathedralized" residential attic construction (Rose 1995). In "cathedralized" construction, there may still be roof plane changes that create knee wall areas, such as build-over roofs where girder trusses are used, but these are usually few and relatively easy to access. In many cases, the roof layer (sheathing, roofing paper, flashing) that provides rain-proofing can also provide air leakage control. Some additional air sealing may be necessary at roof penetrations for vents and exhaust ducts. If stucco is used for the exterior wall finish, the fascia, soffit, and rake areas can be finished with stucco as well to provide an attic that is restricted from outdoor air exchange.

Another outcome of using the roof plane to create the air and thermal barrier is that the enclosed attic space is essentially inside the conditioned space. This space can be used to locate the space conditioning equipment and the air distribution system, and possibilities for additional storage are available. Also, the mechanical systems (electrical, plumbing, HVAC) placed in the attic are left exposed and accessible in the event of the need for repair or remodeling.

Current building codes across the United States require attic ventilation. In cold climates, the primary purpose of attic ventilation is to maintain a cold roof temperature to avoid ice dams created by melting snow (Tobiasson et al. 1994) and to vent moisture that moves from the conditioned space to the attic (Rose 1992; Lstiburek 1988; Spies 1987; Gatsos 1985). Melted snow, in this case, is caused by heat loss from the conditioned space. When water from melted snow runs out over the unheated eave portion of the house, it freezes and expands, often driving its way back up the roof and between shingles. In cathedral ceiling areas, a minimum one-inch air space is required between the roof sheathing and insulation, extending from soffit to ridge. In predominantly cold climates, for cathedral and "cathedralized" ceilings, a vented air chute

BACK TO PAGE ONE

that ensures an air gap between the roof sheathing and the insulation is the critical factor in controlling moisture accumulation in the sheathing (Rose 1995).

In hot climates, the primary purpose of attic ventilation is to expel solar-heated hot air from the attic to lessen the building cooling load. TenWolde and Carll (1992) also observed that "during summer, attic vents provide some cooling, but with sufficient ceiling insulation, the effect on cooling loads should be minor." Roof shingle temperatures will be higher during no-wind conditions, leading to a higher heat load on the attic. Therefore, the greatest need for attic ventilation is when there is little wind pressure to force air in and out of the attic; then, stack effect is the prime air mover, driven by the attic to outside air temperature difference. Relying on stack effect alone can require such large vents that it is difficult to prevent rain entry (Ledger 1990).

The required amount of ventilation area is measured by a unit termed "net free vent area." The net free vent area is the actual, unobstructed area where air can freely flow from outside to inside to outside. Most estimable manufacturers provide documentation of the net free vent area with their product, although a standardized test has not been universally adopted (Sullivan 1994). The building codes usually report the required ventilation area as a ratio of the net free vent area to the horizontal projection of attic floor area (i.e., 1:300 or 1:150). Typically, if at least 50% of the ventilating area is in the upper portion of the space and a continuous ceiling vapor retarder in cold climates is installed on the warm side, the required ratio is 1:300; otherwise, it is 1:150 (Hutchings 1998).

Sealed attic construction, by excluding vents to the exterior, can be a good way to exclude moisture-laden outside air from attics and may offer a more easily constructed alternative for air leakage control at the top of residential buildings. However, the space conditioning energy use and roof temperature implications of this approach have not been extensively studied.

COMPUTER MODEL SETUP

To evaluate the effects of sealed attics in hot climates on space conditioning energy use and roof temperatures, a computer modeling study was conducted for the Orlando, Florida, and Las Vegas, Nevada, climates. The computer model utilized was the FSEC 3.0 program (FSEC 1992) containing the attic model developed and validated by Parker et al (1991). The one-dimensional, finite-element program calculates combined heat and mass transfer, including conductive, convective, and radiant heat transfer, and lumped moisture modeling by the Effective Penetration Depth Method (Kerestecioglu 1989). Hourly simulations are performed using Typical Meteorological Year (TMY) weather data. In addition to building loads and heating and cooling system loads, individual surface temperatures and heat fluxes can be obtained, as well as air temperature and humidity ratio. Similar to a temperature setpoint, an optional humidity setpoint can be specified. The cooling system load will reflect the appropriate change in latent load, and if the specified equipment cannot meet the load, that will be reflected in the indoor air conditions. A real cooling machine performance model is used to calculate the air conditions leaving the cooling coil. A real thermostat model is also employed (Henderson 1992).

The reference house configuration used was a one-story, 139 m^2 (1500 ft^2) house that had been used in the past for many building energy modeling studies. Figure 1 shows a plan view of the house. The main house roof geometry is a 22.6 degree (5/12 pitch) hip roof with the ridge running east to west. Another hip roof runs over the garage, with that ridge running north to south. Table 1 lists the characteristics that were common to the Orlando and Las Vegas reference houses. The characteristics specific to the Orlando reference house are listed in Table 2. Model inputs were parametrically varied to isolate the effect of the item(s) in question. Table 3 lists the values that were changed for each Orlando simulation, along with a comment regarding the research question being asked. The characteristics specific to the Las Vegas reference house are listed in Table 4. Table 5 lists the parametrically varied model inputs for each Las Vegas simulation, along with a comment regarding the question being asked.

An early attic model (Fairey and Swami 1992), used primarily for modeling the performance of attic radiant barrier systems, treated the attic as two zones, an upper zone and a lower zone. An improved two-zone attic model (Parker et al. 1991), used in the FSEC 3.0 program, accounts for detailed radiation, buoyancy, and wind-driven airflows and thermal stratification within the attic airspace. The upper attic zone airflow was driven by wind, and the soffit inlet area was treated as an orifice with a discharge coefficient. The upper attic zone had a defined thickness and ran parallel to the bottom of the roof sheathing. The lower attic zone encom-

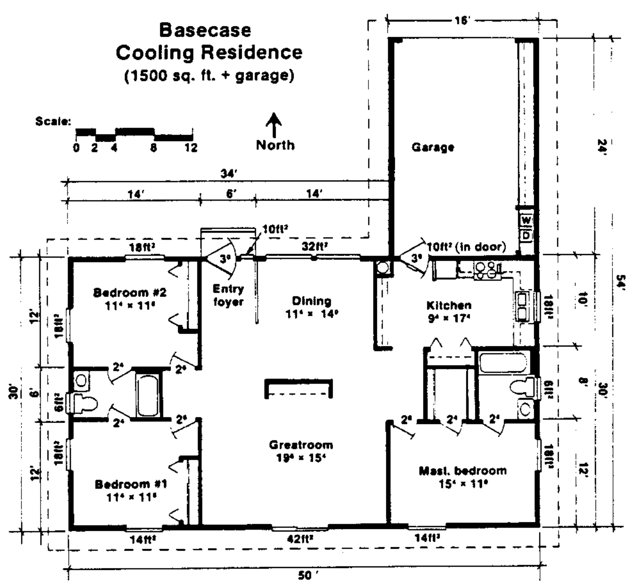


Figure 1 *Plan view of the reference house.*

BACK TO PAGE ONE

TABLE 1
Characteristics Common to Both the Orlando and Las Vegas Reference Houses

Component	
Construction type	Wood frame
Foundation type	Slab-on-grade
Roof type	Hip
Floor area	1500 ft^2 (139.4 m^2)
Window area	224 ft^2 (20.8 m^2)
Door area	20 ft^2 to outdoors 20 ft^2 to garage
Roof overhang	2 ft (0.61 m)
Roof solar absorptance, onyx black asphalt shingles, (Parker 1993)	0.966
Roof solar absorptance, white tile, (Parker 1993)	0.35
Roof infrared emittance	0.9
Attic plywood infrared emittance	0.8
Wall solar absorptance	0.75
Wall infrared emittance	0.9
Heating system	Electric resistance
Cooling system	DX vapor compression, SEER=10.0
Duct insulation R-value	5 hr-ft^2-F/Btu (0.88 m^2·K/W)
Duct location	In attic, unconditioned space
Duct leakage	None
Heating setpoint	72°F (22.2°C)
Cooling setpoint	77°F (25°C)
Humidity setpoint	Not specified, indoor humidity determined by the cooling machine performance
Internal gains	84.3 kBtu/day (24.7 kWh/day)
Air Infiltration, Effective Leakage Area	Calculated each hour, ELA = 99.2 in^2 (0.064 m^2)

TABLE 2
Orlando Specific Reference House Characteristics

1:300 attic ventilation
R-19 insulation on flat ceiling
R-11 wall insulation
Single glazing, aluminum frame

passed the remaining volume of the attic, and airflow was driven by buoyancy forces due to the hot air convecting upwards. Inlet air for the lower attic also entered through the soffit. The total airflow, from both the upper attic and lower attic, exited at the ridge. Convection coefficients were calculated as a function of temperature difference for the lower attic insulation surface and as a function of temperature difference and velocity for the upper attic roof plywood bottom surface.

The attic model (Parker et al. 1991) contained in the FSEC 3.0 program was empirically modified in order to align it with measured data from three roof research facilities (Beal and Chandra 1995; Rose 1996; Fairey 1986). Model alignment

BACK TO PAGE ONE

TABLE 3
Orlando Parametric Simulations

Simulation Number	Input Deck Changes From Reference Case	Research Question Asked
1	1:150 Attic Ventilation	Effect of increasing attic ventilation area from current Orlando building code
2	Sealed Attic, R-19 insulation on flat ceiling	Effect of just sealing attic
3	Sealed Attic, R-28 insulation on flat ceiling	Effect of sealing attic and increasing insulation
4	Sealed Attic, R-19 insulation under roof slope	Effect of sealing attic and moving insulation under roof slope (air and thermal barrier at roof plane)
5	Sealed Attic, R-28 insulation under roof slope	Effect of sealing attic and moving insulation under roof slope and increasing insulation
6	White Tile Roof	Effect of white tile roof alone
7	Sealed Attic, R-19 insulation under roof slope, White Tile Roof	Effect of sealing attic and moving insulation under roof slope and using white tile on roof
8	Sealed Attic, R-28 insulation under roof slope, White Tile Roof	Effect of sealing attic and moving insulation under roof slope and increasing insulation and using white tile on roof
9	Ducts In Conditioned Space	Effect of placing ducts inside conditioned space (conduction heat transfer effect only, no duct leakage)
10	Duct Leakage, 10% Return Side, 5% Supply Side, (Return leak comes from: 70% attic, 20% garage, 10% outdoors)	Effect of average amount of duct leakage (Based on measurements from 160 Florida homes, the average return side leak was 11% of the total flow, and the estimated average supply side leak was 5% (Cummings 1991))
11	Duct Leakage, 15% Return Side, 10% Supply Side	Effect of greater than average amount of duct leakage

TABLE 4
Las Vegas Specific Reference House Characteristics

1:150 attic ventilation
R-28 insulation on flat ceiling
R-19 wall insulation
Double glazing, vinyl frame

was performed using comparable vented vs. sealed measured data with insulation on the flat ceiling. The flat ceiling insulation configurations, both vented and sealed, involve solutions of combined conductive, convective, and radiant heat transfer in an environment where complex convection and radiation are dominant. In contrast, the sealed cathedralized attic is a relatively straightforward conduction-dominated heat transfer problem.

The means for empirical alignment of the attic model with the measured data was a combination of adjusting two parameters as a function of vent area:

1. The convection coefficient at the top of the flat ceiling insulation, as calculated by the Parker model, was reduced by a factor of 0.25 for the 1:300 case and by 0.5 for the 1:150 and 1:120 cases. The convection coefficient was increased by a factor of 10 for the 1:37 case.

2. For the 1:150 case, 14% of the incoming attic ventilation air that was destined for the upper attic zone, as calculated by the Parker model, was diverted to the lower attic. Twenty-one percent and one hundred percent of the upper attic airflow was diverted to the lower attic for the 1:120 and 1:37 cases, respectively. The rationale was that with increased vent area and flow, the attic should become more mixed. Refer to Rudd (1996) for additional details.

Figure 2 shows a plot of the resulting percent ceiling heat flux reductions, compared to the sealed case, for various levels of attic ventilation area as a percentage of attic floor area. One curve shows a fit of the measured data, while a second curve shows a fit of values predicted by the modified attic model.

RESULTS

Peak Cooling Day, Orlando, Florida

The peak cooing day for Orlando, Florida, using TMY weather data, was 1 August. Figure 3 shows the peak cooling

BACK TO PAGE ONE

TABLE 5
Las Vegas Parametric Simulations

Simulation Number	Input Deck Changes From Reference Case	Research Question Asked
1	1:300 Attic Ventilation	Effect of reducing attic ventilation area from current Las Vegas building code
2	Sealed Attic, R-28 insulation on flat ceiling	Effect of just sealing attic
3	Sealed Attic, R-40 insulation on flat ceiling	Effect of sealing attic and increasing insulation
4	Sealed Attic, R-28 insulation under roof slope	Effect of sealing attic and moving insulation under roof slope (air and thermal barrier at roof plane)
5	Sealed Attic, R-40 insulation under roof slope	Effect of sealing attic and moving insulation under roof slope and increasing insulation
6	Sealed Attic, R-28 insulation under roof slope, White Tile Roof	Effect of sealing attic and moving insulation under roof slope and using white tile on roof
7	White Tile Roof	Effect of white tile roof alone
8	Ducts In Conditioned Space	Effect of placing ducts inside conditioned space (conduction heat transfer effect only, no duct leakage)
9	Duct Leakage, 10% Return Side, 5% Supply Side, (Return leak comes from: 70% attic, 20% garage, 10% outdoors)	Effect of average amount of duct leakage (Based on measurements from 160 Florida homes, the average return side leak was 11% of the total flow, and the estimated average supply side leak was 5% (Cummings 1991))
10	Duct Leakage, 15% Return Side, 10% Supply Side	Effect of greater than average amount of duct leakage

day ceiling heat flux curves. Compared to the sealed attic with flat ceiling insulation, ceiling heat flux reductions of 18% and 27% were predicted for the 1:300 and 1:150 ventilated attics, respectively. Figure 4 illustrates the dramatic increase in cooling power required (about one-third more) for the 1:300 vented attic with 15% duct leakage compared to the 1:300 vented attic without duct leakage (reference case). Relatively little difference in cooling power was seen between the reference vented attic and the sealed cathedralized attic with the same insulation thermal resistance (R-19 h·ft^2·°F/Btu). However, in the late afternoon, the sealed cathedralized attic's cooling power is higher for two hours; it is also slightly less in the late morning. Comparing Figures 5 and 6, one can see that there was almost no difference in shingle temperature between the reference vented 1:300 attic and the 1:150 attic. Referring to Figure 7, peak roof shingle temperatures were within 5°C (9°F) for all black shingle cases, peaking at 84°C (183°F),

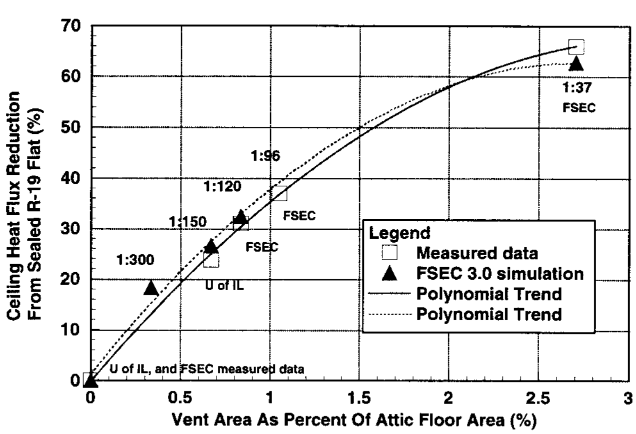


Figure 2 *Measured and predicted ceiling heat flux reduction, as compared to the sealed attic with R-19 flat ceiling insulation.*

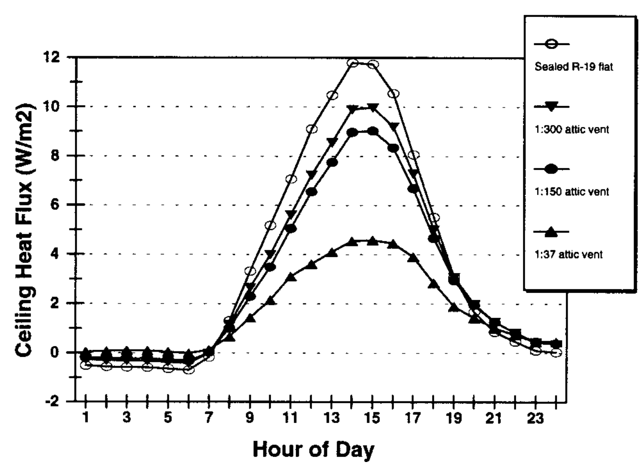


Figure 3 *Orlando peak day ceiling heat flux for the sealed attic, and normal to very large ventilation areas, all with R-19 flat ceiling insulation.*

BACK TO PAGE ONE

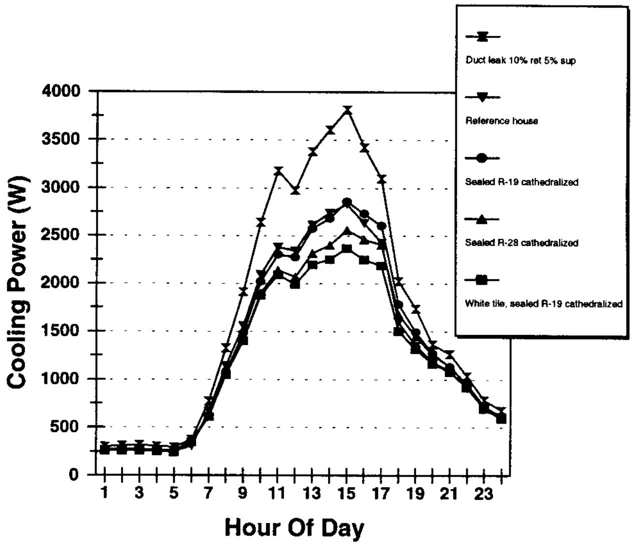


Figure 4 *Orlando peak day cooling system power draw for a vented attic with duct leakage, the reference vented attic, and three variations of the sealed cathedralized attic.*

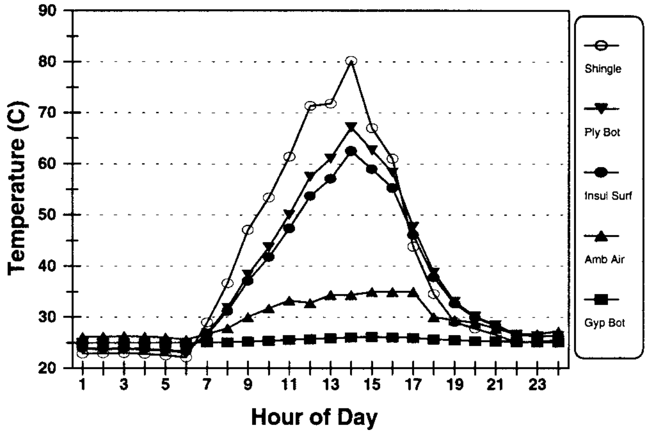


Figure 5 *Orlando peak cooling day temperatures, from roof-top to interior gypsum board, for the reference house (1:300 vented attic, R-19 flat ceiling insulation).*

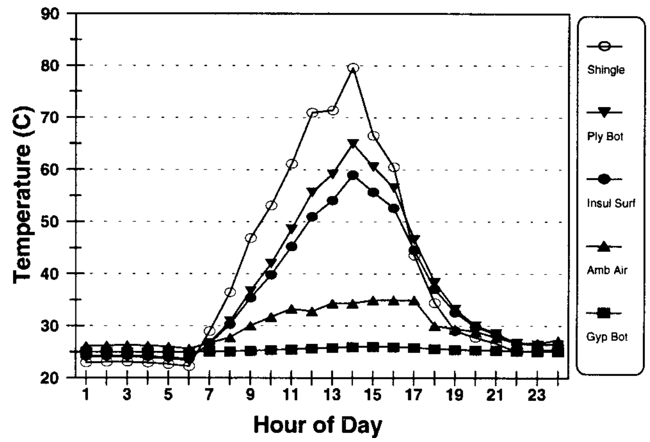


Figure 6 *Orlando peak day temperatures from roof-top to interior gypsum board, for the 1:150 vented attic.*

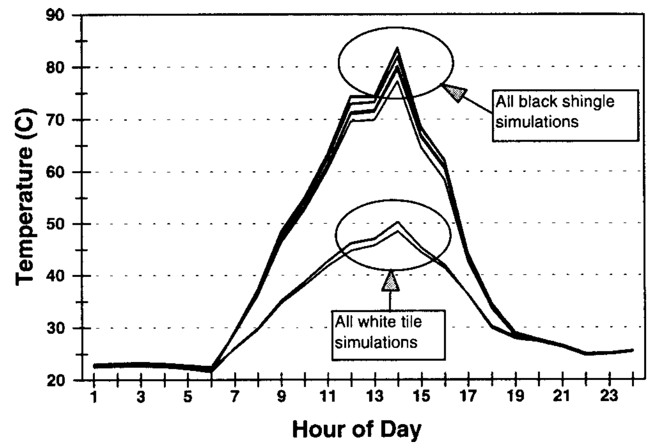


Figure 7 *Orlando peak day top of roof shingle or top of roof tile temperature for all parametric simulations (south side of roof).*

whether the attics were vented or sealed or whether the insulation was flat or cathedralized. Figure 8 shows the peak cooling day temperature at the bottom (facing the attic) of the roof plywood for several of the parametric simulations. Of primary importance here is that the difference in roof plywood temperature between the 1:300 vented attic case and the sealed attic cases was less than 7°C (13°F). There was about 2°C (4°F) difference in roof plywood temperature between the 1:300 vented attic and the 1:150 vented attic. The effect of white tile was dramatic, dropping roof plywood temperature about 24°C (43°F), with respect to the reference 1:300 vented attic.

Peak Cooling Day, Las Vegas, Nevada

The peak cooing day for Las Vegas, Nevada, using TMY weather data, was 30 July. Figure 9 shows the peak cooling day ceiling heat flux curves. Compared to the sealed attic with flat ceiling insulation, ceiling heat flux reductions of 14% and 22% were predicted for the 1:300 and 1:150 ventilated attics, respectively. Figure 10 illustrates a 10% increase in peak cooling power required for the 1:150 vented attic with 15% duct leakage compared to either the 1:150 vented attic without duct leakage (reference case) or the 1:300 vented attic without duct leakage. Almost no difference in cooling power was seen between the 1:150 vented attic and the 1:300 vented attic. At most, a 6% difference in cooling power was seen between the reference vented attic and the sealed cathedralized attic with the same insulation thermal resistance (R-28 h·ft^2·°F/Btu). From morning through hour 16, the sealed cathedralized attic required as much as 6% less cooling power than the reference

BACK TO PAGE ONE

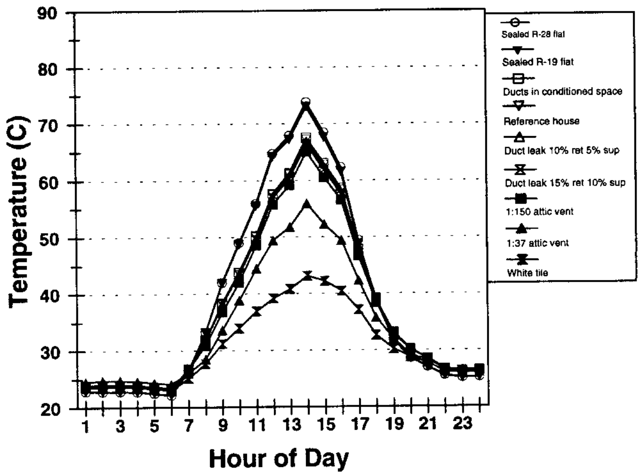


Figure 8 *Orlando peak day bottom-of-roof plywood temperatures (south side).*

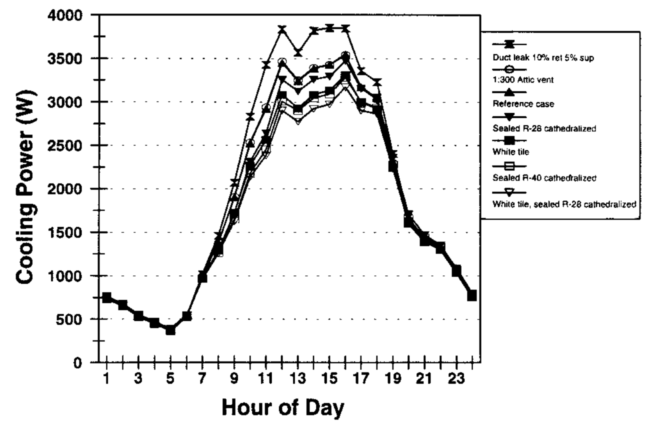


Figure 10 *Las Vegas peak day cooling system power draw for a 1:150 vented attic with duct leakage, a 1:300 vented attic, the reference 1:150 vented attic, white tile roof, and three variations of the sealed cathedralized attic.*

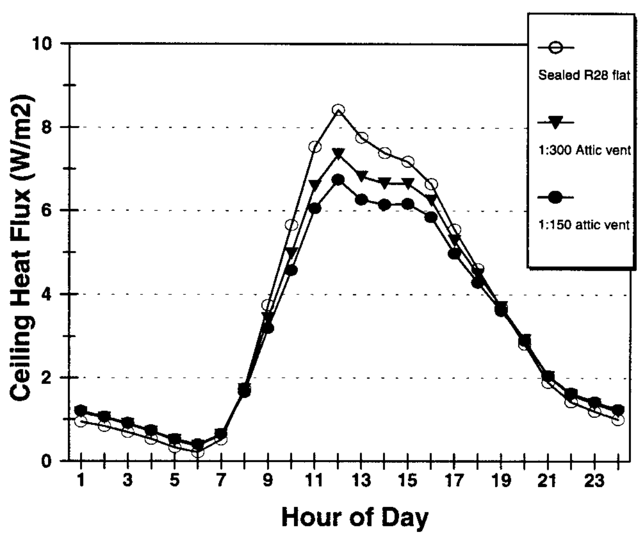


Figure 9 *Las Vegas peak cooling day ceiling heat flux for sealed and normally vented attics, all with R-28 flat ceiling insulation.*

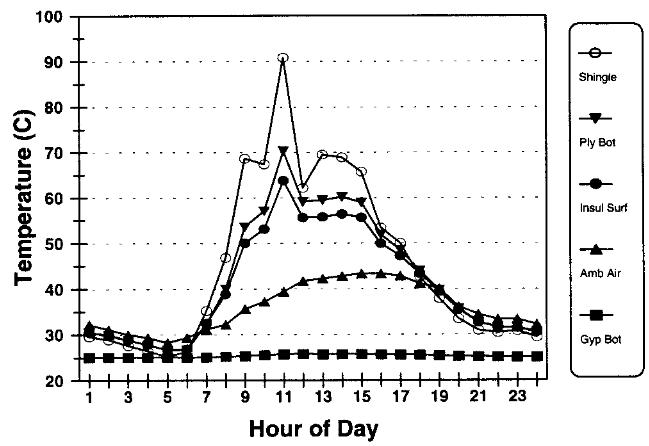


Figure 11 *Las Vegas peak cooling day temperatures, from rooftop to interior gypsum board, for the reference house (1:150 vented attic, R-28 flat ceiling insulation.*

vented attic; after hour 16 the cooling power requirement was essentially the same. Using white tile or using R-40 insulation in the sealed cathedralized attic lowered the cooling power even more, and each had essentially the same effect. Comparing Figures 11 and 12, one can see that there was almost no difference in shingle temperature between the reference vented 1:300 attic and the 1:150 attic. Referring to Figure 13, peak roof shingle temperatures were within 4°C (7°F) for all black shingle cases, peaking at 92°C (198°F), whether the attics were vented or sealed or whether the insulation was flat or cathedralized. Figure 14 shows the peak cooling day temperature at the bottom (facing the attic) of the roof plywood for several of the parametric simulations. Of primary importance here is that the difference in roof plywood temperature between the 1:300 vented attic case and the sealed attic cases was less than 8°C (14°F). There was less than 3°C (5°F) difference in roof plywood temperature between the 1:300 vented attic and the 1:150 vented attic. The effect of white tile was dramatic, dropping roof plywood temperature about 23°C (41°F) with respect to the reference 1:150 vented attic.

Annual Simulations, Orlando, Florida

Orlando annual simulation results are given in Tables 6 and 7. Results showed that, compared to the reference vented attic, with no duct leakage, the sealed cathedralized attic (i.e., sealed attic with the air barrier and thermal barrier [insulation] at the sloped roof plane) could save 2% on space conditioning energy. With the reference case R-5 (h·ft^{2}·°F/Btu) duct insulation and no duct leakage, simply moving the air distribution ducts inside conditioned space could save 3% annually. Thus,

BACK TO PAGE ONE

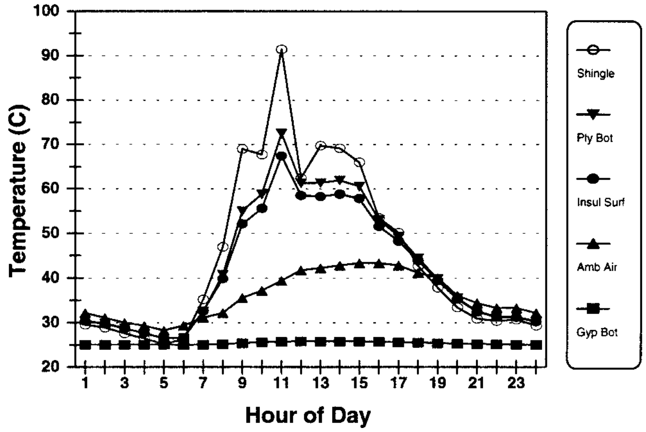


Figure 12 *Las Vegas peak cooling day temperatures, from rooftop to interior gypsum board, for the 1:300 vented attic.*

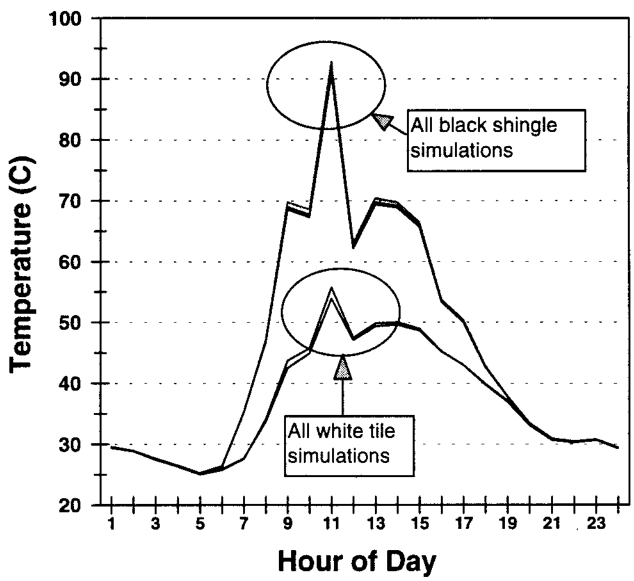


Figure 13 *Las Vegas peak cooling day top of roof shingle or roof tile temperature for all parametric simulations (south side of roof).*

excluding the location of ducts, the annual net effect of sealing the attic and moving the insulation from the flat ceiling to under the sloped roof is less than 1%. When typical duct leakage was modeled (10% return leak, 5% supply leak), the peak cooling load increased by 42% and the sealed cathedralized attic showed annual space conditioning savings of 16%.

Simply sealing the attic, without moving the insulation directly under the roof sheathing, could increase annual space conditioning energy use by a maximum of 6%. A lower shingle absorptivity would produce a lower penalty. However, if attic moisture condensation was a problem in existing housing in the Orlando climate, sealing the attic could be a solution to the attic condensation problem, and increasing the flat ceiling

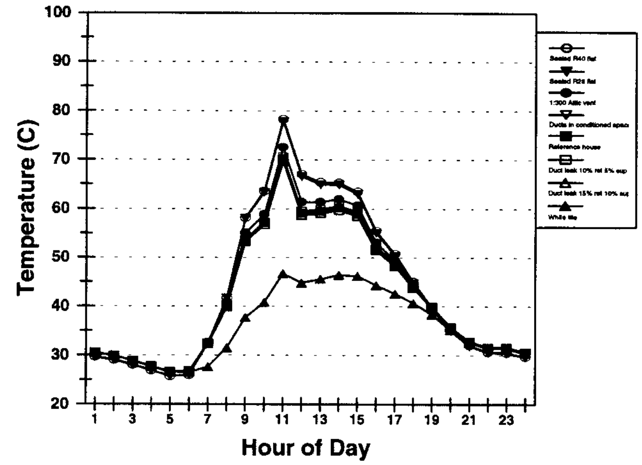


Figure 14 *Las Vegas peak cooling day bottom-of-plywood temperatures (south side of roof).*

insulation from R-19 to R-28 nearly mitigates the space conditioning energy use penalty.

Increasing the attic vent area from 1:300 to 1:150 had less than a 1% annual net effect (–1.3% cooling, +0.8% heating). The use of white roof tile instead of black shingles could save 6% on annual space conditioning energy use in Orlando. A peak cooling load reduction of 13% was shown when simulating white roof tile versus black shingles. The combination of white roof tile and the sealed cathedralized attic, compared to black shingles and vented attic, could save 12% on annual space conditioning energy use in Orlando.

Annual Simulations, Las Vegas, Nevada

Las Vegas annual simulation results are given in Tables 8 and 9. Results showed that, compared to the reference vented attic, with no duct leakage, the sealed "cathedralized" attic (i.e., sealed attic with the air barrier and thermal barrier [insulation] at the sloped roof plane) could save 4% on space conditioning energy. With the reference case R-5 (h·ft^2·°F/Btu) duct insulation and no duct leakage, simply moving the air distribution ducts inside conditioned space could save 4% annually. Thus, excluding the location of ducts, there is no annual net effect of sealing the attic and moving the insulation from the flat ceiling to under the sloped roof in the Las Vegas climate. When typical duct leakage was modeled (10% return leak, 5% supply leak), the peak cooling load increased by 23% and the sealed cathedralized attic showed annual space conditioning savings of 10%.

Simply sealing the attic, without moving the insulation directly under the roof sheathing, could increase annual space conditioning energy use by a maximum of 6%. A lower shingle absorptivity would produce a lower penalty. Increasing the flat ceiling insulation from R-28 to R-40 nearly mitigates the space conditioning energy use penalty.

Decreasing the attic vent area from 1:150 to 1:300 had less than a 1% effect on heating or cooling and had no annual net effect on space conditioning energy use. The use of white

BACK TO PAGE ONE

TABLE 6
Summary of Annual Simulation Results for Orlando

Orlando, Florida / Simulation Description	Annual Cooling kW·h	Diff. %	Annual Heating kW·h	Diff. %	Annual Total kW·h	Diff. %	Peak Cooling kW	Diff. %	Peak Heating kW	Diff. %
Reference case	**4419**		**2193**		**6613**		**1.56**		**1.44**	
White tile, sealed R-28 sloped	3891	-12.0	1904	-13.2	5795	-12.4	1.29	-17.3	1.31	-9.0
Sealed R-28 sloped	4261	-3.6	1793	-18.2	6055	-8.4	1.41	-9.6	1.30	-9.7
White tile, sealed R-19 sloped	3948	-10.7	2142	-2.3	6090	-7.9	1.34	-14.1	1.38	-4.2
White tile	3971	-10.2	2270	3.5	6241	-5.6	1.36	-12.8	1.44	0.0
Ducts in conditioned space	4324	-2.2	2103	-4.1	6427	-2.8	1.46	-6.4	1.34	-6.9
Sealed R-19 sloped	4467	1.1	2002	-8.7	6469	-2.2	1.57	0.6	1.38	-4.2
1:150 attic vent	4364	-1.3	2211	0.8	6575	-0.6	1.53	-1.9	1.46	1.4
Sealed R-28 flat	4531	2.5	2120	-3.3	6651	0.6	1.67	7.1	1.48	2.8
Sealed R-19 flat	4713	6.6	2316	5.6	7029	6.3	1.80	15.4	1.54	6.9
Duct leak 10% ret 5% sup	5058	14.4	2596	18.4	7654	15.7	2.21	41.7	1.81	25.7
Duct leak 15% ret 10% sup	5428	22.8	2895	32.0	8323	25.9	2.71	73.7	2.03	41.0

TABLE 7
Observations of Annual Simulation Results for Orlando

Orlando, Florida	
Simulation Description	**Observations Of Results**
Reference case	*(R-19 ceiling, 1:300 vented attic, ducts in attic, no duct leakage, R-11 walls, single glazing)*
White tile, sealed R-28 sloped	Excellent for cooling and heating
Sealed R-28 sloped	Good for cooling, excel. for heating, excel. for balanced peak load reduction if using heat pump
White tile, sealed R-19 sloped	Excellent for cooling, good for heating
White tile	Excellent for cooling, penalty for heating due to loss of solar gains, net positive benefit
Ducts in conditioned space	Always good
Sealed R-19 sloped	Small penalty for cooling, good for heating, better overall than reference case, essentially the same as placing ducts in conditioned space or 1:37 attic ventilation
1:150 attic vent	Very little net difference from 1:300 reference case
Sealed R-28 flat	Penalty on cooling, saves on heating, nets essentially the same as reference case
Sealed R-19 flat	Energy use penalty – but excludes moisture laden outside air
Duct leak 10% ret 5% sup	Never good
Duct leak 15% ret 10% sup	Never good

roof tile instead of black shingles could save 2% on annual space conditioning energy use in Las Vegas. Peak cooling load reduction of 6% was shown when simulating white roof tile vs. black shingles. The combination of white roof tile and the sealed cathedralized attic, compared to black shingles and vented attic, could save 5% on annual space conditioning energy use in Las Vegas.

CONCLUSION

A residential attic model (Parker et al. 1991), contained in the finite element computer program FSEC 3.0, was empirically aligned with measured attic data from three roof research facilities in Florida and Illinois. This model was then used to

BACK TO PAGE ONE

TABLE 8
Summary of Annual Simulation Results for Las Vegas

Las Vegas, Nevada Simulation Description	Annual Cooling kW·h	Diff. %	Annual Heating kW·h	Diff. %	Annual Total kW·h	Diff. %	Peak Cooling kW	Diff. %	Peak Heating kW	Diff. %
Reference case	4062		6502		10565		1.94		1.51	
Sealed R-40 sloped	3858	-5.0	5761	-11.4	9619	-8.9	1.78	-8.2	1.40	-7.3
White tile, sealed R-28 sloped	3611	-11.1	6455	-0.7	10066	-4.7	1.73	-10.8	1.46	-3.3
Ducts in conditioned space	3879	-4.5	6243	-4.0	10121	-4.2	1.77	-8.8	1.44	-4.6
Sealed R-28 sloped	4075	0.3	6107	-6.1	10182	-3.6	1.88	-3.1	1.46	-3.3
White tile	3697	-9.0	6669	2.6	10366	-1.9	1.83	-5.7	1.52	0.7
1:300 Attic vent	4096	0.8	6449	-0.8	10545	-0.2	1.94	0.0	1.50	-0.7
Sealed R-40 flat	4261	4.9	6329	-2.7	10590	0.2	2.12	9.3	1.53	1.3
Sealed R-28 flat	4454	9.7	6689	2.9	11144	5.5	2.31	19.1	1.58	4.6
Duct leak 10% ret 5% sup	4399	8.3	7169	10.2	11567	9.5	2.39	23.2	1.95	29.1
Duct leak 15% ret 10% sup	4643	14.3	7649	17.6	12292	16.4	2.62	35.1	2.52	66.9

TABLE 9
Observations of Annual Simulation Results for Las Vegas

Las Vegas, Nevada	
Simulation Description	**Observations Of Results**
Reference case	*(R-28 ceiling, 1:150 vented attic, ducts in attic, no duct leakage, R-19 walls, double glazing)*
Sealed R-40 sloped	Good for cooling, excellent for heating
White tile, sealed R-28 sloped	Excellent for cooling, no difference for heating
Ducts in conditioned space	Always good
Sealed R-28 sloped	No difference for cooling, very good for heating
White tile	Very good for cooling, penalty for heating due to reduced solar heat gain
1:300 Attic vent	Very little net difference from 1:150 reference case
Sealed R-40 flat	Penalty on cooling, saves on heating, nets essentially the same as reference case
Sealed R-28 flat	Not recommended
Duct leak 10% ret 5% sup	Never good
Duct leak 15% ret 10% sup	Never good

simulate hourly space conditioning energy use and roof and attic temperatures for peak cooling days and annual weather for Orlando, Florida, and Las Vegas, Nevada.

Results showed that, when compared to typically vented attics with the air distribution ducts present, sealed "cathedralized" attics (i.e., sealed attic with the air barrier and thermal barrier [insulation] at the sloped roof plane) can be constructed without an associated energy penalty in hot climates.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Dr. Lixing Gu, Philip Fairey, and Dr. Muthusamy Swami with regard to using the FSEC 3.0 computer program and modifying the attic model. Appreciation is conveyed to William Rose of the Building Research Council, University of Illinois at Urbana-Champaign, as well as Dr. Subrato Chandra and David Beal of FSEC for their efforts in making measured attic data available. Funding for this project came through the U.S. Department of Energy's Building America Initiative-Building Science Consortium and the USDOE Energy Efficient Industrialized Housing Program, with George James as Program Manager.

REFERENCES

ASHRAE 1997. *1997 ASHRAE Handbook—Fundamentals*. Atlanta: American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc.

BACK TO PAGE ONE

Beal, D., and Chandra, S. 1995. Side by side testing of four residential roofing and attic ventilation systems. FSEC-CR-822-95. Florida Solar Energy Center, Cocoa, Fla.

Burch, D. M., G. A. Tsongas, and G. N. Walton. 1996. Mathematical analysis of practices to control moisture in the roof cavities of manufactured houses. NISTIR 5880. Gaithersburg, Md.: National Institute of Standards and Technology.

Cummings, J.B. 1991. Investigation of air distribution system leakage and its impact in central Florida homes. FSEC-CR-397-91. Florida Solar Energy Center, Cocoa, Fla.

Fairey, P. 1986. The measured, side-by-side performance of attic radiant barrier systems in hot-humid climates. *Proceedings of the 19th International Thermal Conductivity Conference, Cookeville, Tenn*, October.

Fairey, P., and M. Swami. 1992. Attic radiant barrier systems: A sensitivity analysis of performance parameters. *International Journal Of Energy Research*, 16: 1-12.

FSEC. 1992. *User's manual, FSEC 3.0, Florida software for environment computation* V3.0. FSEC-GP-47-92. Florida Solar Energy Center, Cocoa, Fla.

Gatsos, D. 1995. The question is: To vent or not to vent. *Roofing Siding Insulation*, September.

Henderson, H.I. 1992. Simulating combined thermostat, air conditioner and building performance in a house. *ASHRAE Transactions* 98 (1). Atlanta: American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc.

Hutchings, J.I. 1998. *National codes handbook*. McGraw Hill.

Kerestecioglu, A., and M. Swami. 1990. Theoretical and computational investigation of simultaneous heat and moisture transfer in buildings: Effective penetration depth theory. *ASHRAE Transactions* 96 (1): 447-454. Atlanta: American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc.

Ledger, G. 1990. Principles of attic ventilation. *Roofing Siding Insulation*. 67 (March), pp. 26-32. New York: Harcourt Brace Jovanovich.

Lstiburek, J. 1988. Vented roofs: Pros & cons. *Custom Builder*, April.

Lstiburek, J. 1993. Humidity control in the humid south. *Proceedings Bugs, Mold & Rot II*, Building Environment and Thermal Envelope Council, National Institute of Building Sciences, Washington, D.C.

Parker, D.S., P.Fairey, and L. Gu, 1991. A stratified air model for simulation of attic thermal performance. *Insulation Materials: Testing and Applications*, Vol. 2, ASTM STP 1116, R.S. Graves and D.C. Wysocki, eds. Philadelphia: American Society of Testing and Materials.

Parker, D.S., J.R. McIlvaine, S.F Barkaszi, and D.J.Beal. 1993. Laboratory testing of reflectance properties of roofing materials. FSEC-CR-670-93. Florida Solar Energy Center, Cocoa, Fla.

Rose, W.B. 1992. Measured values of temperature and sheathing moisture content in residential attic assemblies. *Thermal Performance of the Exterior Envelopes of Buildings V.* Atlanta: American Society of Heating Refrigerating and Air-Conditioning Engineers.

Rose, W.B. 1995. Attic construction with sheathing-applied insulation. *ASHRAE Transactions* 101 (2). Atlanta: American Society of Heating Refrigerating and Air-Conditioning Engineers.

Rose, W. 1996. University of Illinois. Private communication and transfer of data.

Rudd, A., 1996. Vented and sealed attics in hot climates. Contract Report submitted to Building Science Corporation, Westford, Mass., and the U.S. Department of Energy, 30 October. Florida Solar Energy Center, Cocoa, Fla., FSEC-CR-911-96.

Spies, H. 1987. Attic ventilation. *Progressive Builder*, August, pp. 21-23.

Sullivan, B. 1994. Exposing attic ventilation myths. *Custom Builder*, Jan/Feb.

TenWolde, A., and C. Carll. 1992. Effect of cavity ventilation on moisture in walls and roofs. *Thermal Performance of the Exterior Envelopes of Buildings V.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

TenWolde, A., and D. Burch. 1993. Ventilation, moisture control, and indoor air quality in manufactured houses. HUD User's Document Reproduction Service, HUD 006250, February.

Tobiasson, W., J. Buska, and A. Greatorex. 1994. Ventilating attics to minimize icings at eaves. *Energy and Buildings* 21: 229-234.

About this Report

This report first appeared in ASHRAE Transactions, Vol. 104, Part 2. Reprinted with permission.

About the Authors

Armin Rudd is a principal engineer at Building Science Corporation in Westford, Massachusetts. More information about Armin Rudd can be found at www.buildingscienceconsulting.com.

Joseph Lstiburek, Ph.D., P.Eng., is a principal of Building Science Corporation in Westford, Massachusetts. Joe is an ASHRAE Fellow and an internationally recognized authority on indoor air quality, moisture, and condensation in buildings. More information about Joseph Lstiburek can be found at www.buildingscienceconsulting.com.

Direct all correspondence to: Building Science Corporation, 30 Forest Street, Somerville, MA 02143.

ASK ABOUT ALL OF OUR OTHER CERTAINTEED® PRODUCTS AND SYSTEMS:

ROOFING • SIDING • TRIM • DECKING • RAILING • FENCE
GYPSUM • CEILINGS • INSULATION

www.certainteed.com http://blog.certainteed.com

CertainTeed Corporation
20 Moores Road
Malvern, PA 19355

Professional: 800-233-8990
Consumer: 800-782-8777

Code No. 20-20-3067
1/2016

SAINT-GOBAIN

CertainTeed

2016 Limited Warranty

Symphony™

CertainTeed
SAINT-GOBAIN


Symphony™
Where old-world elegance meets
new-world technology...in perfect harmony

What the Customer Must Do

If you believe your shingles have a manufacturing defect, you must provide prompt written notification to CertainTeed with proof of the date of purchase and date of shingle application. CertainTeed will investigate each properly reported claim and will repair, replace or reimburse the homeowner for the shingles determined to be defective, in accordance with the terms of this Limited Warranty, within a reasonable amount of time if its inspection of the shingles confirms a manufacturing defect.

Please send all notifications and correspondence to:

CertainTeed Corporation, 20 Moores Road, Malvern, PA 19355
Attn: CertainTeed Roofing Technical Services Department, Telephone number: 800-345-1145

Warranty Registration (not required)

You may register your product warranty on CertainTeed's website: www.certainteed.com/warrantyreg. Each registrant receives a registration confirmation number by return e-mail that can be printed and kept with this Limited Warranty and your proof of purchase. If you do not have internet access, you can register your shingles by sending: (1) your name, address, and telephone number; (2) the name and contact information of the contractor who installed your shingles and the original date of installation; and (3) the type, color and number of squares of your shingles to:
CertainTeed Corporation, CertainTeed Roofing, 20 Moores Road, Malvern, PA 19355

CertainTeed will register your information and mail you a confirmation number.
Failure to register this warranty does NOT void the warranty or any of its terms.

Roofing Plants and Regional Sales Offices

CertainTeed roofing products are sold by the CertainTeed Corporation in eight sales regions. They are manufactured in ten residential roofing plants and two commercial roofing plants.

Through innovation and creative product design, CertainTeed has helped shape the building products industry for more than 100 years. Founded in 1904 as General Roofing Manufacturing Company, the firm made its slogan *"Quality made certain. Satisfaction guaranteed,"* which quickly inspired the name CertainTeed. Today, CertainTeed is North America's leading brand of exterior and interior building products, including roofing, siding, windows, fence, decking, railing, trim, foundations, pipe, insulation, walls, ceilings and access covers. Headquarter in Valley Forge, PA, CertainTeed and its affiliates have approximately 9,000 employees and 70 manufacturing facilities throughout the United States and Canada.
More information is available at **www.certainteed.com.**

CONGRATULATIONS! ...and thank you for your recent purchase of one of the fine products produced by CertainTeed Roofing. Since 1904, CertainTeed has been producing quality roofing products that provide long-lasting beauty and protection for homes of every size, style and age. For the past 100 years, the basis for our name, *"Quality made certain, satisfaction guaranteed,"* has been our ongoing philosophy.

Your CertainTeed roofing warranty fully explains how CertainTeed supports its products with the strongest warranty protection available. It is important that you read the warranty section of this brochure. Take the time to understand how CertainTeed protects your purchase by standing behind our products.

LIMITED, PRORATED, AND TRANSFERABLE WARRANTY

This warranty covers Symphony™ sold only in the United States of America, its territories and Canada.

What and Who is Covered and for How Long

CertainTeed warrants to the original property owner/consumer that, when subject to normal and proper use, Symphony shingles will be free from manufacturing defects that cause leaks for fifty (50) years from the date of original installation and that CertainTeed will pay to repair or replace, at its option, any shingles CertainTeed determines to be defective under the terms of this Limited Warranty.

In the event of repair or replacement pursuant to the terms of this Limited Warranty, the original warranty applicable at the time of original installation shall apply to the replacement shingles or the repaired shingles.

SureStart™ Protection

All of CertainTeed's shingle products are covered by SureStart protection. Under this warranty feature, CertainTeed, at no charge, will pay to repair or replace, at its option, any shingles CertainTeed determines to be defective and that cause leaks during the applicable SureStart period. For Symphony shingles, the SureStart period begins when the original shingle installation has been completed and terminates at the completion of its seventh (7th) year of service following original installation. CertainTeed's maximum liability under SureStart is equal to the reasonable material and labor cost to replace or repair the defective shingles that cause leaks, as determined by CertainTeed. Roof tear-off, metal work, flashing and disposal expenses, and other costs or expenses incurred during such repair or replacement are not covered or reimbursed by this Limited Warranty.

SureStart protection does not extend to any Symphony shingles applied to any non-ventilated or inadequately ventilated roof deck systems, except as stated below. CertainTeed's maximum contribution toward the cost of repairing or replacing defective shingles applied to a non-ventilated or inadequately ventilated roof deck system shall not exceed $350/square, less 1/120th of that amount times the number of months from the date the shingles were originally installed to the date when CertainTeed determined the shingles to be defective. Labor costs, roof tear-off, metal work, flashing and disposal expenses, and other costs or expenses incurred during such repair or replacement are not covered or reimbursed by this Limited Warranty.

Beyond SureStart™ Protection

If CertainTeed determines the Symphony shingles to be defective and cause leaks after the SureStart period, CertainTeed's maximum contribution toward the cost of repairing or replacing such defective shingles shall not exceed $350/square, less 1/600th of that amount times the number of months from the date the shingles were originally installed to the date when CertainTeed determined the shingles to be defective. Labor costs, roof tear-off, metal work, flashing and disposal expenses, and other costs or expenses incurred during such repair or replacement are not covered or reimbursed by this Limited Warranty.

Transferability

The Limited Warranty for Symphony shingles may only be transferred by the original property owner/consumer to a subsequent property owner one (1) time in the first two (2) years after original installation. The warranty transfer is only effective if the subsequent property owner provides written notice of the transfer to CertainTeed within sixty (60) days from the real estate transfer date. (A warranty transfer request must be sent to RPG Technical Services Department, 20 Moores Road, Malvern, PA 19355.) After two (2) years, this Limited Warranty is not transferable.

Limitations

This Limited Warranty does not provide protection against and CertainTeed will have no liability for any failure, defect or damage caused by situations and events beyond normal exposure conditions, including but not limited to:

- Winds, including gusts, greater than 90 mph, lightning, hurricane (see "Limited Wind Warranty" section for hurricane wind exception), tornado, hailstorm, earthquake, fire, explosion, flood or falling objects.
- Distortion, cracking or other failure or movement of the base material over which the shingles are applied, of the roof deck, or of the walls or foundation of the building itself.
- Damage caused by structural changes, alterations or additions, or by the installation of equipment (such as aerials, signs or air-conditioning equipment) to the structure after the original shingles have been applied.
- Shading, stains or discoloration to the shingles arising from outside sources such as but not limited to the sun, algae, fungus, moss, lichens or other vegetation, mold or mildew growth, or paints, chemicals or other similar materials.
- Misuse, abuse, neglect, or improper transportation, handling or storage of the shingles.
- Installation of the shingles over non-approved roof decks as more fully explained in the CertainTeed Symphony installation instructions.
- Improper installation or installation not in accordance with CertainTeed's written installation instructions applicable at the time of original installation.
- Damage to the shingles, the roof deck or the structure caused by ice backup or ice damming.
- Distortion or warping due to excessive or unusual heat sources, including without limitation, window reflections and heat buildup caused by inadequate roof ventilation.
- Vandalism or acts of war.
- Any other cause not a result of a manufacturing defect in the shingles.

Mold and mildew are functions of environmental conditions and are not manufacturing defects. As such, mold and mildew are not covered by this Limited Warranty or any implied warranty.

CertainTeed reserves the right to discontinue or modify any of its products, including the color of its shingles, and shall not be liable as a result of such discontinuance or modification, nor shall CertainTeed be liable in the event replacement material varies in color in comparison to the original product as a result of normal weathering. If CertainTeed replaces any material under this warranty, it may substitute products designated by CertainTeed to be of comparable quality or price range in the event the product initially installed has been discontinued or modified.

Inadequately Ventilated and Non-Ventilated Decks

Any shingles applied to inadequately ventilated or non-ventilated decks, other than the shingles and deck systems described in the section titled "Insulated Decks and Radiant Barriers," are subject to a reduced limited warranty period of ten (10) years. Shingle damage or defects related to the absence of adequate roof system ventilation do not qualify for SureStart protection, and are limited to ten (10) years of Beyond SureStart coverage.

Insulated Decks and Radiant Barriers

CertainTeed's Limited Warranty, including SureStart coverage, will remain in force when Symphony shingles are applied to roof deck assemblies (slopes ≥ 3:12) where foam insulation is prefabricated into the roof deck system (often called "nailboard insulation"), where insulation is installed beneath an acceptable roof deck system, or where radiant barriers are installed, with or without ventilation directly below the deck. Acceptable roof deck surfaces must consist of at least 3/8" thick plywood or 7/16" thick OSB. If a different deck surface material will be utilized, please contact CertainTeed's Technical Services Department for assistance.
<u>See the following important restrictions.</u>

The design professional is responsible for ensuring 1) proper quality and application of the insulation and/or radiant barrier, 2) provision of adequate structural ventilation and/or vapor retarders as determined to be necessary, and 3) that all local codes are met (particularly taking into account local climate conditions). Special attention must be taken if cellular foam, fiber glass, cellulose insulations or other highly-permeable insulation will be used in an unventilated system, or if the insulation/rafter or insulation/joist planes may create an air leak that could lead to moisture transmission and condensation problems.
*All these important factors and decisions, while **not** the responsibility of CertainTeed Corporation, are critical to assure proper deck system performance.*

Ventilated Nail-Base Roof Insulation

Ventilated nail-base roof insulation products consist of rigid insulation (typically foam board) and another layer of material that provides air space above the insulation and below the nailable deck (which is typically at least 7/16" thick OSB or minimum 3/8" plywood). These products can provide soffit-to-ridge ventilation over cathedral-type ceilings, and if used and installed properly will not reduce the scope or length of CertainTeed's Limited Warranty coverage period. It is important to follow the deck manufacturer's instructions to achieve sufficient ventilation. CertainTeed offers FlintBoard™ CV – cross-ventilating insulation boards with 1", 1-1/2", or 2" air channels.

Limited Wind Warranty

CertainTeed warrants Symphony shingles to resist blow-off damage due to wind velocities, including gusts and hurricane winds, up to 90 mph during the first five (5) years following original installation.

If any blow-off damage occurs in the first five (5) years following original installation, CertainTeed will replace all damaged shingles without charge. CertainTeed will not be responsible for or reimburse labor costs or any other costs incurred during removal or replacement of damaged shingles. Such costs or damages are the property owner's responsibility (and may be covered by homeowner's insurance).

LIMITED WARRANTY AND LIMITATION OF REMEDIES

THE OBLIGATIONS CONTAINED IN THIS LIMITED WARRANTY CONSTITUTE THE EXCLUSIVE REMEDY AND ARE EXPRESSLY IN LIEU OF ANY AND ALL OTHER OBLIGATIONS, GUARANTEES AND WARRANTIES. APPLICABLE STATE LAW WILL DETERMINE THE PERIOD OF TIME FOLLOWING THE SALE THAT A PROPERTY OWNER/CONSUMER MAY SEEK A REMEDY UNDER THE IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CERTAINTEED'S OBLIGATIONS, RESPONSIBILITIES, AND/OR LIABILITY SHALL BE LIMITED TO REPAIRING OR REPLACING THE DEFECTIVE PRODUCT OR PROVIDING A REFUND PER THE TERMS OF THIS LIMITED WARRANTY. IN NO EVENT SHALL CERTAINTEED BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING ANY DAMAGE TO THE BUILDING, ITS CONTENTS, OR ANY PERSONS OR PROPERTY, THAT OCCUR AS A RESULT OF A BREACH. IF YOUR STATE DOES NOT ALLOW EXCLUSIONS OR LIMITATIONS OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU.

This warranty applies to Symphony shingles installed during the calendar year of 2016.

Interim Report for Project Entitled:

Impact of Spray Foam Insulation on Durability of Plywood and OSB Roof Decks

Performance Period: 10/14/2014 – 6/30/2015

Submitted on

February 15, 2015

DRAFT

Presented to the

Florida Building Commission
State of Florida Department of Business and Professional Regulation

by

Forrest J. Masters, Ph.D., P.E., masters@ce.ufl.edu, (352) 392-9537 x 1505, Principal Investigator
Kurtis R. Gurley, Ph.D., kgurl@ce.ufl.edu, (352) 392-9537 x 1508
David O. Prevatt, Ph.D., P.E. (MA), dprev@ce.ufl.edu, (352) 392-9537 x 1498
Trent Vogelgesang, Graduate Research Assistant

Designated Project Leader: David O. Prevatt

Engineering School for Sustainable Infrastructure & Environment

UF | UNIVERSITY of FLORIDA

Table of Contents

1. Relevant Sections of the Code (and Related Documents)

- R806.4 – Florida Building Code – Residential Buildings
- 611.7.1.2 – Florida Building Code – Existing Building
- 606.3 – Florida Building Code – Existing Building
- TAS 110 Testing Application Standard – Florida Building Code
- ICC-ES AC 377 – Acceptance Criteria for Spray Polyurethane Foam
- ASTM C1029

2. Progress Summary

The first project goal is to create a state-of the art literature review on the state-of-the-art review on the properties and field performance of spray applied foam insulations (open cell and closed cell foams), and related causes of water leakage and deterioration of wood roof decks. The research required the formation of an Advisory Panel of experts to advise the research team. A list of Advisory Panel Members and list of persons invited to the join the Panel is provided in Appendix A.

A primary question in the researchers' minds is to determine whether a reasonable concern for moisture buildup in wood decks in homes in Florida that have spray-applied foam insulations on their roof decks. Through discussion of the Advisory Panel it was felt that a survey of construction professionals (not in current scope) might be valuable tool in determining the awareness by the industry on the issues discussed. The research team has spent a great part of the time to locate and review peer-reviewed papers, and authentic reports pertinent to this topic. The researchers have preliminarily identified a list of nearly 70 peer-reviewed papers, reports and other information. Some of the recurring subjects within our literature review include:

- Properties of wood and spray foam
- Early studies on moisture movement
- Experimental Research
- Numerical Analysis of Hygrothermal Movement in Roof Decks
- Health Related Issues
- Forensic Studies of Roof Systems

Other categories will be added to the final report. A complete list of the collected documents is included in Appendix A. The literature review itself, is currently 30% complete. The Advisory Panel members continue to advise the research team and assist in identifying additional sources of literature to be considered by the Roofing TAC.

The research team held a two-day Advisory Panel Meeting in Orlando FL in 21st and 22nd January 2015 attended by 18 participants (in person and via web conferencing), to discuss the research objectives, and provide direction to the research team. Notes of meetings were circulated and the comments of the Advisory Panel members are being incorporated into the report. A second Advisory Panel Meeting was held on 12 February 2015 to review the progress and development of the experimental research plans and the work on the research team. A second project goal is to conduct field and experimental investigations into the relative drying characteristics of mock-ups of typical wood-spray foam composite structures that are used in Florida residential construction. Through discussion with the Advisory Panel, three experimental research directions are proposed:

- Relative-drying rates (see Experimental Research Plan 3a): Test parameters included type of wood deck (OSB and plywood), type of spray foam (open-cell vs. closed cell), and type of roof underlayment (1 layer, and 2-layer 30 lb building felt underlayment, and self-adhering bituminous membrane). The experimental research requires the construction of a temporary hot-box and the purchase of radiant heaters to provide the heat source for the roof specimens. The radiant heaters have been identified and will be purchased for the project by February 2015. Most of the instrumentation for measuring relative humidity and temperatures of the specimens will be used from UF's existing inventory.

- Moisture spread from Point-Source Water Leakage (see experimental Research Plan 3b): Test parameters include type of wood deck (OSB and plywood), type of spray foam (closed cell vs. none), and type of roof underlayment (2-layer 30 lb building felt underlayment and self-adhering bituminous membrane). The experimental research requires mono-sloped roof deck specimens and water source of dripping water leak. The study will compare the se roof samples will be monitored over time to develop a relationship between the moisture spread (gravimetric weighing) and timescale respectively.
- Field Survey of roof constructions with installed spray foam insulations (see Experimental Research Plan 3c): The Advisory Panel recommended reducing this scope because given the short time available it may not be as helpful to the overall objectives. The PI proposes a modified to include few homes in the study (reduce from five to two) but still include the interviews with the homeowner/occupant as to the comfort and thermal efficiency and risk perception of the installations. The numerical modeling of hygrothermal performance may provide limited results given that some the researchers. Efforts are underway to develop a complementary numerical modeling that matches the experimental research plans described in ERP 3a and ERP 3b.

3. Description of Issues

- Survey questions of Member Associations. Work with Advisory Panel to augment list
    - FRSA (Mark Zehnal), FBHA (Arlene Stewart), ARMA (Mike Fischer)
- Further refinement of the ERPs
- Update demographics on volume of foam (board feet installed) roof deck construction in Florida and the US as a whole SPFA (Rick Duncan)was deemed crucial
- Florida Building Code review on chronology of changes related to spray foam
- Definitions of terms relating to attic roofing systems.

4. Recommendations for the Code

No recommendations at this stage

5. Deliverables

- A report providing a state of the art literature review and conclusions, including technical information on the problem background, results and implications to the FL Building Code will be submitted to the Program Manager by June 1, 2015.

- Summary of experimental research, objectives, methods, results and recommendations for future investigations.

- A breakdown of the number of hours or partial hours, in increments of fifteen (15) minutes, of work performed and a brief description of the work performed. The Contractor agrees to provide any additional documentation requested by the Department to satisfy audit requirements.

6. Appendices:

6.1. Appendix A: Cited Literature

Literature Review:
Impact of Spray Foam Insulation on Durability of Plywood and OSB Roof Decks
Updated: 02/11/15

1. Saber, H. H., Maref, W., Elmahdy, A. H., Swinton, M. C., and Glazer, R. (2010). "3D thermal model for predicting the thermal resistance of spray polyurethane foam wall assemblies." *National Research Council Canada*.

2. Bomberg, M. T., and Lstiburek, J. W. (1998). *Spray polyurethane foam in external envelopes of buildings*, CRC Press.

3. Booth, R. J., DeRushie, C., and Liu, K. (2002). "Protection of foam plastic thermal insulation in low sloped roofing systems." *Journal of Thermal Envelope and Building Science*, 25(4), 255-274.

4. Carll, C., and Wiedenhoeft, A. C. (2009). "Moisture-related properties of wood and the effects of moisture on wood and wood products." *Moisture control in buildings: the key factor in mold prevention, 2nd ed. West Conshohocken, PA: ASTM International*, 54-79.

5. Datin, P. L., Prevatt, D. O., and Pang, W. (2011). "Wind-uplift capacity of residential wood roof-sheathing panels retrofitted with insulating foam adhesive." *Journal of Architectural Engineering*, 17(4), 144-154.

6. Derome, D., and Fazio, P. (2000). "Large-scale testing of two flat roof assemblies insulated with cellulose." *Journal of Architectural Engineering*, 6(1), 12-23.

7. Hendron, R., Anderson, R., Reeves, P., and Hancock, E. (2002). *Thermal performance of unvented attics in hot-dry climates*, National Renewable Energy Laboratory.

8. Huang, Y.-C. T., and Tsuang, W. (2014). "Health effects associated with faulty application of spray polyurethane foam in residential homes." *Environmental Research*, 134(0), 295-300.

9. Jerman, M., and Cerny, R. (2012). "Effect of moisture content on heat and moisture transport and storage properties of thermal insulation materials." *Energy and Buildings*, 53, 39-46. `

10. Lstiburek, J. (2002). "Moisture control for buildings." *ASHRAE journal*, 44(2), 36-41.

11. Lstiburek, J. W.(1993) "Humidity control in the humid south." ,*Proc., BETEC Workshop Proceedings*, 1-14.

12. Parker, D. (2005). "Literature review of the impact and need for attic ventilation in Florida homes." *Florida Solar Energy Center-Revised Draft Report, FSECCR-1496-05, submitted to the Florida Department of Community Affairs*.

13. Prevatt, D., McBride, K., Roueche, D., and Masters, F. (2014). "Wind Uplift Capacity of Foam-Retrofitted Roof Sheathing Panels Subjected to Rainwater Intrusion." *Journal of Architectural Engineering*, B4014001.

14. Rudd, A. F., and Lstiburek, J. W. (1998). "Vented and sealed attics in hot climates." *TRANSACTIONS-AMERICAN SOCIETY OF HEATING REFRIGERATING AND AIR CONDITIONING ENGINEERS-ASHRAE*, 104, 1199-1212.

15. Smits, G. F. (1994). "Effect of cellsize reduction on polyurethane foam physical properties." *Journal of Building Physics*, 17(4), 309-329.

16. Timusk, P. C. (2008). *An investigation of the moisture sorption and permeability properties of mill-fabricated oriented strandboard*.

17. Trechsel, H. R. (1985). "MOISTURE IN BUILDINGS: AN OVERVIEW." *Building Standards*, 54(2), 3-321.

18. Wu, L., Van Gemert, J., and Camargo, R. E. "Rheology Study in Polyurethane Rigid Foams." *Huntsman Corporation*.

19. Zabel, R. A., and Morrell, J. J. (1992). *Wood microbiology: decay and its prevention*, Academic press, 249-262.

20. Salonvaara, M., Karagiozis, A., and Desjarlais, A. "Moisture Performance of Sealed Attics in Climate Zones 1 to 4.", ASHRAE, Thermal Performance of the Exterior Envelope of Whole Buildings XII International Conference

21. Gates, C., and America, B. (2013). *Byggmeister Test Home: Analysis and Initial Results of Cold Climate Wood-Framed Home Retrofit*, US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program.

22. Dickson, B., and America, B. (2013). *Guide to Closing and Conditioning Ventilated Crawlspaces*, US Department of Energy, Energy Efficiency & Renewable Energy.

23. Lukachko, A., Grin, A., and Bergey, D. (2013). *Hybrid Wall Construction and Quality Control Issues in Wyandotte, Michigan*, US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Office.

24. Zoeller, W., Shapiro, C., Vijayakumar, G., and Puttagunta, S. (2013). *Retrofitting the Southeast: The Cool Energy House*, US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program.

25. Pallin, S., Kehrer, M., and Miller, W. A. (2013). "A Hygrothermal Risk Analysis Applied to Residential Unvented Attics." Oak Ridge National Laboratory (ORNL).

26. Mayer, R., Enache-Pommer, E., Parsons, G., Mazor, M., Hansbro, J., Lastovica, J., Buck, C., and Maurer, M. (2014). "Finite element thermal modeling and correlation of various building wall assembly systems." *Energy and Buildings*, 75(0), 410-418.

27. Puttagunta, S., Grab, J., and Williamson, J. (2013). "Performance House--A Cold Climate Challenge Home." US Department of Energy, National Renewable Energy Laboratory (NREL), Golden, CO.

28. Walker, I., and Less, B. "An Assessment of Envelope Measures in Mild Climate Deep Energy Retrofits." ASHRAE, *Proc., Thermal Performance of the Exterior Envelope of Whole Buildings XII International Conference*.

29. Morse-Fortier, L. (2012). "Potential Problems Arising from the Use of Composite Foam Panels on Sloping Roofs." *Forensic Engineering 2012*, American Society of Civil Engineers, 161-168.

30. Dixon, C., Masters, F., Prevatt, D., and Gurley, K. (2012). "Investigation of the Wind Resistance of Asphalt Shingles." *Advances in Hurricane Engineering*, American Society of Civil Engineers, 517-527.

31. Badiu, E., and Brătucu, G. (2013). "RESEARCHES REGARDING THE CAUSES OF DEGRADATION OF ROOF SYSTEMS." COMEC, 353-356

32. Ojanen, T. T. (2001). "Thermal and Moisture Performance of a Sealed Cold-Roof System with a Vapor-Permeable Underlay." ASHRAE, *Thermal Performance of the Exterior Envelopes of Buildings VIII*, 1-13

33. Straube, J., Smegal, J., and Smith, J. (2010). "Moisture-Safe Unvented Wood Roof Systems." Buildingscience Corporation, 1-13

34. Grin, A., and Lstiburek, J. W. (2012). *Moisture and Structural Analysis for High Performance Hybrid Wall Assemblies*, Citeseer. US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program, 1-65

35. Alturkistani, A., Fazio, P., Rao, J., and Mao, Q. (2008). "A new test method to determine the relative drying capacity of building envelope panels of various configurations." *Building and Environment*, 43(12), 2203-2215.

36. Grin, A., Smegal, J., and Lstiburek, J. (2013). "Application of Spray Foam Insulation Under Plywood and Oriented Strand Board Roof Sheathing." National Renewable Energy Laboratory (NREL), Golden, CO.

37. Oustad, M., Gustavsen, A. U., and Uvslokk, S. " Calculation of Moisture and Heat Transfer in Compact Roofs and Comparison with Experimental data.", Norwegian University and NBI, 1-8

38. Lstiburek, J. W. (2014). "Cool Hand Luke Meets Attics." AMERICAN SOCIETY HEATING REFRIGERATING AIR-CONDITIONING ENG. - ASHRAE , Buliding Science Corporation, 1-6

39. Prevatt, D. O., Shreyans (2010). "Field evaluation of thermal performance and energy efficiency of ccSPF retrofitted vented residential attic." *Rep. No. UF01-10, Univ. of Florida, Gainesville, FL*.

40. Sorahan, T., and Pope, D. (1993). "Mortality and cancer morbidity of production workers in the United Kingdom flexible polyurethane foam industry." *British journal of industrial medicine*, 50(6), 528-536.

41. Lesage, J., Stanley, J., Karoly, W. J., and Lichtenberg, F. W. (2007). "Airborne Methylene Diphenyl Diisocyanate (MDI) Concentrations Associated with the Application of Polyurethane Spray Foam in Residential Construction." *Journal of Occupational and Environmental Hygiene*, 4(2), 145-155.

42. McBride, K. (2011). "WIND UPLIFT PERFORMANCE OF CCSPF-RETROFITTED ROOF SHEATHING SUBJECTED TO WATER LEAKAGE - THESIS - UNIVERSITY OF FLORIDA." D. Prevatt, ed., University of Florida.

43. Shreyans, S. (2011). "Thermal Performance of Foam Retrofitted Vented Residential Attic - THESIS - UNIVERSITY OF FLORIDA." D. Prevatt, ed., University of Florida, 1-131.

44. 44. ComPliaNce, C. "Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing.

45. Nelson, P. E., and Der Ananian, J. S. (2009). "Compact asphalt shingle roof systems: Should they be vented?" *Journal of ASTM International*, 6(4).

46. Honeywell "Energy Performance and Closed-Cell Spray Foam: A Better Building Technology." Honeywell, 1-10.

47. "Insulate with Integrity: Learn the facts about SPF & What the Experts are saying" Owens Corning, (http://ww3.owenscorning.com/insulate-with-integrity/)

48. Yuan, S., and Karagiozis, A. N. (2010). "The Hygrothermal Performance of Wood-Framed Wall Systems Using Spray Polyurethane Foam Insulations and a Smart Vapor Retarder in the Pacific Northwest."

49. Parker, D. S., Sonne, J. K., Sherwin, J. R., and Moyer, N. "Comparative evaluation of the impact of roofing systems on residential cooling energy demand in Florida." 219.

50. Straube, J., and Smegal, J. (2009). "Building America special research project: High-R walls case study analysis." *RR-0903 at www. buildingscience. com*.

51. "Vacate and Safe Re-Entry Time - SPF." Environmental Protection Agency.

52. Shafer, J. (2013). "Spray Foam Basics for the Fire Service." Green Maltese.

53. Smegal, J., and Lstiburek, J. (2013). "Hygric Redistribution in Insulated Assemblies: Retrofitting Residential Envelopes Without Creating Moisture Issues." National Renewable Energy Laboratory (NREL), Golden, CO

54. Morris, C. (2013). "Customer Letter." DPIS Engineering, LLC: The Builders Solution.

55. "What happens with a roof leak and spray foam?", Centex.

56. Anderson, J. (2011). "SPF Guidelines for Re-occupancy." Insulation Contracting Association of America, 1-44.

57. Holladay, M. (2014). "Open-Cell Spray Foam and Damp Roof Sheathing." Green Building Advisor, 1-8.

58. Bailes, A. (2014). "Will open-cell spray foam insulation really rot your roof?"Green Building Advisor.

59. (2009). "Water vapor permeance of wood sheathing panels and wood wall construction." *Number J450*, APA - The Engineered Wood Association.

60. (2011). "Wood moisture content and the importance of drying in wood building systems." APA – The Engineered Wood Association, 1-3.

61. Schumacher, C. J. (2008). "Hygrothermal performance of insulated, sloped, wood-framed roof assemblies."1-165

62. C.A.S.M.A (2013). ""Hot Roof" Designs: Technical Bulletin."

63. Santos, S. "Solving the Air Barrier Riddle: Permeable or Impermeable? ." Building Envelope Forum, 1-8.

64. Hubbs, B., and Hircock, M. "Building envelope performance monitoring."

65. Icynene (2013). "Open-cell spray foam & what every contractor should know ", 1-6.

66. BSC (2008). "Building Science Corporation: Unvented Roofs, Hot-Humid Climates, and Asphalt Roofing Shingles " *Research Report*.

67. Datin, P., Prevatt, D., and Pang, W. (2010). "Wind-Uplift Capacity of Residential Wood Roof-Sheathing Panels Retrofitted with Insulating Foam Adhesive." *Journal of Architectural Engineering*, 17(4), 144-154.

68. Prevatt, D. O. (2007). "Improving the Wind Uplift Capacity of Wood Roof Panels Retrofitted with ccSPF Adhesives , submitted to NCFI ."

6.2. Appendix B: Advisory Panel Members

Advisory Panel Member	Organization
Scott Kriner	Metal Construction Association
Jason Hoerter	NCFI Polyurethanes
Mark Zehnal	Florida's Association of Roofing Professionals (FRSA)
Todd Wishneski	BASF Polyurethanes
Mike Fischer	Asphalt Roofing Manufacturers Association (ARMA)
Mike Ennis	Single Ply Roofing Industry (SPRI)
Marcin Pazera	Owens Corning
John Broniek	Icynene
David Roodvoets	DLR Consultants
Tim Smail	Federal Alliance for Safe Homes
Eric Vaughn	Federal Alliance for Safe Homes
Jaime Gascon	Miami-Dade Regulatory and Economic Resources (RER)
Rick Olson	Tile Roofing Institute
Sean O'Brien	Simpson Gumpertz & Heger (SGH)
David Brandon	Brandon Construction Company
Yuh Chin T. Huang	Duke University
Bill Coulbourne	Applied Technology Council (ATC)
Arlene Stewart	AZS Consulting Inc
Tim Reinhold	Insurance Institute for Business & Home Safety
Mo Mandani	Florida Building Commission
Rick Duncan	Spray Polyurethane Foam Alliance (SPFA)
Paul Coats	American Wood Council
BJ Yeh	Engineered Wood Association

Other Invited Participants	Organization
Philip Fairey	Florida Solar Energy Center
Robin Vieira	Florida Solar Energy Center
John Straube	Building Science Consulting
Kurt Koch	Huber Engineered Woods LLC
William (Bill) Miller	Oak Ridge National Laboratories
Pamela Dixon	Homeowner
Michael Goolsby	Miami Dade County Department of Regulatory and Economic Resources
Peter Parmenter	Cedar Shake & Shingle Bureau

6.3. Appendix C: Changes to Florida Building Code

2010 FLORIDA BUILDING CODE

UNVENTED ATTIC CODE REFERENCES

2010 Florida Energy Conservation Code

Definitions

CONDITIONED SPACE. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*. See "Space."

SPACE. An enclosed space within a building. The classifications of spaces are as follows for the purpose of determining building envelope requirements.

1. Conditioned space: a cooled space, heated space, or indirectly conditioned space or unvented attic assembly defined as follows.

a. Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h•ft^2 of floor area.

b. Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h•ft^2.

c. Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the *U*-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds the combined sum of the product of the *U*-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semi-heated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding 3 air changes per hour (ACH) (e.g., atria).

d. Unvented attic assembly: as defined in Section R806.4 of the *Florida Building Code, Residential*. These spaces shall not require supply or return outlets.

2. Semiheated space: an enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h•ft^2 of floor area but is not a conditioned space.

3. Unconditioned space: an enclosed space within a building that is not a conditioned space or a semiheated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

405.6.3 Installation criteria for homes using the unvented attic assembly option.

The unvented attic assembly option may be used if the criteria in Section R806.4 of the *Florida Building Code, Residential* have been met.

2010 Florida Residential Code

NON-HIGH VELOCITY

R806.4 Unvented attic assemblies.

Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) shall be permitted if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum $^{1}/_{4}$ inch (6 mm) vented air space separates the shingles or shakes and the roofing underlayment above the structural sheathing.
4. Either Items 4.1, 4.2 or 4.3 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.
4.1 Air-impermeable insulation only. Insulation shall be applied in direct contact with the underside of the structural roof sheathing.
4.2 Air-permeable insulation only. In addition to the air-permeable installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing as specified in Table R806.4 for condensation control.
4.3 Air-impermeable and air-permeable insulation. The air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing as specified in Table R806.4 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

TABLE R806.4 INSULATION FOR CONDENSATION CONTROL

CLIMATE ZONE	MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION *R*-VALUE[a]
1, 2 (All Florida)	R-5

a.Contributes to but does not supersede requirements of the *Florida Building Code, Energy Conservation.*

High Velocity Hurricane Zone (Miami-Dade & Broward Counties)

R4409.13.3.2.5 Unvented attic assemblies.

Unvented attic assemblies shall be permitted if all the following conditions are met:
1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarder is installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum continuous $^{1}/_{4}$ inch (6 mm) vented air space separates the shingles or shakes from the roofing underlayment.
4. One of the following shall be met, depending on the air permeability of the insulation under the structural roof sheathing:
a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.
b. Air-permeable insulation only. In addition to air-permeable insulation installed

directly below the structural sheathing, at least R-5 rigid board or sheet insulation shall be installed directly above the structural roof sheathing for condensation control.
c. Air-impermeable and air-permeable insulation. At least R-5 air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

2007 FLORIDA BUILDING CODE

UNVENTED ATTIC CODE REFERENCES

2007 Florida Building Code: Energy

Chapter Subchapter 13-2 – Definitions

CONDITIONED SPACE. See "Space, (a) conditioned space.

SPACE. An enclosed space within a building. The classifications of spaces are as follows for the purpose of determining building envelope requirements.

(a) **Conditioned space:** A cooled space, heated space, indirectly conditioned space or unvented attic assembly defined as follows:
(1) Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^2 of floor area.
(2) Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h·ft^2.
(3) Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the *U*-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds the combined sum of the product of the *U*-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semiheated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding three air changes per hour (ACH) (e.g., atria).
(4) Unvented attic assembly: as defined in Section R806.4 of the *Florida Building Code, Residential*. These spaces shall not require supply or return outlets.
(b) **Semiheated space:** An enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 of floor area but is not a conditioned space.
(c) **Unconditioned space:** An enclosed space within a building that is not a conditioned space or a semiheated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

13-604.A.5 Installation criteria for homes using the unvented attic assembly option. The unvented attic assembly option may be used in EnergyGauge USA Fla/Res if the criteria in Section R806.4 of the *Florida Building Code, Residential,* have been met.

R806.4 Unvented attic assemblies. Unvented attic assemblies shall be permitted if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarder is installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum continuous $^{1}/_{4}$ inch (6 mm) vented air space separates the shingles or shakes from the roofing underlayment.
4. One of the following shall be met, depending on the air permeability of the insulation under the structural roof sheathing:

a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.

b. Air-permeable insulation only. In addition to air-permeable insulation installed directly below the structural sheathing, at least R-5 rigid board or sheet insulation shall be installed directly above the structural roof sheathing for condensation control.

c. Air-impermeable and air-permeable insulation. At least R-5 air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

2004 FLORIDA BUILDING CODE

UNVENTED ATTIC CODE REFERENCES

2004 FLORIDA BUILDING CODE: BUILDING

Chapter 13 - Energy Efficiency

Section 13-202. DEFINITIONS

CONDITIONED SPACE. That volume of a structure which is either mechanically heated, cooled, or both heated and cooled by direct means. Spaces within the thermal envelope that are not directly conditioned shall be considered buffered unconditioned space. Such spaces may include, but are not limited to, mechanical rooms, stairwells, and unducted spaces beneath roofs and between floors. Air leakage into dropped ceiling cavities does not constitute conditioned space (see “Space.”)
SPACE. An enclosed space within a building. The classifications of spaces are as follows for the purpose of determining building envelope requirements.

(a) **Conditioned space:** A cooled space, heated space, or indirectly conditioned space defined as follows.

(1) Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^{2} of floor area.

(2) Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h·ft^{2}.

(3) Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the *U*-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds

the combined sum of the product of the *U*-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semiheated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding three air changes per hour (ACH) (e.g., atria).

(b) **Semiheated space:** An enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 of floor area but is not a conditioned space.

(c) **Unconditioned space:** An enclosed space within a building that is not a conditioned space or a semiheated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

2004 Florida Building Code: Residential

Chapter 8 - Roof-Ceiling Construction

R806.4 Conditioned attic assemblies.

Unvented conditioned attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) are permitted under the following conditions:

Chapter 8, Section R806, (4)(ab1)
1. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.

Chapter 8, Section R806, (4)(ac2)
2. An air-impermeable insulation is applied in direct contact to the underside/interior of the structural roof deck. "Air-impermeable" shall be defined by ASTM E 283.

Chapter 8, Section R806, (4)(ad3)
3. Shingles shall be installed as shown:

Chapter 8, Section R806, (4)(3)(a)
a. For asphalt roofing shingles: A 1-perm (57.4 mg/s · m^2 · Pa) or less vapor retarder (determined using Procedure B of ASTM E 96) is placed to the exterior of the structural roof deck; i.e. just above the roof structural sheathing.

Chapter 8, Section R806, (4)(3)(b)
b. For wood shingles and shakes: A minimum continuous ¼-inch (6 mm) vented air space separates the shingles/shakes and the roofing felt placed over the structural sheathing.

6.4. Appendix D: ERP #2: Field Survey

Experimental Research Plan
Task #2: Field Survey Existing Roofs with Spray Foam Insulation

David O. Prevatt [a], Trent Vogelgesang [b],
[a] Associate Professor, [b] Graduate Research Assistant
Department of Civil and Coastal Engineering, University of Florida

1. Objective

Conduct field survey of roof constructions of five single-family residential buildings with wood roof decks insulated with spray foam insulation. Install temperature and relative humidity measuring devices in the attic, the exterior and interior of houses. Interview the homeowner/occupants as to the comfort and thermal efficiency, costs and risk perception of these installations. The original objective was to provide a

2. Approach

Instrument the homes with temperature and relative humidity sensors that currently have SPF installed on the underside of roof sheathing for comparative full-scale testing. Use wireless download technique to capture bi-weekly data without disturbing residents.

We have identified two homes for this study (Lynch and Brandon) and with the Advisory Panel's suggestion the project scope is reduced from 5 to 2 homes because of lack of useful results. We will work with the FBC to modify the project scope if needed.

Interview homeowners regarding roofing and foam installation.
Questions for interview:

(i) Owner perceptions of spray foam insulation: comfort and energy savings.
(ii) Age of roofing, age of home and orientation
(iii) Type of insulation: retrofit versus new construction
(iv) Material and Geometry
(v) Type of wood
(vi) Problems or Roof Repairs

2.2. Instrumentation

- HOBO Temperature and Relative Humidity data nodes (http://bit.ly/17FoneD) – per house to record temperature and RH of unvented attic system. Record temperature and relative humidity at 15 minute intervals.
- HOBO Wireless Data Receiver (http://bit.ly/1DWh7p1) to extract data from nodes onto laptop every 20 days. 1 Receiver needed for all homes.

Figure 1: HOBO Wireless Data Node

Figure 2: HOBO Wireless Data Receiver

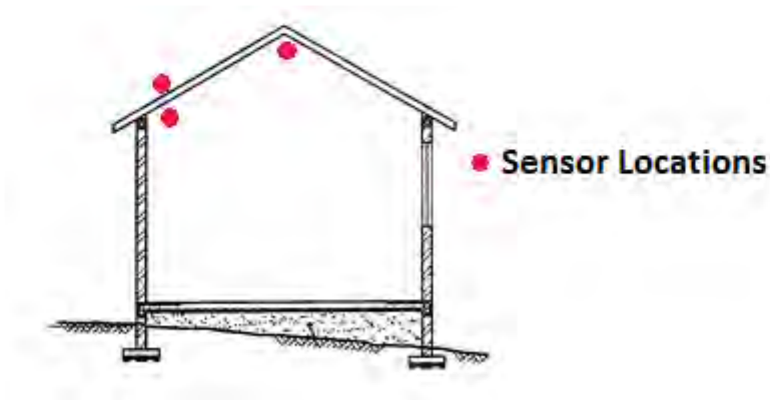


Figure 3: Sensor Locations

6.5. Appendix E: Task 3a: Comparative Drying Rate Test

Experimental Research Plan

Task #3a: Comparative Drying Rate Tests on Wood Deck-Spray Foam Samples

David O. Prevatt [a], Trent Vogelgesang [b],
[a] Associate Professor, [b] Graduate Research Assistant
Department of Civil and Coastal Engineering, University of Florida

3. Objective

The objectives of this research are to: determine relative drying rates of wood roof deck configurations with various foam insulation characteristics of the systems. The results will serve as preliminary study.

4. Motivation

Small-scale proof of concept experiment is needed to confirm an approach for monitoring roof deck drying rates. Experiment will be used as precursor to more elaborate testing, if this is justified by results.

5. Approach

Fabricate 36, 12” x 12”, flat roof specimens and measure the 1-D comparative drying rates through wood roof cross-sections having a) traditional (no insulation), b) open-cell and c) closed-cell spray foam insulation. Measure interior and exterior climate for 3 months. Interior conditions will be representative of a conditioned space. Exterior conditions will artificially simulate a hot/humid climate via heat lamps and humidifiers. This will create a vapor drive with hygrothermal properties typical of Climate zone 1. Roof sheathing will be water-soaked at start of experiment up to a moisture content exceeding threshold for decay of 20%.

Testing Matrix			
Underlayment	(A) 30 lb felt - 1 layer, (B) 30 lb felt - 2 layers , (C) Peel and Stick		
Foam Type	No Foam	ocSPF	ccSPF
Plywood - A	X	X	X
Plywood - B	X	X	X
OSB - A	X	X	X
OSB - B	X	X	X

Note: This matrix shows different foam and sheathing types will repeat 3 times for each underlayment type. 12 Specimens x 3 = 36 total roof specimens.

Figure 4: Isometric view of Test Hut

Moisture content will be monitored via gravimetric weighing per ASTM D4442 of removable roof specimens. Relative humidity and temperature of interior and exterior space monitored with LogTag sensors.

6. Interior – Specimen

The interior space houses our 36 roof specimens in a grid like manner and consists of 2 x 4 framing with 5/8 sheathing and is approximately 11’ x 5’ x 6’ (LxWxD). These specimens are carefully installed to provide 1-D moisture movement occurs by ensuring the roof sheathing does not come in contact with “dry” framing and is varnished along its edges. This space will not be insulated in order to acclimate to the conditions of the lab. The temperature and relative humidity will be monitored in this space.

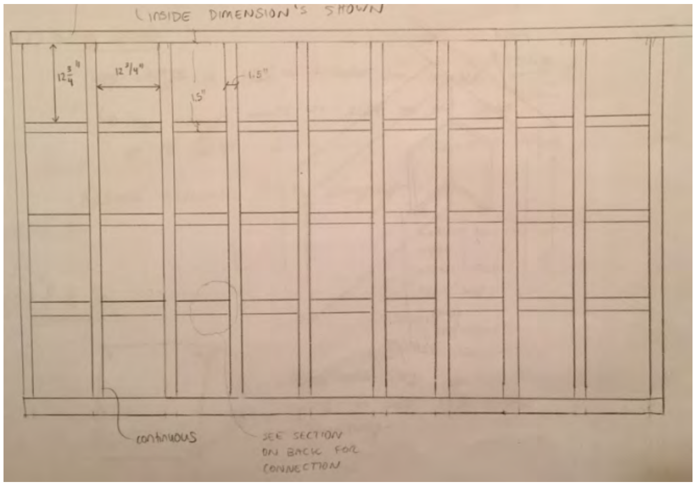


Figure 5: 9 x 4 Specimen Grid

7. Exterior Hot Box

The insulated exterior hotbox is an enclosed room with radiant heaters installed to maintain constant temperature above 150 degrees Fahrenheit. The exterior covering will be reprehensive of the hot/humid climate of Florida by introducing heat lamps and forced ventilation in the system. The hotbox insulation will consist of R19 batt insulation and 2 in in. thick rigid polystyrene board. This space will include heaters (specifications below).

RADIANT
ELECTRIC HEAT

COVE HEATER SUBMITTAL SHEET

ceramicircuit

UL

Date: 11 Feb 2015

Project: University of Florida - FBC Roofing Project

Architect:

Engineer:

Contractor:

Submitted by:

Approved by:

HEATERS

QTY	MODEL #	VOLTS	WATTS	CUSTOM FEATURES
2	945C	120	1,000	CL - Flush Mount Ceiling Brackets

ACCESSORIES & CONTROLS

QTY	CAT. NO.	DESCRIPTION

(06/11) www.electricheat.com

RADIANT
ELECTRIC HEAT

N112W14600 Mequon Road
Germantown, WI 53022
www.electricheat.com

ARCHITECT'S AND ENGINEER'S SPECIFICATIONS

Furnish and install where indicated on the Drawings, "High Efficiency Ceramic Infrared Panel" heaters manufactured by Radiant Electric Heat. Germantown, Wisconsin. Heaters shall be UL listed.

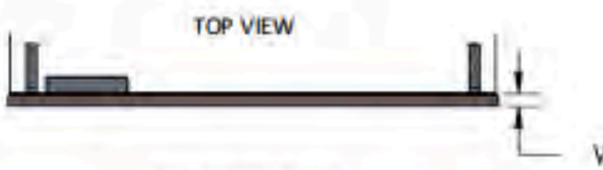
CONSTRUCTION

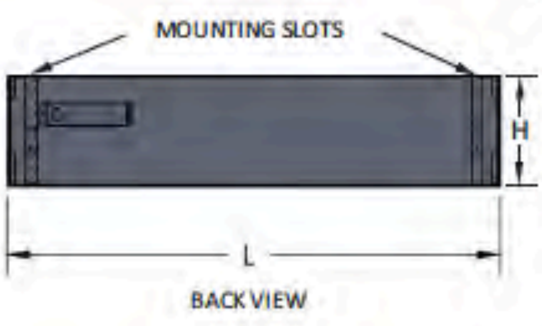
Heating Elements: Porcelain enamel coated 18 gauge steel plate, with energizing ceramic circuit on internal face of heating element; minimum 2.3 Watts per square inch of emissive surface area.
Heater Body: 20 gauge steel, high-temperature resistant powder coating. Provided with manufacturer's standard 7/8 inch knockouts for power feed.
Accessories: Provide as indicated, thermostat, NEMA 1 Enclosure control panel, and mounting brackets for models specified.
Installation: Install heating units where indicated, in accordance with manufacturer's written instructions, applicable requirements of IEC, in compliance with recognized industry practices to ensure products fulfill requirements. Secure in place with mounting brackets. Top of heater unit and trim shall be level. Where heating units are mounted adjacent to each other, the top edges shall be at the same height.

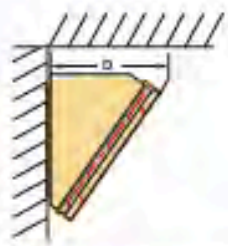
ACCESSORIES & CONTROLS

MODEL	INSTALLATION	WATTS	VOLTAGE	AMPS	SHIPPING WEIGHT
632C	CEILING COVE	585	120 240 208 277		14 lbs
645C	CEILING COVE	825	120 240 208 277		17 lbs
945C	CEILING COVE	1,000	120 240 208 277		22 lbs
1445C	CEILING COVE	1,500	120 240 208 277	12.5	40 lbs

*RADIANT ELECTRIC HEAT RESERVES THE RIGHT TO CHANGE SPECIFICATIONS WITHOUT PRIOR NOTICE







Cove Model	Watts	L	H	W	D
632C	585	33"	7"	1.125"	5.5"
645C	825	46"	7"	1.125"	5.5"
945C	1000	46"	10"	1.125"	7.5"
1445C	1500	46"	15"	1.125"	10"

6.6. Appendix F: ERP 3b: Point-source wetting and moisture spread

Experimental Research Plan

Task #3b: Time variation in moisture from Point-source Water Leakage in Wood Roof Decks

David O. Prevatt [a], Trent Vogelgesang [b],
[a] Associate Professor, [b] Graduate Research Assistant
Department of Civil and Coastal Engineering, University of Florida

1. Objective

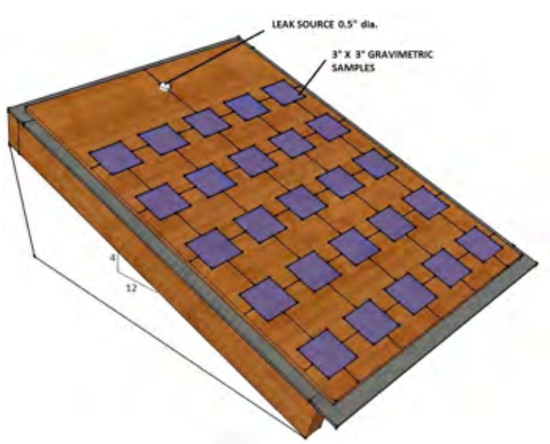
The objectives of this research are to determine: (i) the rate of moisture spread in plywood and OSB roof decking from a point leak source; (ii) if a non-destructive method of detecting moisture due to a roof leak is feasible. The results will serve as a preliminary study.

2. Motivation

To determine the moisture spreading effect over time that spray foam and roof sheathing have when subjected to a typical roof failure and leakage scenario. The purpose is to perform comparative testing to existing homes with roof damage and spray foam.

3. Approach

Fabricate 48, 3'x4', test samples with 4 and 12 mono-sloped south-facing roof pitch installed with spray foam insulation to determine the mitigation of moisture from a point source leak. The south orientation yields the highest moisture contents (Prevatt et al. 2014) and the constant roof slope is typical of one side of a roof assembly. Variables can be seen in the test matrix below. The methodology for the point source leakage is from (Prevatt et al. 2014) in which a series of sprinklers will provide continuous wetting. The moisture accumulation over time will be monitored via gravimetric sampling of 3" x 3" roof samples per ASTM D4442 and LogTag sensors will be installed to monitor relative humidity and temperature. These moisture contents will be plotted versus time to develop contour plots to show the spread of moisture throughout sheathing. This will answer: (A) Does P/S limit absorption of moisture into wood? and (B) Does having 2 vapor retarders (top-underlayment, bottom- SPF) limit drying of moisture?



Impact of Spray Foam Insulation on the Durability of Plywood and OSB roof sheathing				
Prepared by: Trent Vogelgesang		Date Modified: 02/11/15		
Perform Test Matrix for both Plywood and OSB Roof Sheathing				
Underlayment	#30 Felt - 1 layer		Peel and Stick	
Foam Type	No Foam	ccSPF	No Foam	ccSPF
Duration of Time				
Start	X	X	X	X
1 week	X	X	X	X
2 week	X	X	X	X
4 week	X	X	X	X
6 week	X	X	X	X
12 week	X	X	X	X

Figure 6: Point Source Induced Leakage

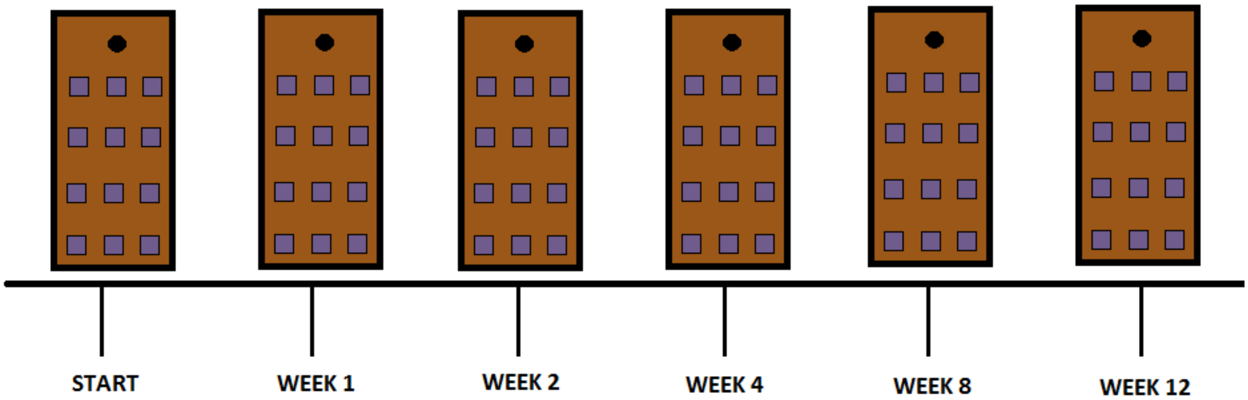


Figure 7: Time-table for gravimetric weighing

Note: Gravimetric samples will be cut out and weighed at time scales above to determine change in Moisture content over time per ASTM D4442.

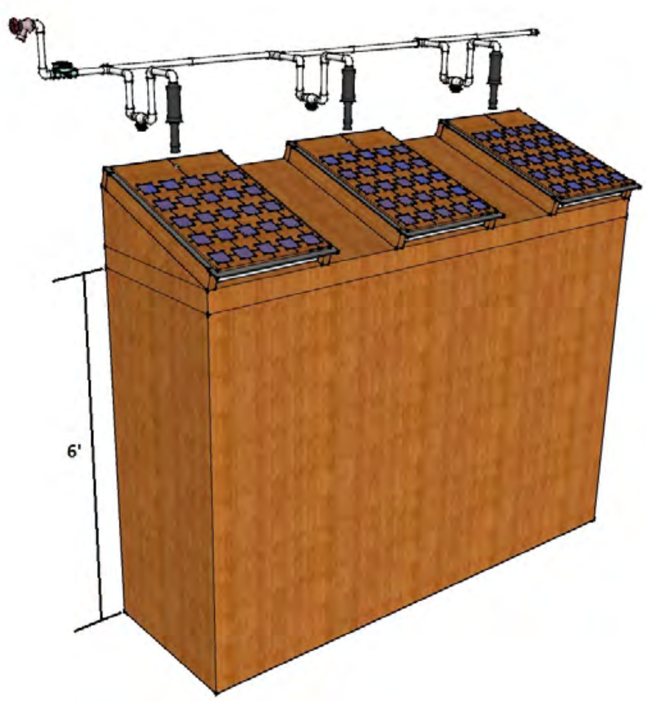


Figure 8: Isometric View of Test Setup

References:

Prevatt, D., McBride, K., Roueche, D., and Masters, F. (2014). "Wind Uplift Capacity of Foam-Retrofitted Roof Sheathing Panels Subjected to Rainwater Intrusion." Journal of Architectural Engineering, B4014001.

TECHNICAL ADVISORY BULLETIN

To: GAF Residential Sales, GAF Contractors, GAF Field Services

From: Technical Services Department

Subject: Under Deck Sprayed-In-Place Foam Insulation

Quality You Can Trust… From North America's Largest Roofing Manufacturer!™

Issued Date: 05/27/2011

Revised Date: 03/12/2015

No: TAB-R 2011-135

Residential

What Is Sprayed-In-Place Foam Insulation?

Sprayed-in-place insulation is…
Usually a two-part spray on foam insulation, commonly applied to wall cavities and the bottom of roof decks as a part of the building envelope's insulation assembly.

Additional Information About Sprayed-In-Place Foam Insulation You Should Know About…

Using sprayed-in-place insulation…

- Is installed to assist in the energy performance of a home.
- When installed in accordance with the 2015 International Residential Code (the IRC) is an accepted method of insulating a roof assembly.
- May lead to condensation problems, mold growth, deck deterioration, damage of fiberglass asphalt shingles, and structural damage when not installed according to the manufacturer's instructions and building code requirements.

Will Sprayed-In-Place Foam Insulation Damage My Roof?

Sprayed-in-place insulation…

- Applied directly to bottom side of roof decks, the insulation does not allow for airflow on the bottom of the deck like in a traditional vented attic assembly. It is the responsibility of the design professional to examine the need for structural ventilation and to insure interior air quality. For any building, construction must be in compliance with local codes.

What Does GAF Recommend?

GAF recommends…

- ThermaCal® Ventilated Nail Base along with Cobra® soffit and ridge vents should be installed to provide a ventilated substrate for shingles when under deck spray-in-place foam insulation is installed on new construction or on tear-off reroofing projects.
- Proper attic ventilation following the FHA/HUD 1/300 rule, which calls for 1 sq.ft. of net free (open) soffit to ridge ventilation of per 300 sq.ft. of attic floor space.
- GAF does, however, recognize the emergence of unvented attic assemblies and recommends that all code requirements be met and the manufacturer's recommendations followed when installing an unvented attic assembly.
- There are retrofit applications of sprayed-in-place foam insulation that allow for ventilated attic assemblies. Where this type of application is installed, GAF's recommendation of proper attic ventilation amounts should be followed.

Will Sprayed-In-Place Foam Insulation Void My Warranty?

No, the GAF Shingle Limited Warranty against manufacturing defects will remain in effect.

- However, any damage to the shingles attributable to using sprayed-in-place insulation directly applied to the roof deck or lack of ventilation is excluded from GAF's responsibility under the terms of our Limited Warranty.

Where Can I Get More Information?

GAF Technical Services Can Assist You… with these and other questions you may have regarding your new roof installation. GAF Technical Services can be contacted **at 800-ROOF-411** (800-766-3411). Also, the GAF website is a great resource for just about any question you may have or for additional information you may require. Please visit www.gaf.com to find the latest information on our products and their installation.

Important: This document supersedes any prior GAF Technical Advisory Bulletins on this topic. Please always check www.gaf.com to make sure you have the most up to date information.

20 YEARS 1989-2009

NEI®

Northern Elastomeric Incorporated

July 15, 2011

Bulletin:

Re: "Spray Foam" – Sealed Attics

NEI will no longer accept or warrant roofing underlayment installed over roof decks insulated with spray foam insulation.

Spray foam insulation applied directly to the bottom of the roof decking material can trap moisture. This would include spray foam types with either "Open Cell" or "Closed Cell". The roof deck needs to be able to vent the heat and or moisture out of the system. The trapped moisture in the plywood could have an adverse effect to the adhesion of the underlayment.

The only installation exception would be to first mechanically fasten a base sheet to the deck. The base sheet would insure the adhesion to the underlayment.

Best regards,

Michael VanWyngarden
VP of Sales & Marketing
NEI

Owens Corning Roofing and Asphalt, LLC

Technical Services Bulletin

Bulletin Number: RD – 032911
Date: 3/29/2011
Phone: 1-419-248-6557
Email: gettech@owenscorning.com

Subject: Warranty Coverage of WeatherLock® Specialty Tile and Metal over Sealed or Unvented Attic Systems

Owens Corning Roofing and Asphalt, LLC ("Owens Corning") will provide warranty coverage within the terms stated in the WeatherLock® Specialty Tile and Metal Waterproofing Limited warranty when installed over unvented or sealed attic systems. In single-family residential applications less than 100 squares.

The following guidelines must be followed for coverage extension:

Roof System is approved and compliant with all local building codes

Decking is either 3/8" plywood (minimum) or 7/16 OSB (minimum)

Insulation, radiant barrier, and any other components of the roof deck assembly must be installed in strict accordance with manufacturer's installation instructions

All other installation practices for Owens Corning™ WeatherLock® Specialty Tile and Metal must be performed in strict accordance with our installation instructions

Owens Corning's WeatherLock® Specialty Tile and Metal Waterproofing Limited warranty will be valid within the terms and conditions stated in the warranty when the above conditions are met. Owens Corning warranty doesn't cover workmanship or application, only defects in the product.

Owens Corning's position is that proper ventilation of a residential attic and rafter spaces is the preferred design consideration. Not venting attics may introduce moisture related problems in the attic. Moisture management issues can lead to mold and damage to the internal structure of a home. Further, installing a spray foam system can make it more difficult to detect roof leaks. Should you desire more information regarding the value of using ventilation in residential applications, please review information found at www.ravcoalition.org.

OWENS CORNING
INNOVATIONS FOR LIVING®

BUILDING SCIENCE
INSIGHTS
Physics to the Field™

High Performance Unvented Attics with Fiberglass Insulation

Building Science Group, Sustainability
Owens Corning

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Acknowledgments

Field Testing # 1

Field Testing # 2

Advanced Modeling

Mixed Climate Hot-Cold-Humid

Hot-Dry

Both Climates

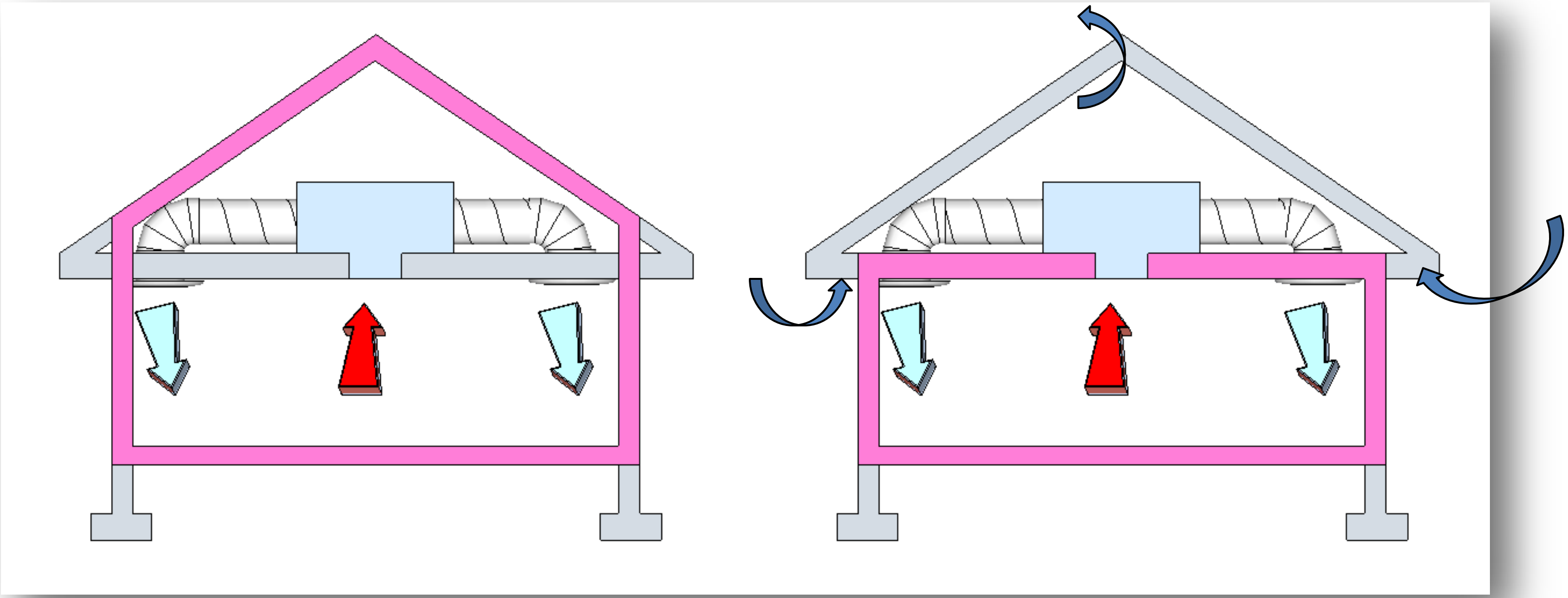
- Dr. William Miller – Oak Ridge National Laboratory
- Dr. Andre Desjarlais – Oak Ridge National Laboratory
- Mikael Salonvaara – Owens Corning
- Abe Cubano –Owens Corning
- Neil Freidberg – Owens Corning

Outline

- Moisture in above and below roof deck insulation
- Impact of vented and non-vented attics on moisture in attics
- Performance Results
- Discussion and Conclusions

Attic Types and Moisture Management

Sealed (Unvented) Attic | Vented Attic



Ducts inside thermal boundary	Ducts in unconditioned space
Attic is not living space and not intentionally conditioned	Attic is ventilated with outdoor air

Approach

- Focus on moisture performance
  - Condensation, wetting and drying of roof deck
- Tools
  - Simulations with hygrothermal models
  - Field testing
    - Air tightness and temperature/humidity measurements

Typical Insulation in Unvented Attics

OWENS CORNING
INNOVATIONS FOR LIVING®

BUILDING SCIENCE INSIGHTS
Physics to the Field™

- Spray foam: Chemicals mixed, applied and cured on-site
  - Open Cell
    - Low density (~0.5 pcf), Vapor permeable
  - Closed Cell
    - High density (~2 pcf), Low vapor permeability

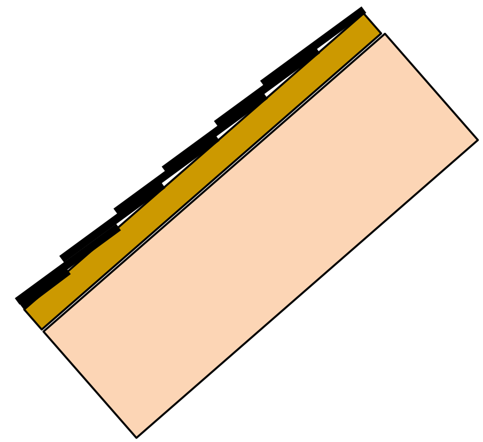
www.Insulatewithintegrity.com

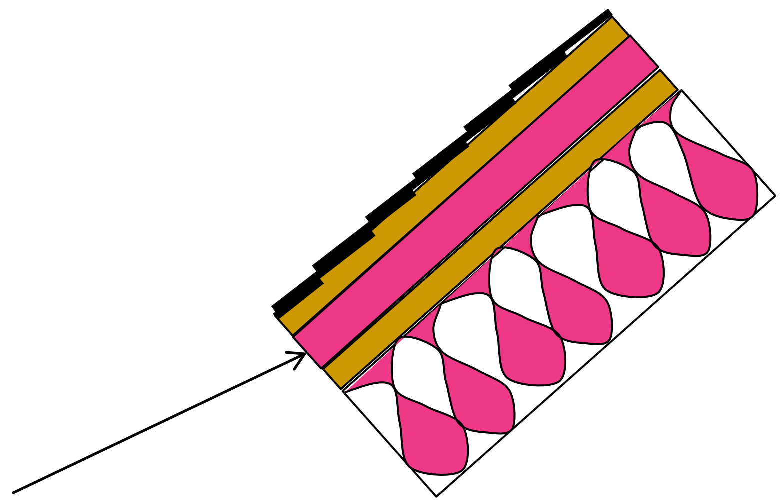
- Air permeable insulation
  - Dense packed fibrous insulation
  - Condensation control layer e.g. exterior foam may be needed

Unvented Attics in Building Codes

International Residential Code (IRC) R806.5

- "Unvented attic and unvented enclosed rafter assemblies"
  - Requires air impermeable insulation in direct contact with the roof sheathing
  - If air permeable insulation is used
    - The air permeable insulation has to be supplemented with a condensation control layer (air impermeable insulation) either on top of or under the roof sheathing.





Condensation Control - IRC

Table 3. Minimum R-values of Air-impermeable Insulation in Unvented Attics. (IRC 2012 table R806.5)

Climate Zone	Minimum rigid board or air-impermeable insulation R-value
2B and 3B tile roof only	None required
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

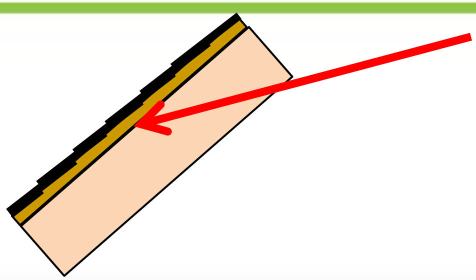
ORNL Test House – Model Calibration

MEASURED AND SIMULATED TEMPERATURE & RELATIVE HUMIDITY

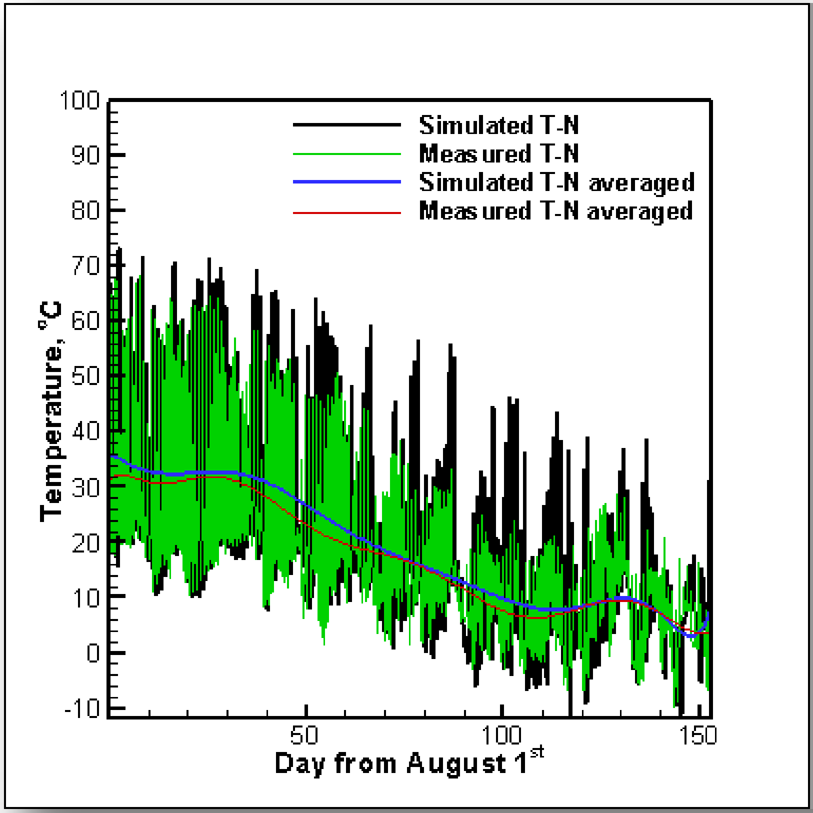
Model Calibration

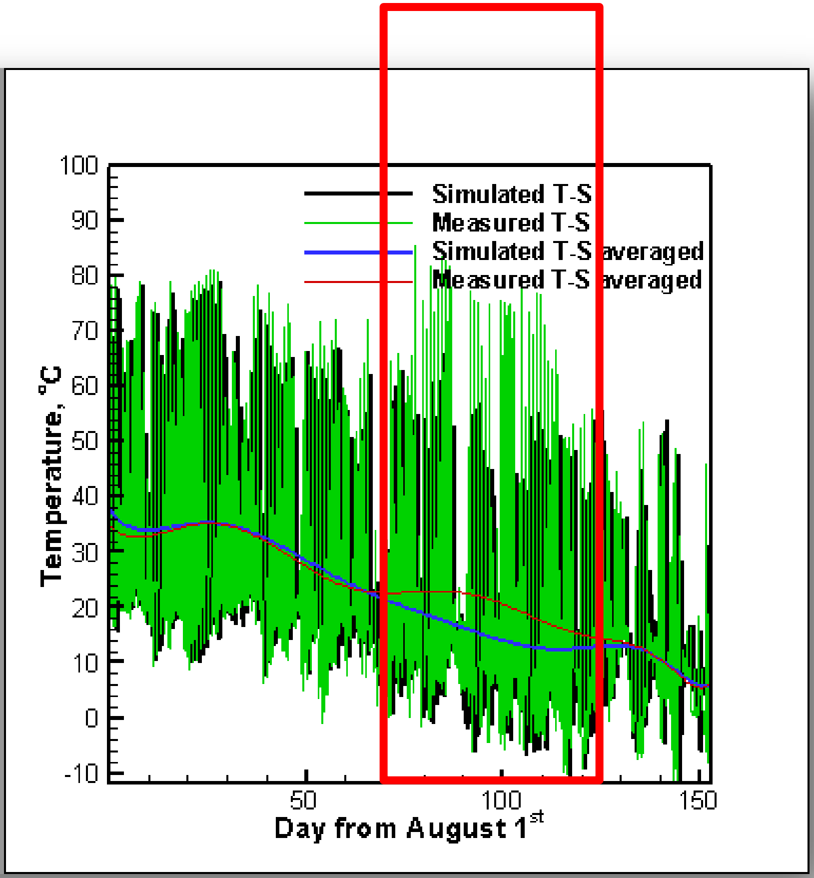
- Field Testing
  - ORNL test house with Sealed Attic
- Structure
  - Shingles
  - Underlayment
  - OSB
  - 1” Closed Cell **
  - ~5” Open Cell
  - Spray-on fiber glass insulation 2”

Measured and Simulated Temperature

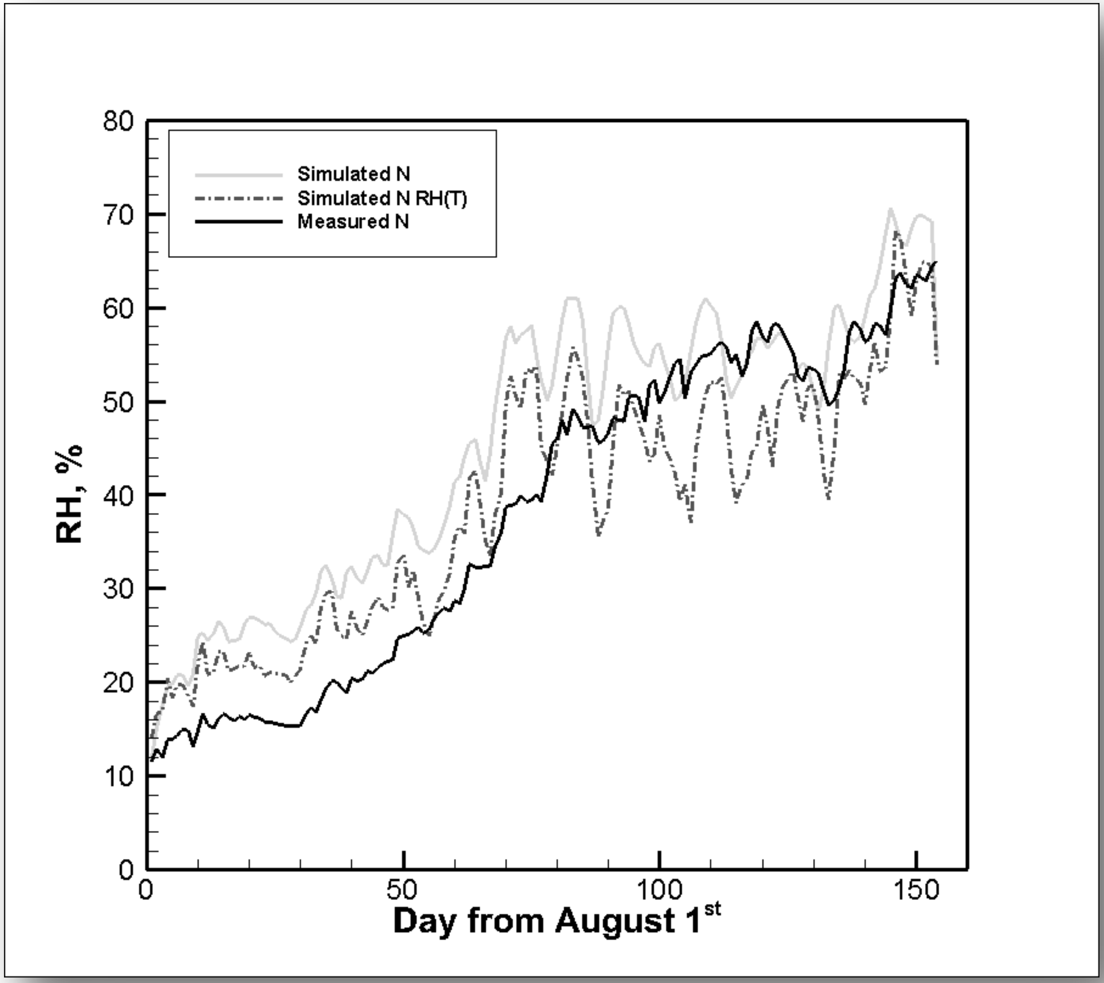


Temporary plastic on top of roof





Measured and Simulated Relative Humidity



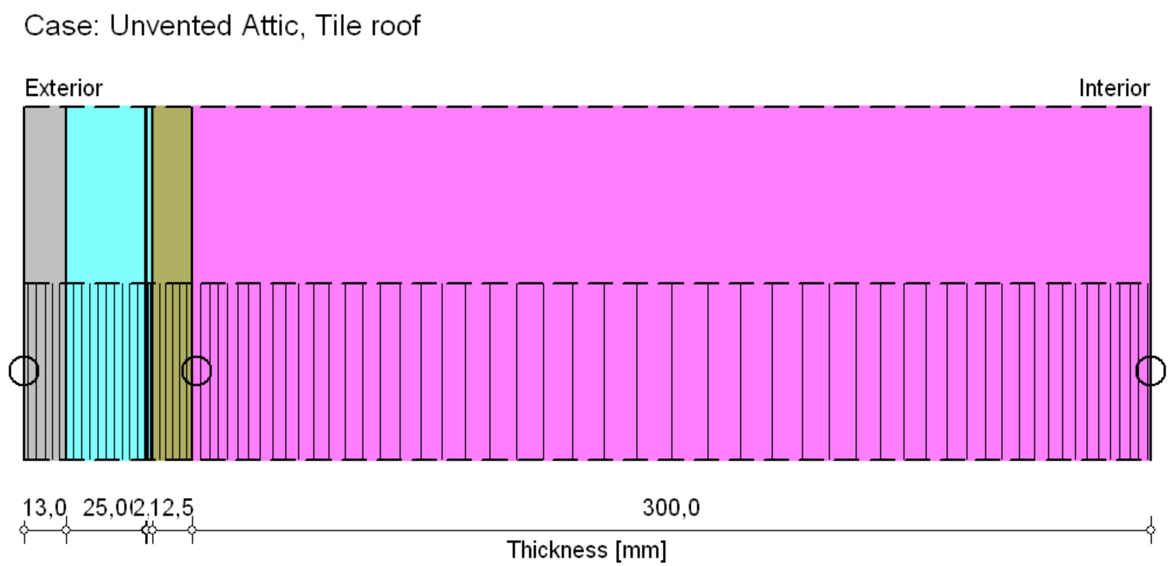
Climate zones 3B

ROOF DECK MOISTURE – MODELING OF DEMO HOUSE

Roof Assembly

Component Assembly

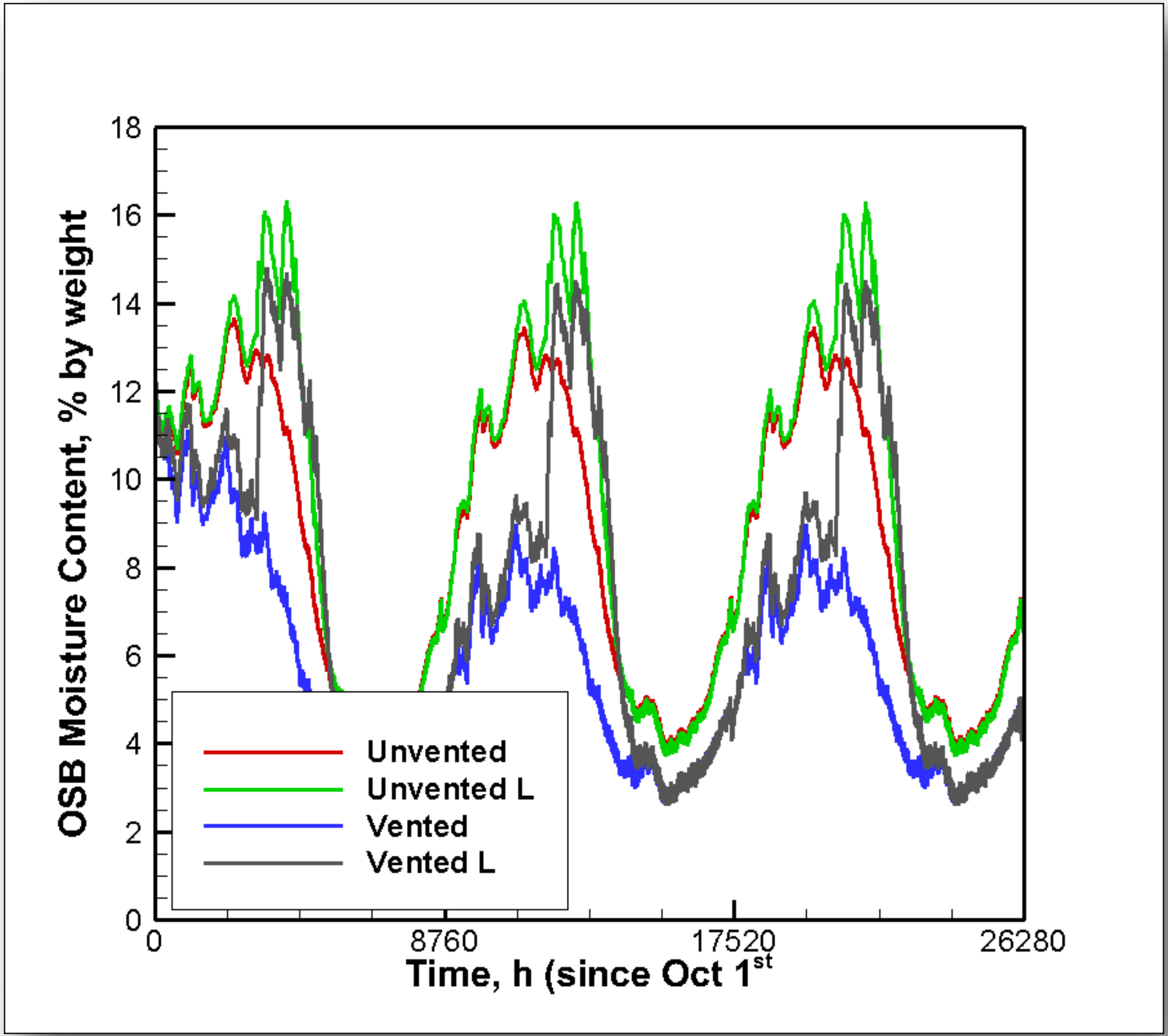
WUFI Model



- The layers in the roof listed – from exterior to interior – are:
  - Roof tile
  - 1" Air gap
  - Roofing underlayment
  - ½" Roof sheathing (OSB) and
  - Fiberglass insulation.

ASHRAE 160

OSB moisture content in Unvented and Vented attics



Climate zones 3B

San Marcos, CA

More forgiveness in Ventilated Attics

Fiberglass solution Works well for Unvented Attics

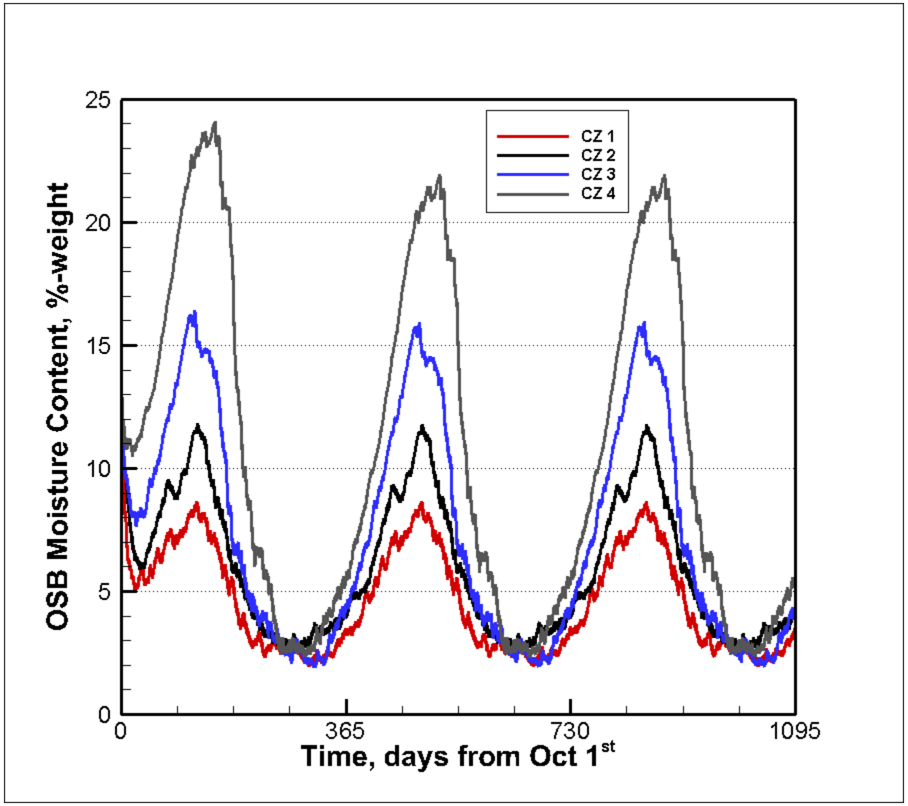
Roof Deck Performance Results

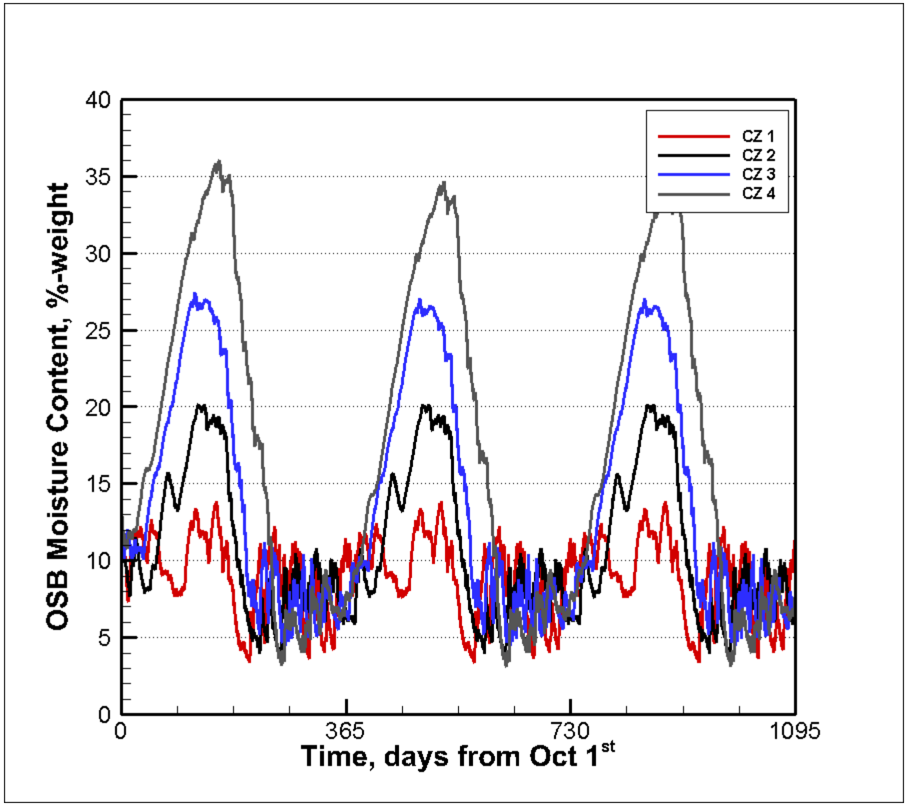
- Unvented Attic

- Climate Zone and City
- Indoor moisture loads +4 g/m^3
- Focus on Roof Deck Moisture (OSB)

1	Miami, FL
2	Houston, TX
3	Atlanta, GA
4	Baltimore, MD

Unvented Attic – Roof Deck Moisture



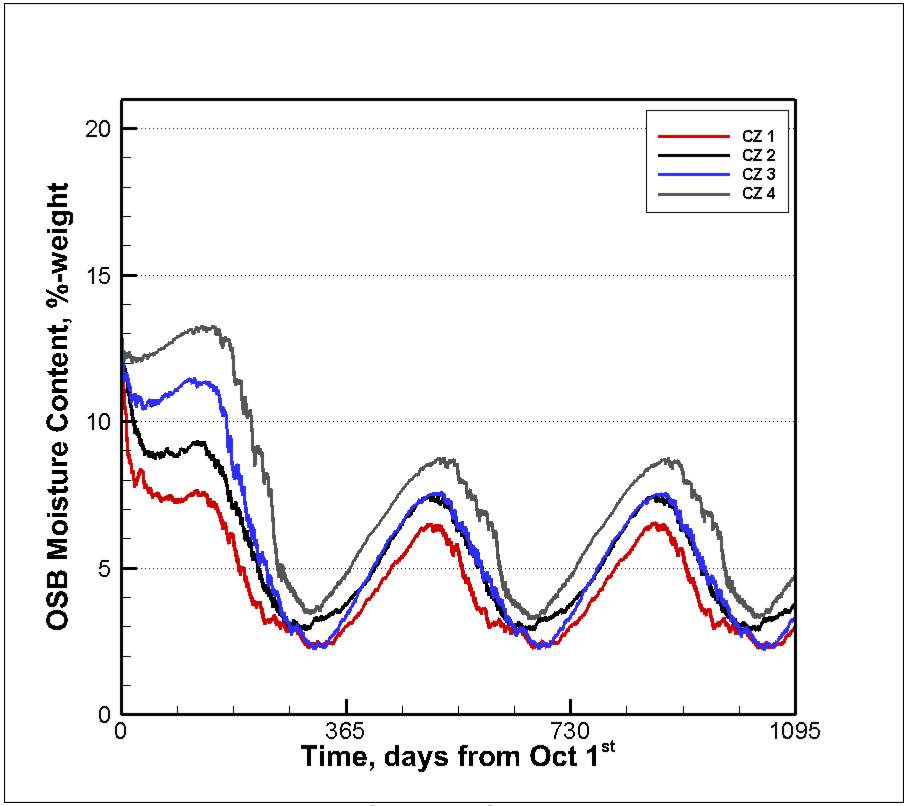


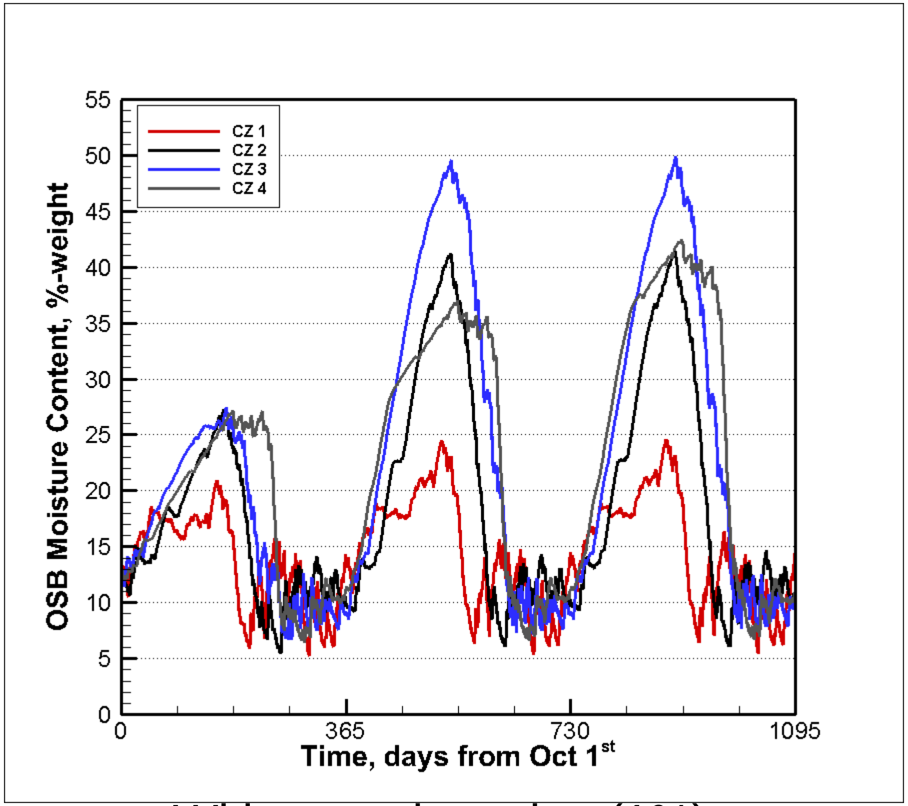
No water intrusion

With water intrusion (1%)

Open Cell A2 (54 perm-in)

Unvented Attic – Roof Deck Moisture





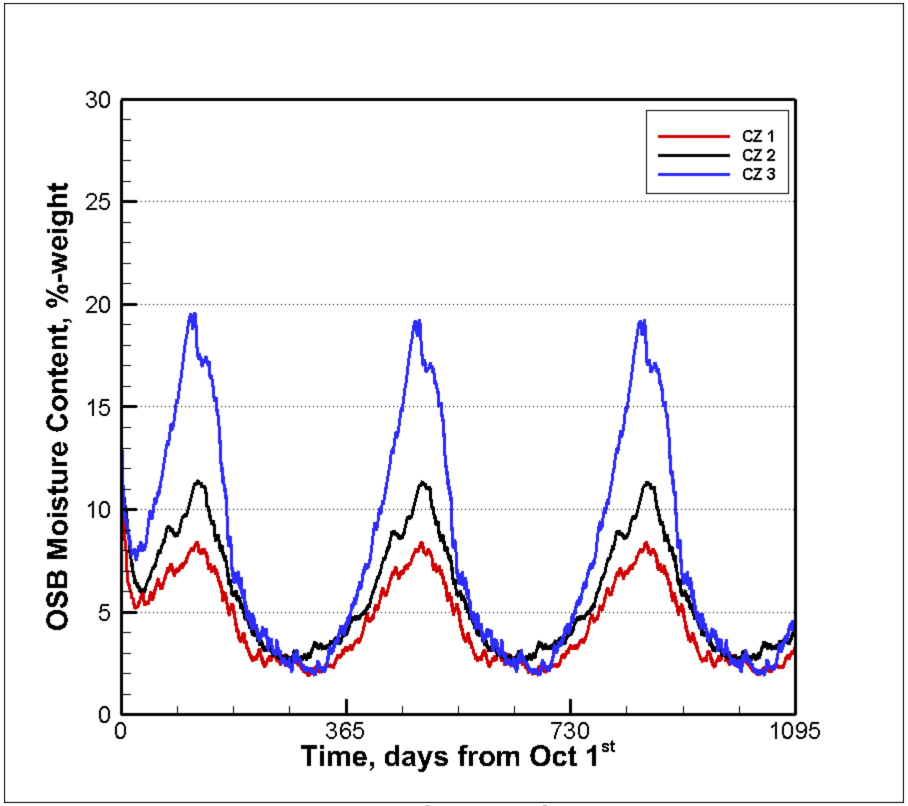
No water intrusion

With water intrusion (1%)

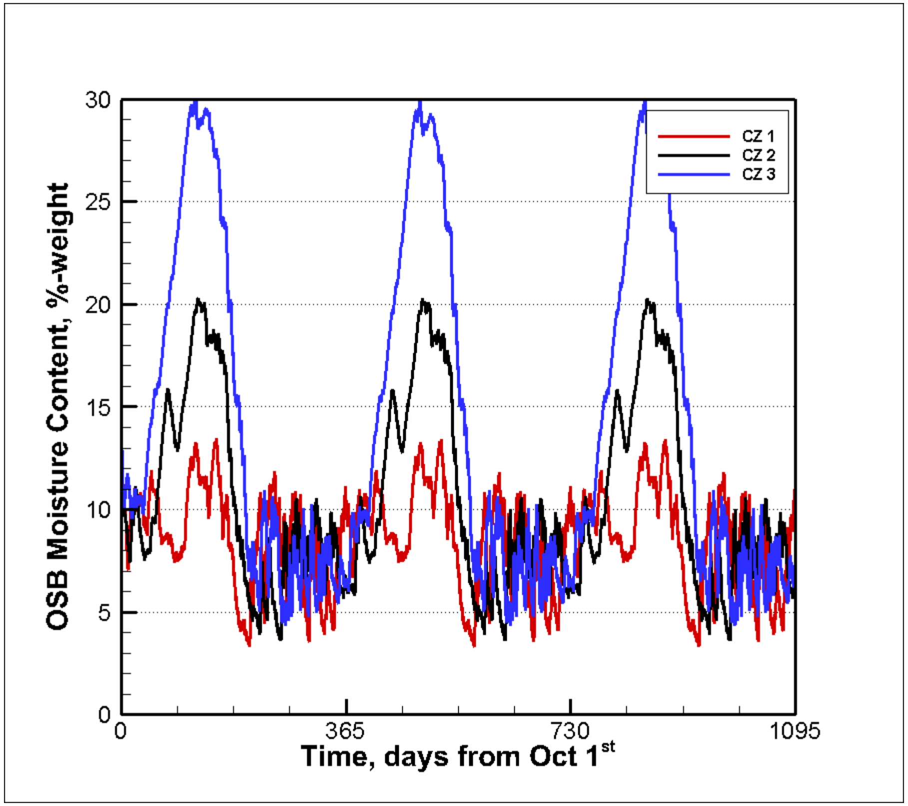
Open Cell A1 + Intumescent Coating (1-3 perms)

Note: Closed Cell foam is even more vapor tight than the above

Unvented Attic – Roof Deck Moisture



No water intrusion

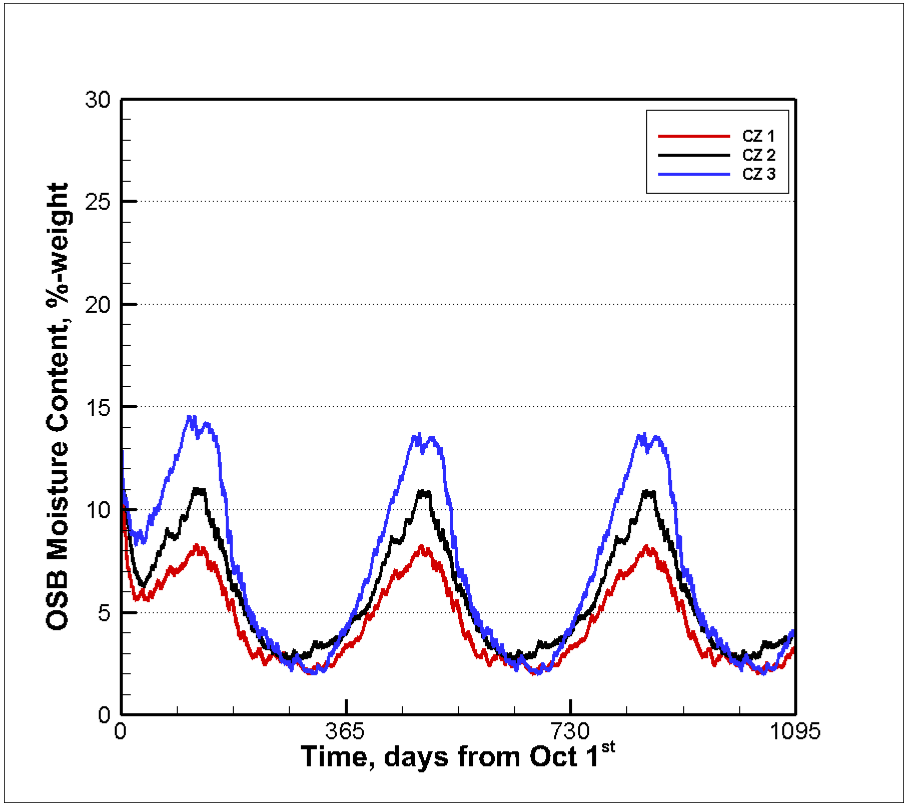


With water intrusion (1%)

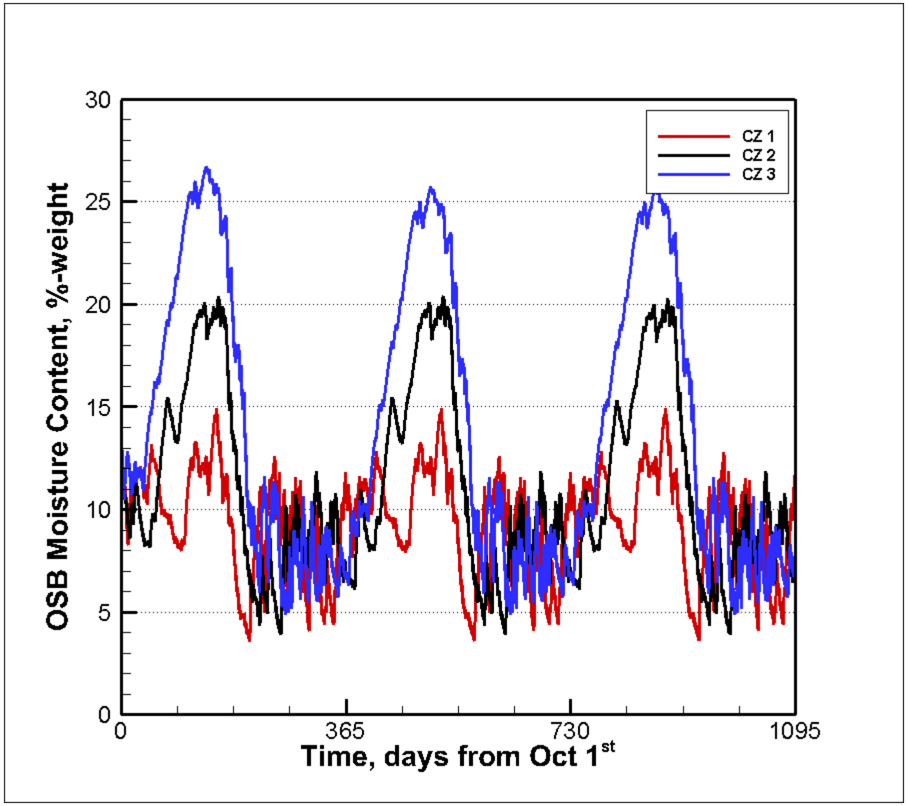
Fiberglass Insulation (100 perm-in) + Air sealing

Unvented Attic – Roof Deck Moisture

BUILDING SCIENCE INSIGHTS
Physics to the Field™



No water intrusion



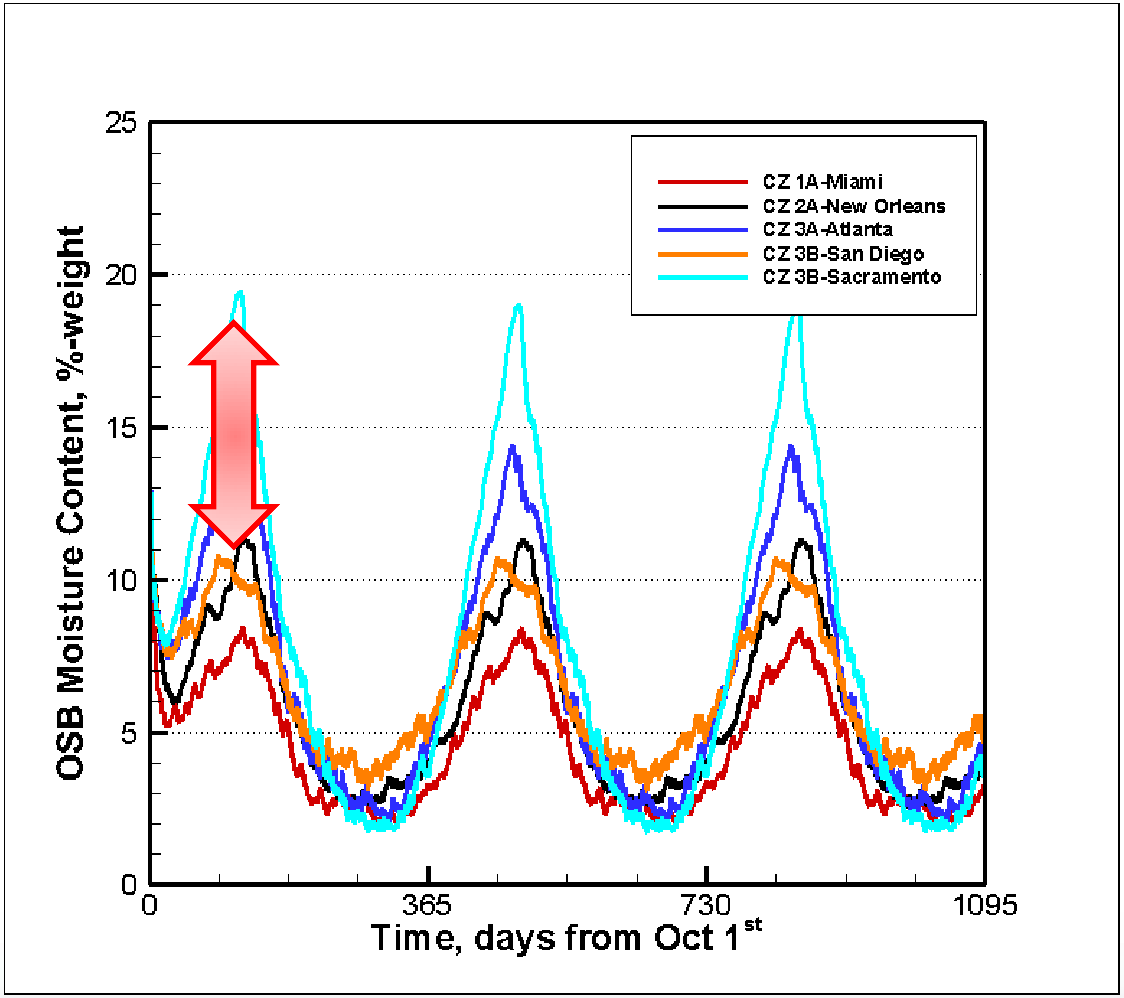
With water intrusion (1%)

Fiberglass Insulation (100 perm-in) +
Air sealing +10 perm VR

Climate Makes a Difference

BUILDING SCIENCE INSIGHTS
Physics to the Field™

- Hot to Cold, Wet to Dry climates (CZs 1-3)



Asphalt
FG

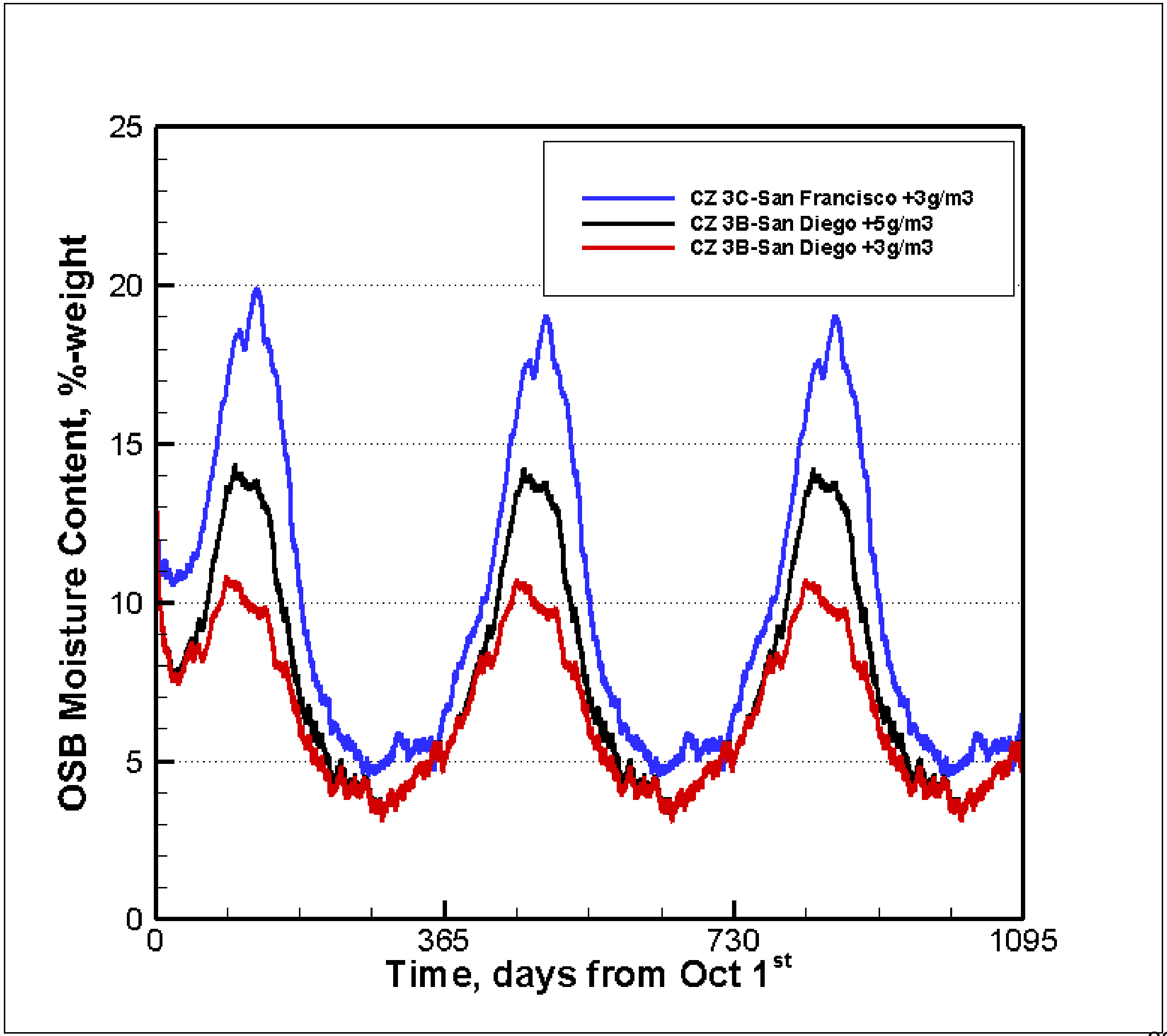
Climate vs Moisture Load

BUILDING SCIENCE INSIGHTS
Physics to the Field™

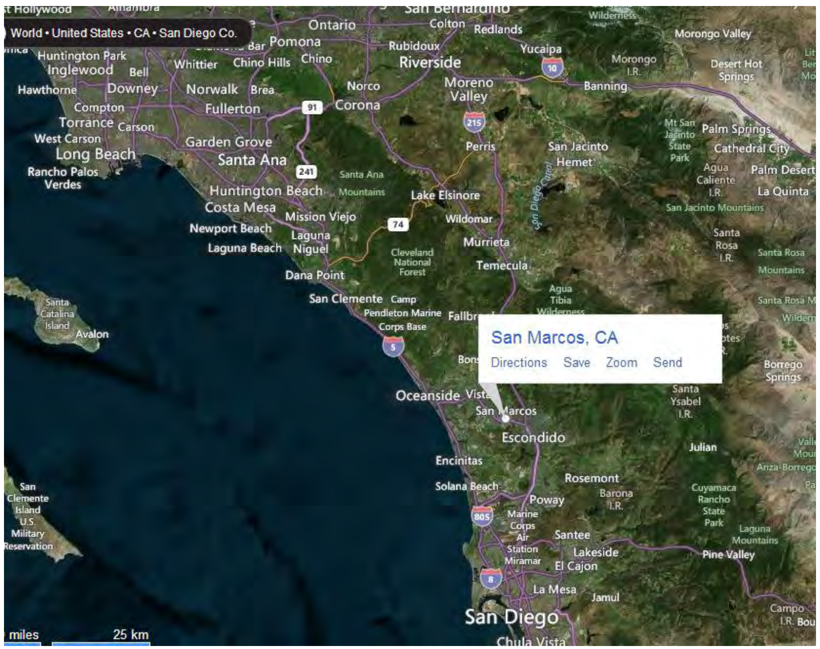
San Francisco
CZ3C, sensitive

San Diego, high moisture
load causes no problems

Asphalt shingles



FIELD HOME – SAN MARCOS CALIFORNIA

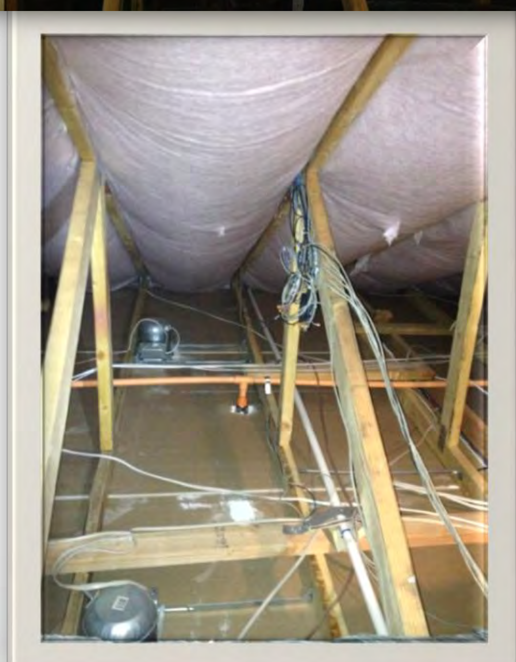


KB Homes

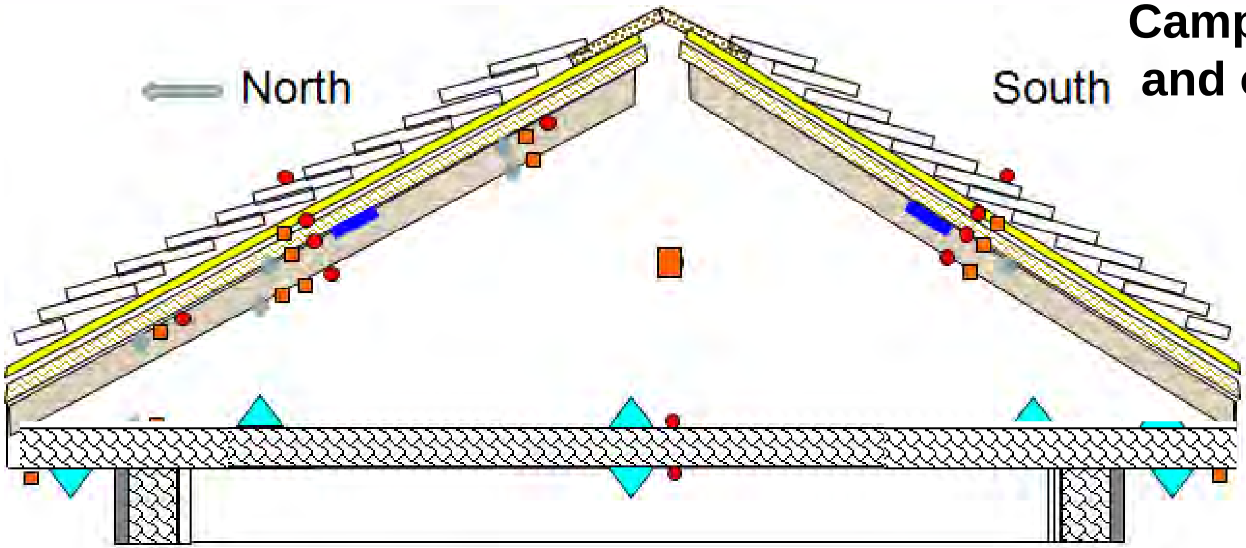
24-hr Average Temperature

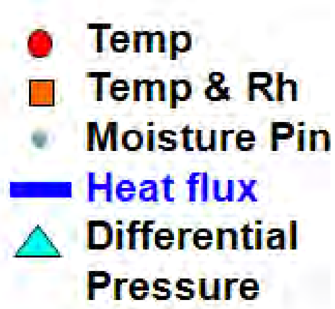
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
°C	11.1	12.1	12.8	14.0	15.2	16.8	18.5	19.3	18.7	16.8	13.6	11.2	15.0
°F	52.0	53.8	55.0	57.2	59.4	62.2	65.3	66.7	65.7	62.2	56.5	52.2	59.0

Sealed Attic



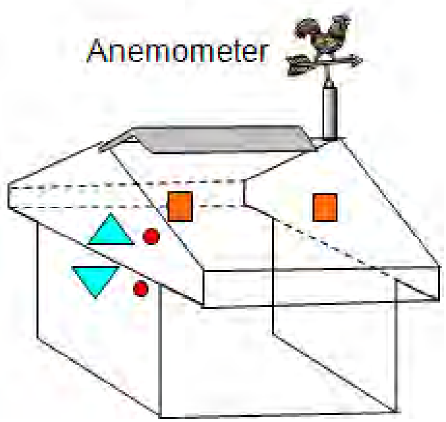
Instrumentation Plan





Campbell Scientific Model CR23X and or CR10X micro-loggers

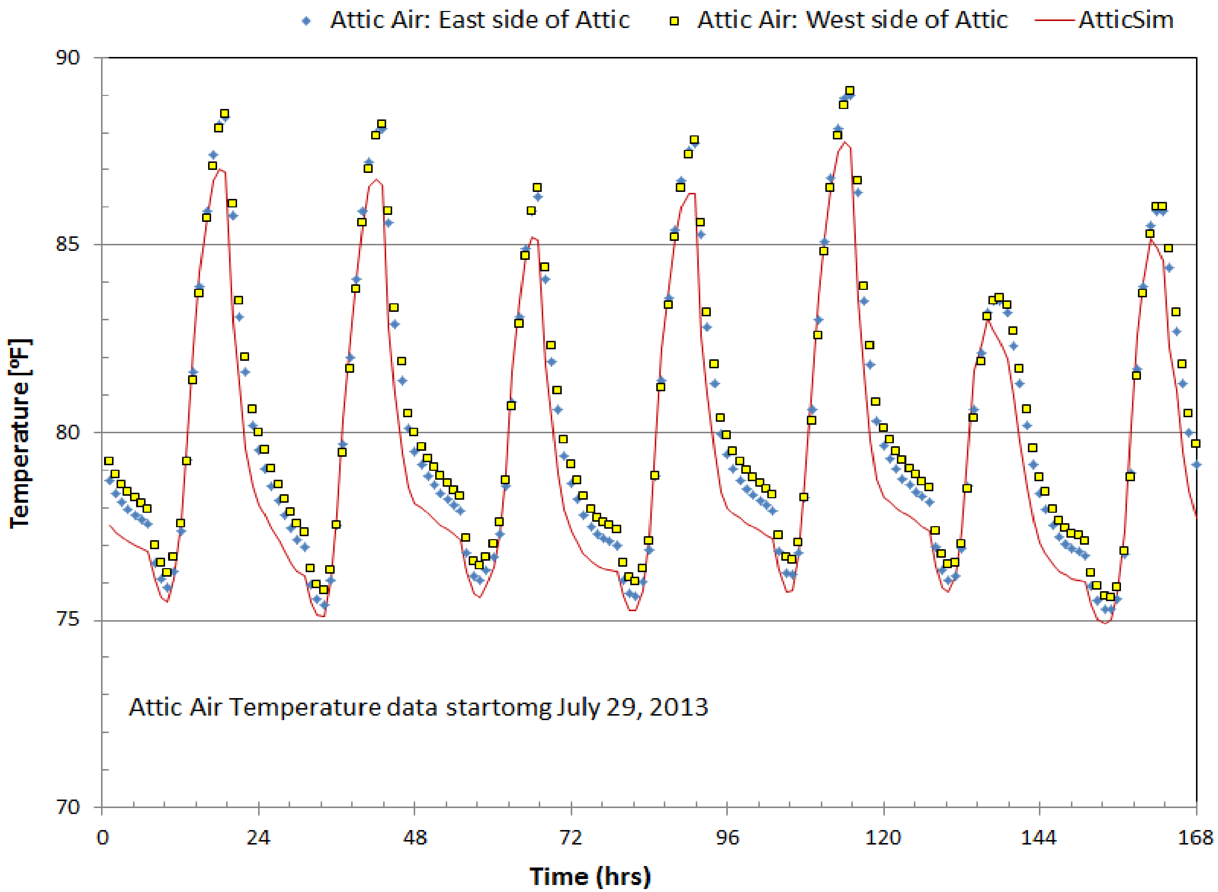
- Roof surface temperatures
- Roof sheathing temperatures, humidity and moisture content
- Attic air temperatures north and south side of attic
- I ndoor air temperature at thermostat
- Weather conditions
- Whole-house energy use
- HVAC run time.



Building Electrical Monitoring Points		
Wattnode transducer	Model WNA-1P-240-P	Whole House Power
ACL1 Event counter	OPTI-Line Monitor with DC power supplied by data logger	HVAC On Time

Computer Simulations

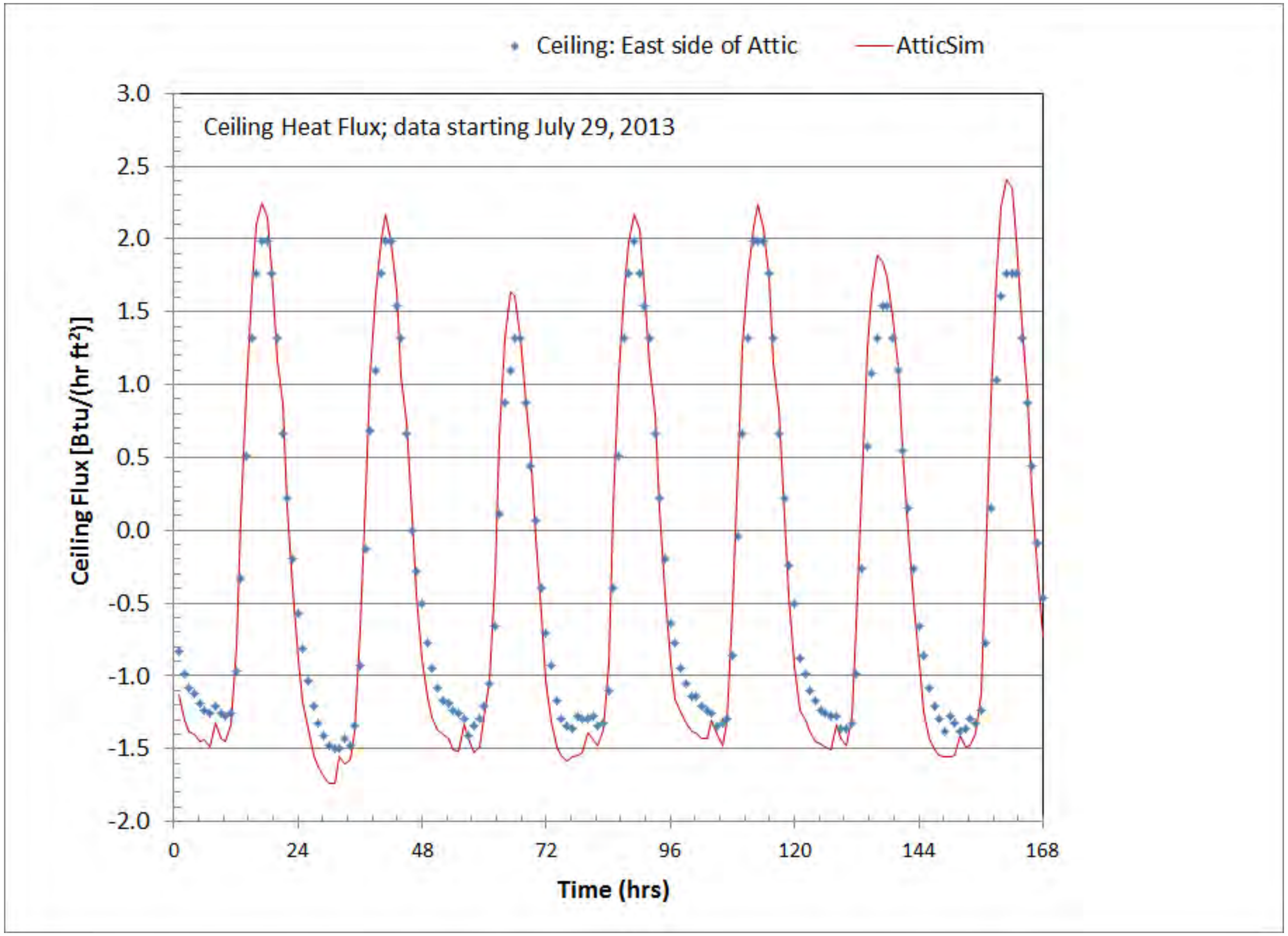
- Validation of AtticSim: Measured vs Simulated Attic T



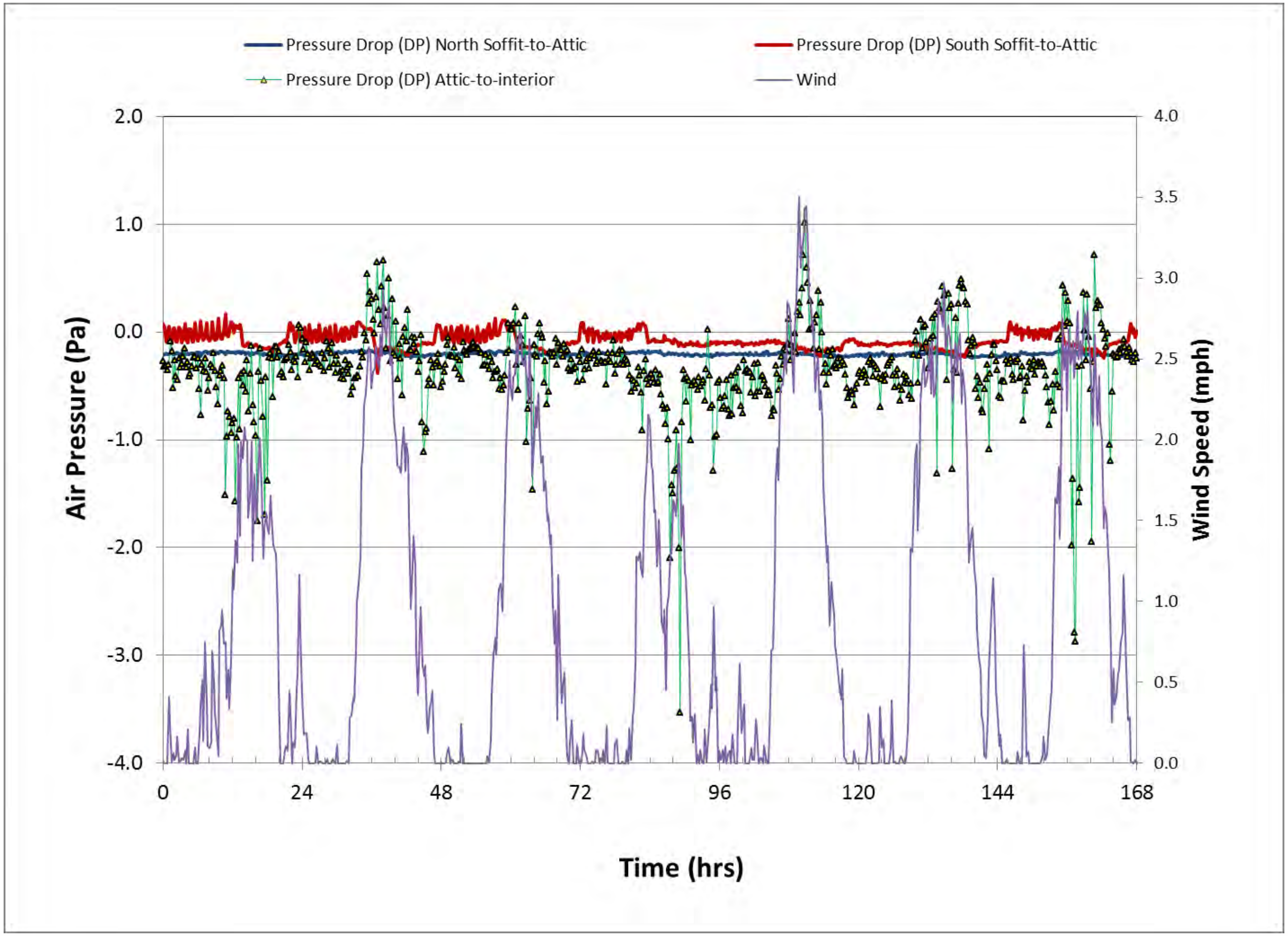
AtticSim (version 12.6)

Energy Performance

- Ceiling heat flux



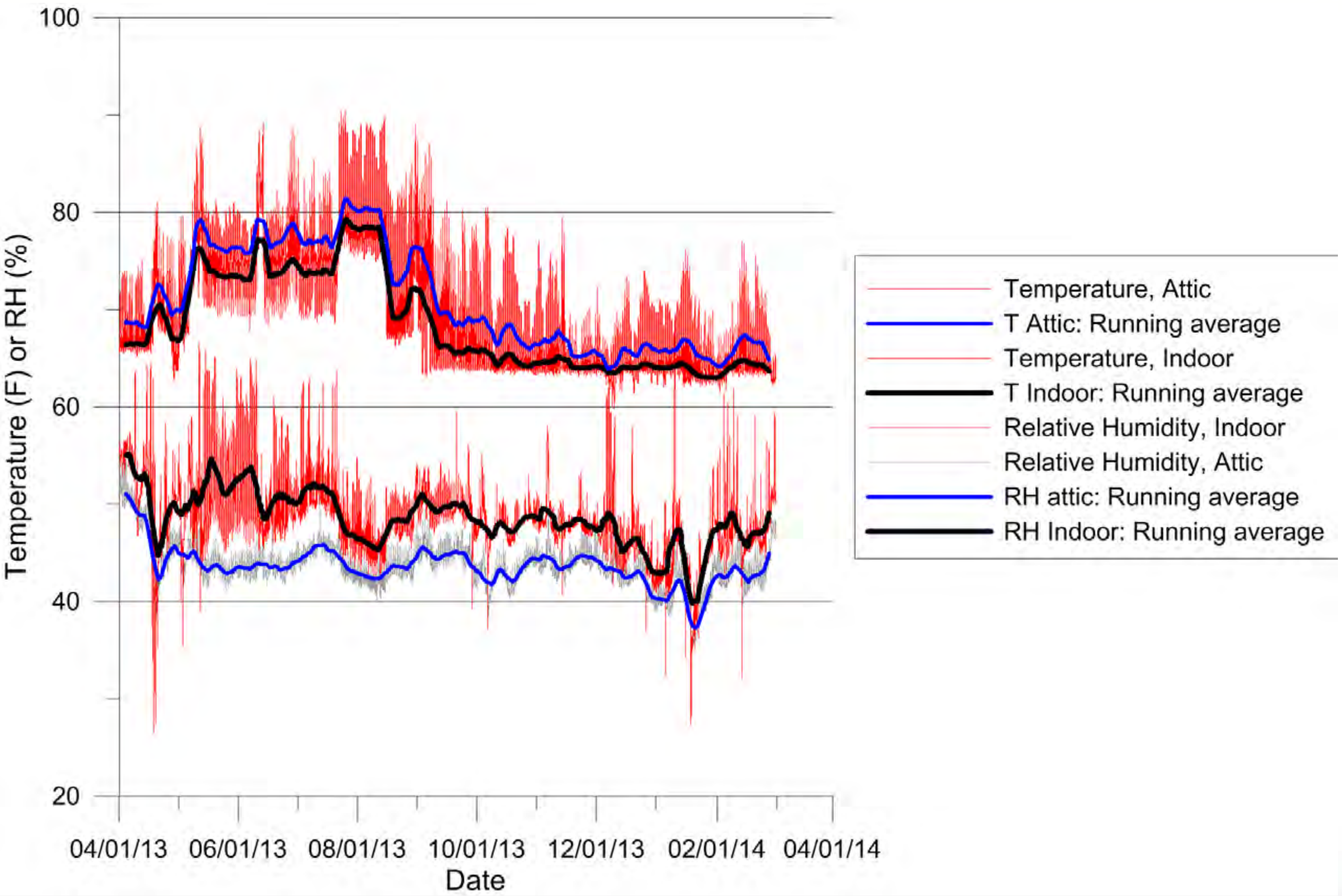
Air Pressure across attic floor varies ±1 Pa



Data collected August 26, 2013

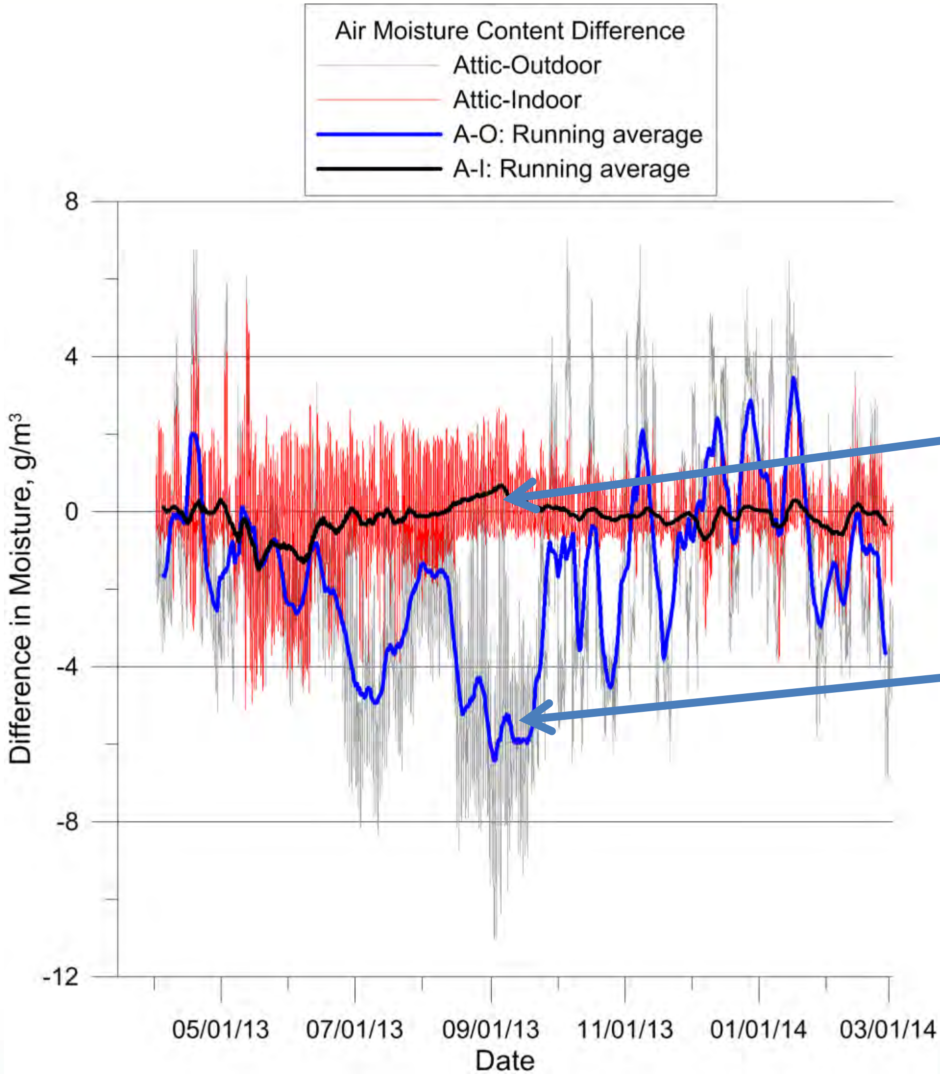
Wind affects attic-to-indoor pressure gradient
Minimal air leakage at soffits

Attic and Indoor T and RH



Moisture Loads

Indoor=Air Return

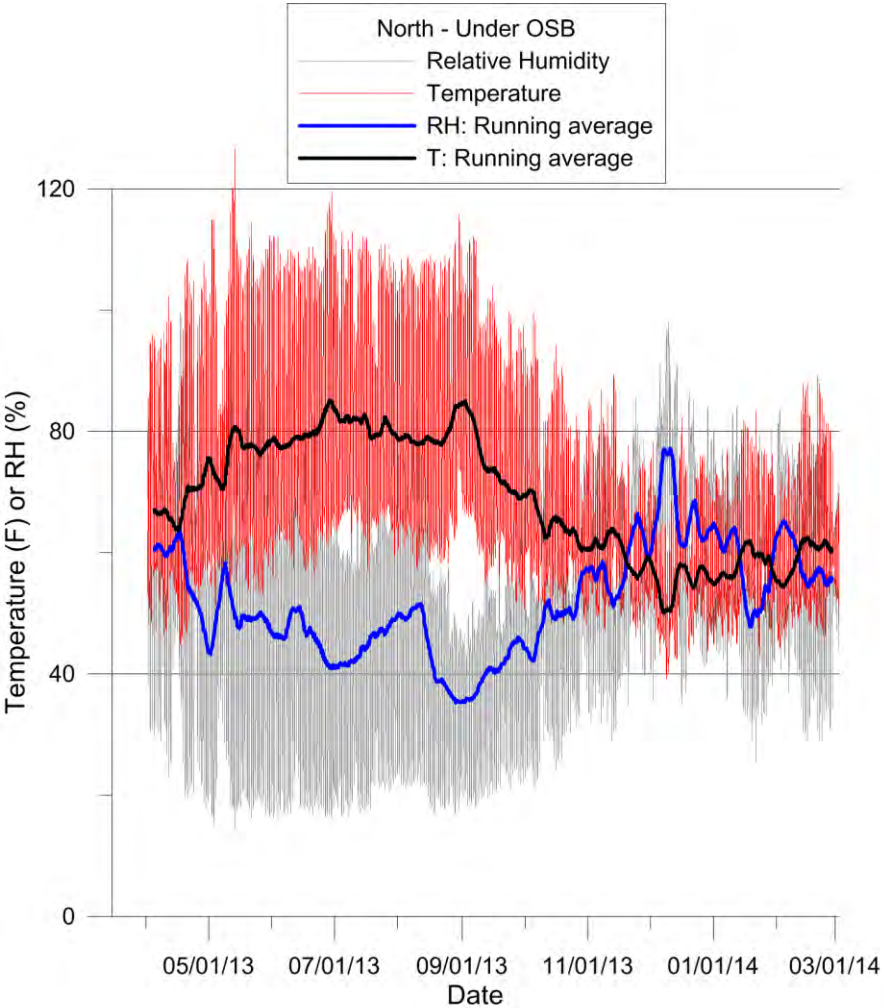


Attic air has about the same moisture content as indoor air

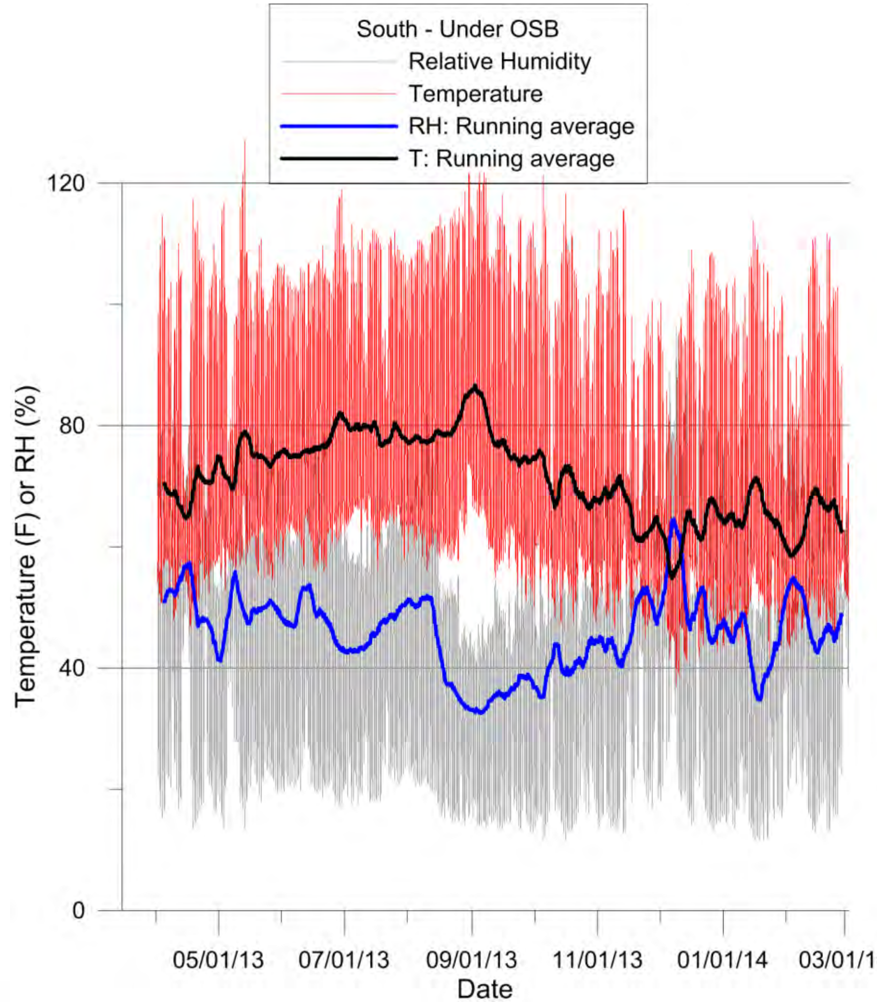
Attic/Indoor is drier than outdoors most of the year

T/RH Under Roof Deck

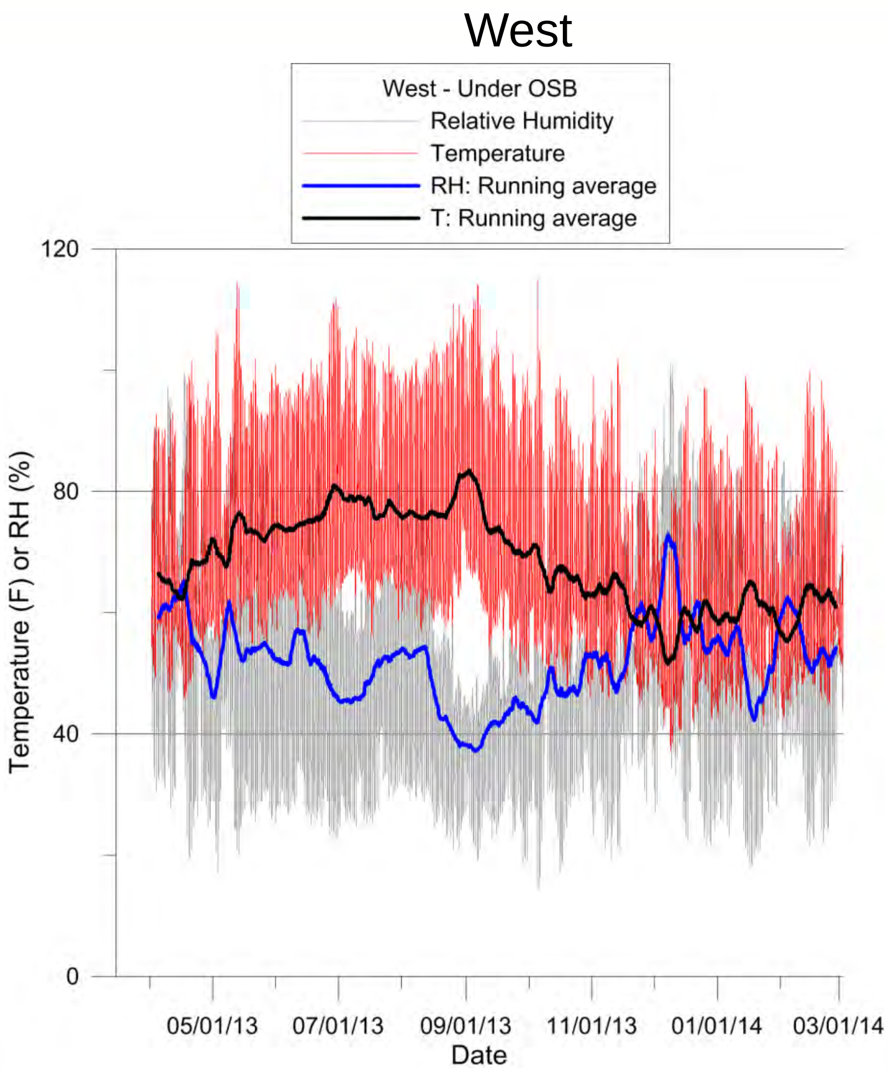
North

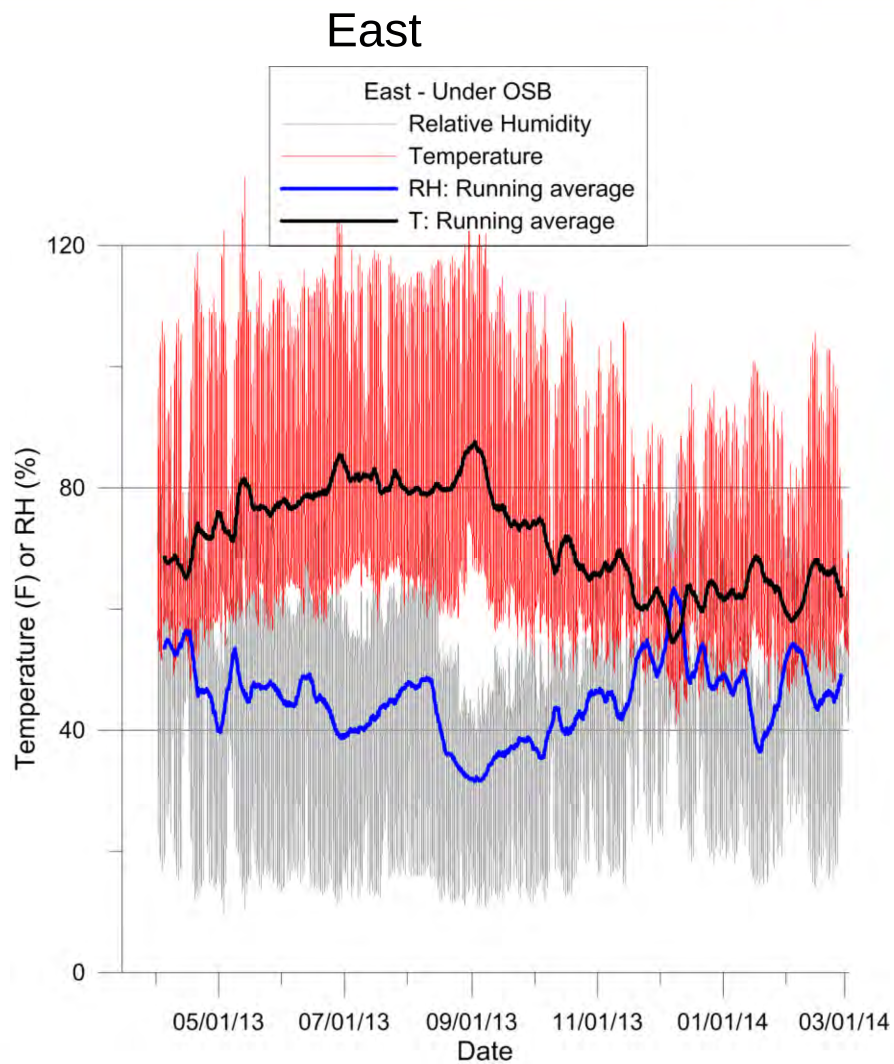


South

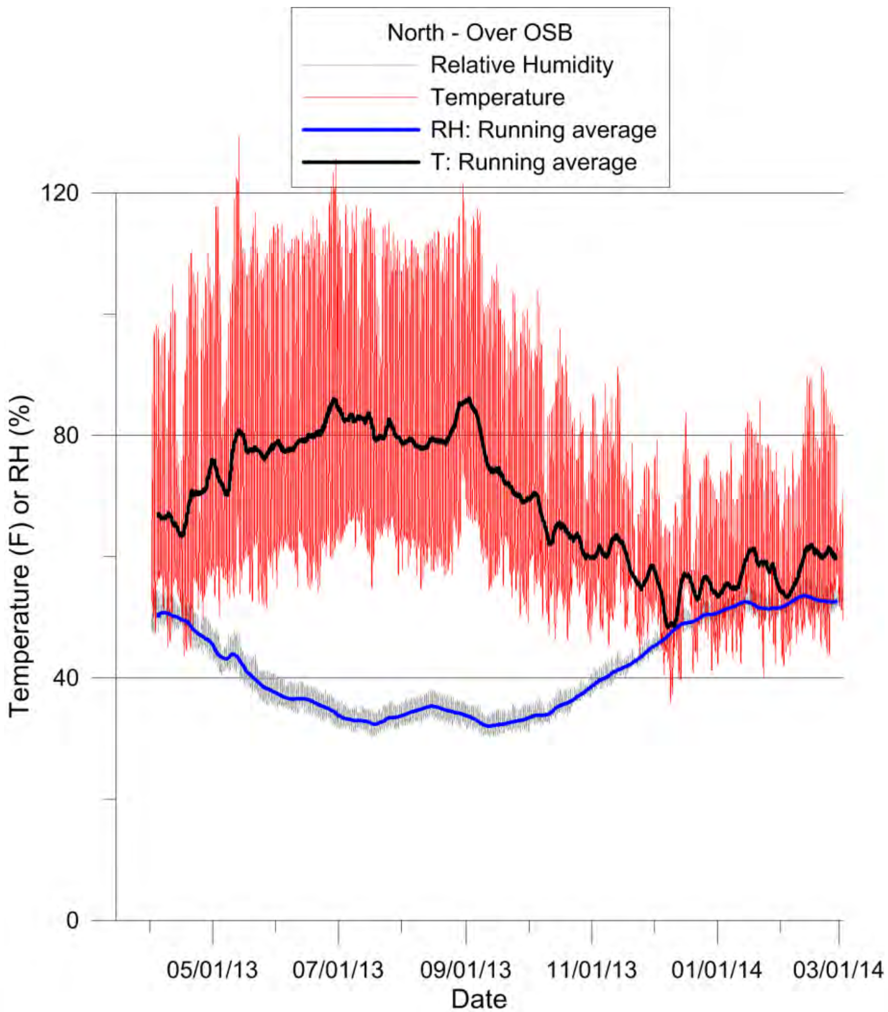


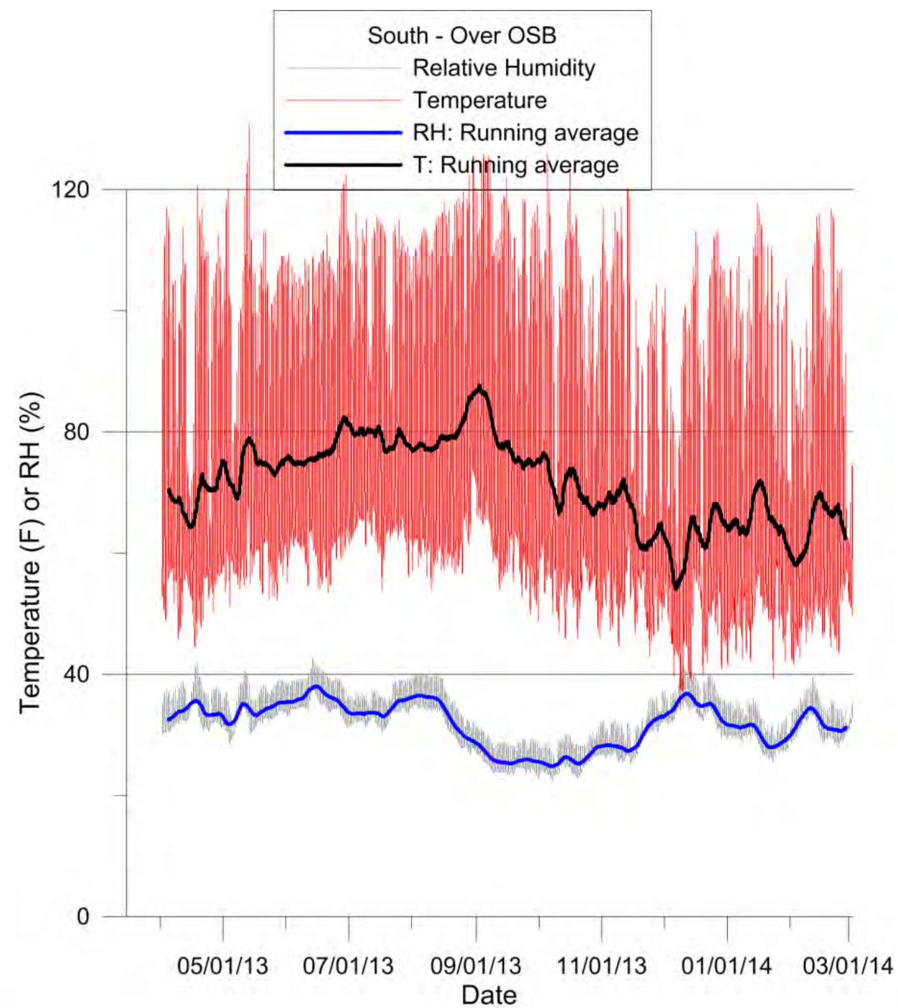
T/RH Under Roof Deck





T/RH Over Roof Deck

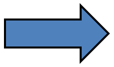


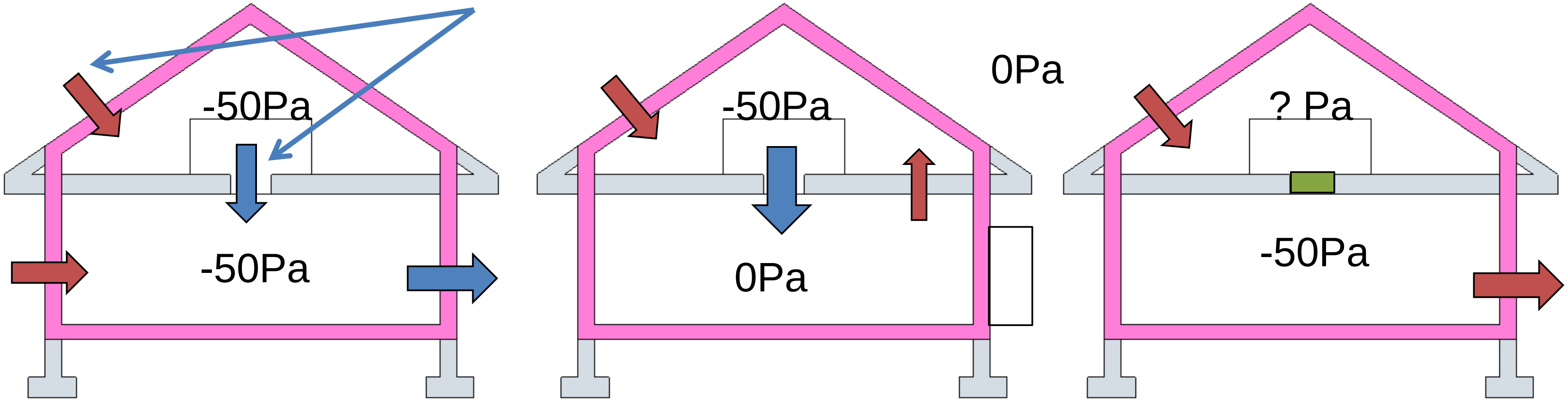


Roof Deck Air Leakage

- Air leakage between attic and outdoors must be understood
  - Is the attic 'sealed'?
- Dual blower door testing is needed to separate component leakage

Air Tightness of the Attic

- Testing to separate Attic-to-Outdoors and Attic-to-Indoors air leakage characteristics
- Methods
  - Dual Blower Door:  = Blower door flow
  - Multi-scenario tests at multiple pressure levels



Attic-to-Outdoors Air Leakage

- Fiberglass attics
  - First house (San Marcos) cfm50=515
  - Second house (Lancaster) cfm50=369
- SPF attic
  - Knoxville, TN: cfm50=336

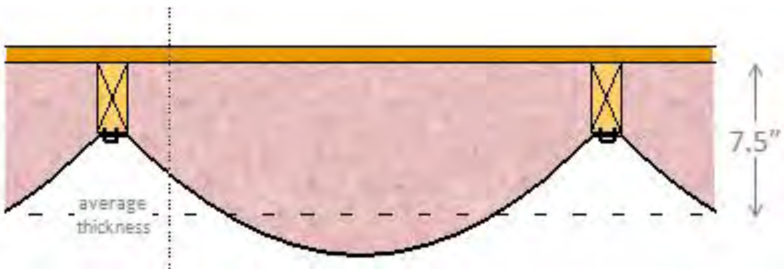
- First house was ‘test and learn’
- Second house shows fiberglass attic can be air sealed as well as a sprayfoam attic

Draped vs Boxed Netting

Thermal Performance with the same average thickness of 7.5”

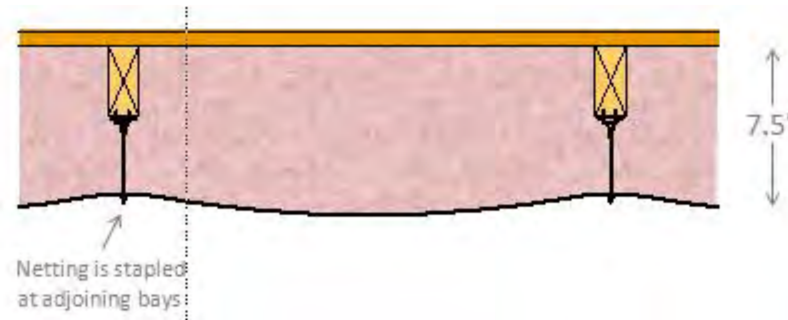
Thermal Performance

- Draped Netting



- U-value = 0.044
- Truss cords exposed to attic – thermal bridge and cold spot (condensation)

- Boxed Netting



- U-value = 0.033
  25% better
- Permits future vapor permeance tuned netting for controlling truss cord moisture

Box Netting- evolved
Wolf/Walden/Salonvaara

OWENS CORNING
INNOVATIONS FOR LIVING

BUILDING SCIENCE INSIGHTS
Physics to the Field™

Conclusions

Summary:

1. Unvented Attic design # 1 (Drapped systems) has demonstrated outstanding performance for a full year of monitoring.

2. Fiberglass is a cost effective solution with excellent performance.

3. No risk was found for the hygrothermal performance of the unvented attic

4. Fiberglass is non-flammable, non VOC and mold resistant

5. Box netting results in superior thermal & moisture performance

TAMKO
BUILDING PRODUCTS

TECHNICAL NOTICE

August 18, 2014

USE OF BELOW-DECK SPRAY FOAM INSULATION WITH ASPHALT SHINGLES*

What is spray foam insulation?

Spray foam insulation is a spray-applied material that can be used on the underside of roof decks as insulation.

Why is spray foam insulation used?

Beginning with the 2006 version of the International Residential Code (IRC) and continuing with later versions, use of spray foam insulation has been recognized as a method of insulating a roof assembly when installed in accordance with requirements of the code and the manufacturer's application instructions.

Any concerns with using below-deck spray foam insulation?

Spray foam insulation may create an unvented attic. An improperly designed and constructed unvented attic may be subject to vapor condensation and moisture accumulation in the attic space which may penetrate into the habitable areas of the building and may cause mold and mildew. It may also lead to premature deterioration of insulation, wood and other roofing and construction materials.

Will use of below-deck spray foam insulation affect my asphalt shingles?

Spray foam insulation applied to the underside of the roof deck will prevent free flow of air on the bottom side of the deck and the associated dissipation of heat that occurs with traditional vented attic construction. Lack of adequate ventilation immediately below the roof deck may lead to unacceptable deck movement and premature roofing system failure. Ensuring proper design and construction of unventilated spaces and appropriate management of moisture are essential and are the responsibility of the building owner, design professional, and contractor.

What is TAMKO's recommendation for ventilation?

TAMKO recommends adequate attic ventilation that meets Federal Housing Administration (FHA) minimum standards of one square foot of net free ventilation area to each 150 square feet of space to be vented and provides for unobstructed air flow from soffit to ridge. This may be reduced to one square foot of ventilation area per 300 square feet if 2012 International Residential Code (IRC) requirements associated with this reduction are followed.

Are there spray foam applications that maintain ventilation?

There are options to maintain free-flow ventilation on the underside of the roof deck from soffit to ridge when installing spray foam insulation. Installation of baffles between rafters before application of spray foam is one example. In these situations, follow TAMKO recommendations for minimum ventilation and ensure each cavity is ventilated.

But what about completely unventilated installations with spray foam insulation?
TAMKO acknowledges the growing desire for unvented attic constructions and recommends all code requirements and manufacturer's instructions be followed. Use of an experienced design professional is highly recommended.

What effect will use of below-deck spray foam insulation have on my limited warranty?
In situations in which spray foam is applied to the underside of the roof deck, the TAMKO Fiberglass Shingles Limited Warranty against manufacturing defects which have directly caused leaks remains in full force and effect. However, in the event of a future claim under the Limited Warranty, coverage may be affected if the claim or damage to the roofing system is attributable to use of spray foam insulation. See the Limited Warranty for complete details.*

This document is not intended nor should it be construed to modify or alter the terms of TAMKO's Fiberglass Shingles Limited Warranty.

Additional information about TAMKO products is available at tamko.com.

* To obtain the current version of this Technical Notice and the most recent Limited Warranty, visit TAMKO's website at tamko.com.

One Information Way, Suite 225
Little Rock, AR 72202
501-945-4506 ■ 800-365-4506 ■ Fax: 501-945-7718
www.tarcoroofing.com

TECHNICAL BULLETIN
LB-10-12A

Installation of Self-Adhesive Membranes over Substrates Sprayed with Insulation Adhesives

This bulletin states Tarco's position regarding installation of LeakBarrier® self-adhesive roofing membranes applied directly to substrates which have sprayed insulation adhesives applied to the underside. This technical bulletin is effective **December 08, 2010**.

Tarco is aware of the installation of self-adhesive membranes direct to substrates that have Polyisocyanurate foam insulation adhesive *spray-applied* to the underside. We understand that this is done to achieve energy efficiencies. However, such application has the potential to totally encapsulate the underside of the substrate, thereby limiting the amount of ventilation throughout the attic space.

Proper ventilation is vital for the long-term performance of the roofing system. Therefore, it is the responsibility of the applicator to ensure the roofing system is designed to meet the necessary ventilation requirements.

Tarco recommends the use of a suitable mechanically attached base sheet in lieu of the direct application of self-adhesive membranes to substrates that have insulation adhesive sprayed to the underside.

Tarco will not be liable for any issues and/or failures arising from the use of such insulating systems. Acceptable substrates for adhesion of LeakBarrier membranes can be found at the Tarco website at www.tarcoroofing.com

If you have any questions or require additional information, please contact your local Tarco Sales Representative or email Tarco Technical Services at technicalservice@tarcoroofing.com