Insulating the underside of roofs - making the case for the Unvented Attic Assembly

This article was originally written for Construction Specifier magazine. Written by John Broniek, Senior Engineer Manager, Icynene.

The quest for greater energy efficiency in buildings has led to increasing interest and need for insulation, improvements in HVAC equipment, more airtight construction, new materials and assemblies. Together with the rising cost of construction, there is increasing pressure to fully utilize all cavity spaces including attics such that valuable floor space in the building does not have to be sacrificed. To this end, an unvented attic construction approach permits designers to locate equipment in the attic, knowing its performance will not be compromised. Furthermore, significant energy savings and building durability benefits are possible and energy efficiency targets can be more easily realized. For some designers this construction approach and how spray foam insulation can be used in it is unfamiliar.

Background

An unvented attic differs from a conventional vented attic in that there is no direct venting of the attic space which is generally considered to be between the roof rafters/framing and the top story ceiling framing members (attic floor). The unvented attic is indirectly conditioned space since heat and moisture transfer occurs through the top floor ceiling, particularly if the ceiling is not airtight. There

are typically no supply or return registers from the HVAC system specifically located in an unvented attic space.

Unvented attic construction is most common in housing and type V construction located in the warm climate zones of 1 through 4, but is suitable for any climate zone. If the space conditioning system is located in the attic, such as it is in warm locations, the energy savings that can be realized are very apparent. Ten percent or more HVAC energy savings, when compared to vented attic construction, are widely accepted by the building science community for the unvented attic construction approach if airtight equipment and ducts are located in the attic. When HVAC equipment and ducts with significant air leakage inhabit the attic, much greater energy savings are possible as that leakage is now contained.

Most unvented attics incorporate Spray Polyurethane Foam (SPF) on the underside of the roof deck and attic walls. This construction approach was first used in the 1970s, and it has been implemented much more widely since it was first included in the International Code Council's (ICC) model building code in 2007 (IRC Section 806.4). Using spray foam facilitates the easy and efficient creation of a layer of insulation and a continuous air barrier at all interior surfaces of the attic that are adjacent to the outdoors.

Advantages of Unvented Attic Assemblies

Unvented attic assemblies offer numerous performance advantages versus vented attic assemblies:

1. When HVAC equipment is in the attic, insulation and an air barrier at the roof line brings that equipment within the conditioned enclosure/envelope, thereby allowing it to operate in more favorable temperature and humidity conditions without air leakage and heat loss/gain directly to the exterior.
2. They often simplify insulation and air sealing details versus conventional insulation on the floor of the attic that may be compromised by numerous penetrations from recessed lighting, fans, equipment and ductwork. Building air tightness would now preside at the top of the building enclosure at the roof deck and attic walls (gables).
3. Ductwork is also brought back into the conditioned envelope and duct leakage no longer occurs directly to the exterior which is a more energy efficient situation than the air leakage escaping to the outside. With traditional vented attic designs, HVAC equipment and ductwork systems are exposed to high outdoor humidity levels and elevated daytime temperatures which can approach 130˚F (in the attic) in hot climate locations. This reduces the efficiency of the HVAC system.
4. Unvented attic designs offer protection from the ingress of burning embers (in areas where wildfires are a risk), rain, and blowing snow thereby increasing building durability. A structural benefit of wind

uplift resistance from reduced depressurization has been shown to be evident in high-wind circumstances.

5. They potentially offer construction cost savings because attic venting and attic floor airtightness measures can be eliminated. Sizing of HVAC equipment is often reduced in unvented attic buildings since the overall heating and cooling load is reduced as the entire building becomes more airtight while maintaining a control on heat loss and gain.
6. Service water connections, condensate lines, pumps and other equipment are no longer in danger of freezing.

The positive experiences of using an unvented attic in residences led to the 2015 IBC inclusion of unvented attics in section 1203.3 and requirements nearly identical to those in the IRC, now in section 806.5. The various requirements of the 2015 versions of IRC Section 806.5 and IBC section 1203.3 include the following:

- The unvented attic space must be completely contained within the building thermal envelope. This addresses conditions where a lack of containment of the attic space would result in the attic being open to the exterior such as at points of intersection with an attached garage or an occupied space.
- An air impermeable insulation material is installed in direct contact with the underside of exterior sheathing. This helps ensure air leakage is minimal, so air borne moisture resulting in condensation is minimized.
- In climate Zones 5, 6, 7 and 8, when an air impermeable insulation material is used it needs to be a class II vapor retarder or have such a coating on it (the IRC calls for a class II vapor retarder coating or covering, IBC calls for a class III). This avoids diffusion of moisture into the assembly in heating-predominant climates where the potential for condensation occurrences are greater.
- Wood shingles and shakes are provided a 6 mm (1/4”) venting space and underlayment separating the shingles and shakes from the sheathing. This allows moisture sensitive shingles to dry efficiently.

Design Considerations

Whether the building of the unvented attic takes place in a warm or cold climate zone location, there are some design considerations that are consistent throughout, while other considerations require a greater understanding of the materials that could be used based on the climatic environment.

Figure 1: Instead of insulating and making airtight walls adjacent to a vented attic space an unvented attic application using spray foam eliminates this need in this difficult to access assembly. *Image Courtesy of D7 Spray Foam Insulation, Houston TX*

Using Spray Foam Insulation in an Unvented Attic Application

Both low density, open cell and medium density, closed cell spray foam can be used in an unvented attic to provide the needed thermal resistance and airtightness. The Evaluation Service Report (ESR) for spray foam insulation products provides a valuable resource, based on a third party review, of testing information useful for utilizing these products successfully and according to code requirements. For example, this document contains details on a spray foam product's code compliance approvals, density, R-values at different thicknesses, airtightness characteristics, surface burning characteristics, 15 minute thermal barrier approvals and applicability in fire-rated assemblies.

To allow more design flexibility, energy codes allow performance-based compliance or the Performance Approach. This approach requires the use of approved software and results in the comparison of the total annual energy consumption of the proposed design to that of the standard reference design, which is modeled according to the prescriptive R-value requirements of the energy code. By following the Performance Approach, particularly when designing houses, the R-values needed in the unvented attic when using spray foam are, in most cases, substantially lower than those prescriptively specified for the ceiling once the airtightness benefit of the spray foam is considered.

In warm climates, zones 1 through 4, low density open cell spray foam insulation is the typical choice since it is vapor permeable and will allow drying of the exterior sheathing and roof framing, if they happen to get wet, via diffusion into the interior of the building. Open cell spray foam can also be used to create an unvented attic in cold climate zones provided Code requirements for a vapor retarder are followed. Some spray foam manufactures have tested primer/coating products that result in the formulation of a class II vapor retarder directly on the surface of the open cell spray foam.

Medium density, closed cell foam is typically a Type II vapor retarder at 1 ½" and greater thickness. It can thereby provide the vapor retarder required by the codes in climate zones 5 and higher. Having an R-value in the neighborhood of R-7 per inch, and the ability for some products to be applied 5 inches at once, high R-value applications are easily achieved. Closed cell foam can

also add to the structural strength of the roof system which can make it a more appealing choice in locations that frequently endure high winds.

Intumescent coatings are not always needed to coat spray foam in the attic in order to meet code thermal barrier requirements. Normally, in occupied areas, all spray foam must be covered by a 15 minute thermal barrier, such as ½" thick drywall, per code requirements in IRC section 316.4 and IBC section 2603.4. In limited access areas, such as attics, requirements for less protection (i.e. an ignition barrier) can be triggered. Specific testing of the spray foam is conducted to determine the degree of protection that is needed. This testing, and the associated approval that resulted, is noted in the ESR for the particular product. In general, most closed cell foam and many open cell foam products can be installed without the need of an intumescent coating in an unvented attic, and therefore can go "bare" provided a drywall ceiling (15 minute thermal barrier) directly below the attic exists. Note that a limited access attic is generally recognized as one that is not occupied, entered only for service of utilities, and is not used for storage. Acoustic tile ceiling systems are typically not considered as meeting code 15 minute thermal barrier requirements.
In an unvented attic, penetrations through the ceiling, directly below the attic, do not need to be air sealed. This is because the top floor ceiling is no longer the air barrier for the house – the spray foam at the roof deck underside in the attic is the air barrier. Furthermore, not sealing ceiling penetrations helps the attic become indirectly conditioned. Construction cost savings from not conducting air sealing in a ceiling can be realized particularly when numerous recessed (can) lights exist within it.

An unvented attic air sealed with spray foam insulation limits outdoor air entry and as a result indoor combustion air should not be considered available for fuel-fired combustion appliances located within the attic space. The appliance should be a sealed combustion/direct-vent unit with a separate pipe run from the outside into the sealed combustion chamber. A second pipe is required to vent the exhaust gas from the sealed combustion chamber to the outside.

Some roof assemblies use very impermeable materials such as "peel and stick" membranes on the exterior. Care should be taken with these assemblies particularly in cold climate zone locations (i.e. Zones 5, 6, 7, and 8) in that the manufacturers of these materials assume that roof deck may require ventilation to assist drying. If spray foam is used, a vent space may still be needed directly under the

roof deck. This is not an issue specific to spray foam as much as it is a characteristic of peel and stick membranes.

Wood has an R-value of about one per inch of thickness. Encapsulating the rafter or top truss chord (roof framing members) with spray foam will improve the energy efficiency of the attic space. This is because the effects of thermal bridging are limited which also results in the elimination of melt lines on the roof surface in cold climates.

Some building designs don't feature an attic in the traditional sense. Instead a dead space exists between the roof system and the top floor ceiling, typically comprising of an acoustic tile system, and no roof ventilation is provided. For such constructions, the principles and benefits of unvented attic construction are similar to that occurring in a single family residence. But, spray foam insulation used at the underside of the roof deck would need to be covered by a thermal barrier and intumescent coatings are commonly used.

The movement of air into, indirect conditioning of, an unvented attic is a slow gradual process that will not be noticeable by occupants and typically will not put any strain on the HVAC system. The HVAC system will typically be a smaller capacity system if located in an unvented attic than if located in a vented attic due mainly to the more efficient environment it operates in. HVAC system size is highly dependent on climatic location and load calculations will confirm the requirements necessary in an unvented attic construction.

Lastly, with respect to determining the cost of using spray foam to create an unvented attic, the following changes to vented attic construction need to be considered in order to get the net construction cost of an unvented attic application:

- Elimination of attic floor insulation, high heel (energy) trusses, and insulation at attic access hatch/opening
- Elimination of ridge vent, wind wash baffles and vent baffles/chutes
- Optimizing size of HVAC equipment according to actual building performance with an unvented attic (typically results in smaller capacity equipment)
- Replacement of soffit venting with solid soffit material (optional as soffit can remain vented)
- Elimination of air sealing of penetrations at top floor ceiling, including around recessed lights, ductwork and registers, and attic access hatch/opening

- Lower duct insulation and elimination of duct air leakage testing requirement

In many cases when houses contain an unvented attic with spray foam, and all construction changes are considered, home builders have found moving their construction practices to this approach to come at a reasonable or negligible cost difference.

Figure 2: Looking upward through the open ceiling, if the exterior wall and roof deck assemblies both contain spray foam then a continuous insulation and airtight layer is established from the base of the walls to the peak of the roof. A very energy efficient enclosure results. Image Courtesy of D7 Spray Foam Insulation, Houston TX

Addressing Moisture and Temperature Concerns in Unvented Attics

Changing the orientation and type of insulation applied to an assembly will impact the temperature and moisture conditions experienced by various assembly elements. As a result, some in the building industry have experienced concern with this construction approach.

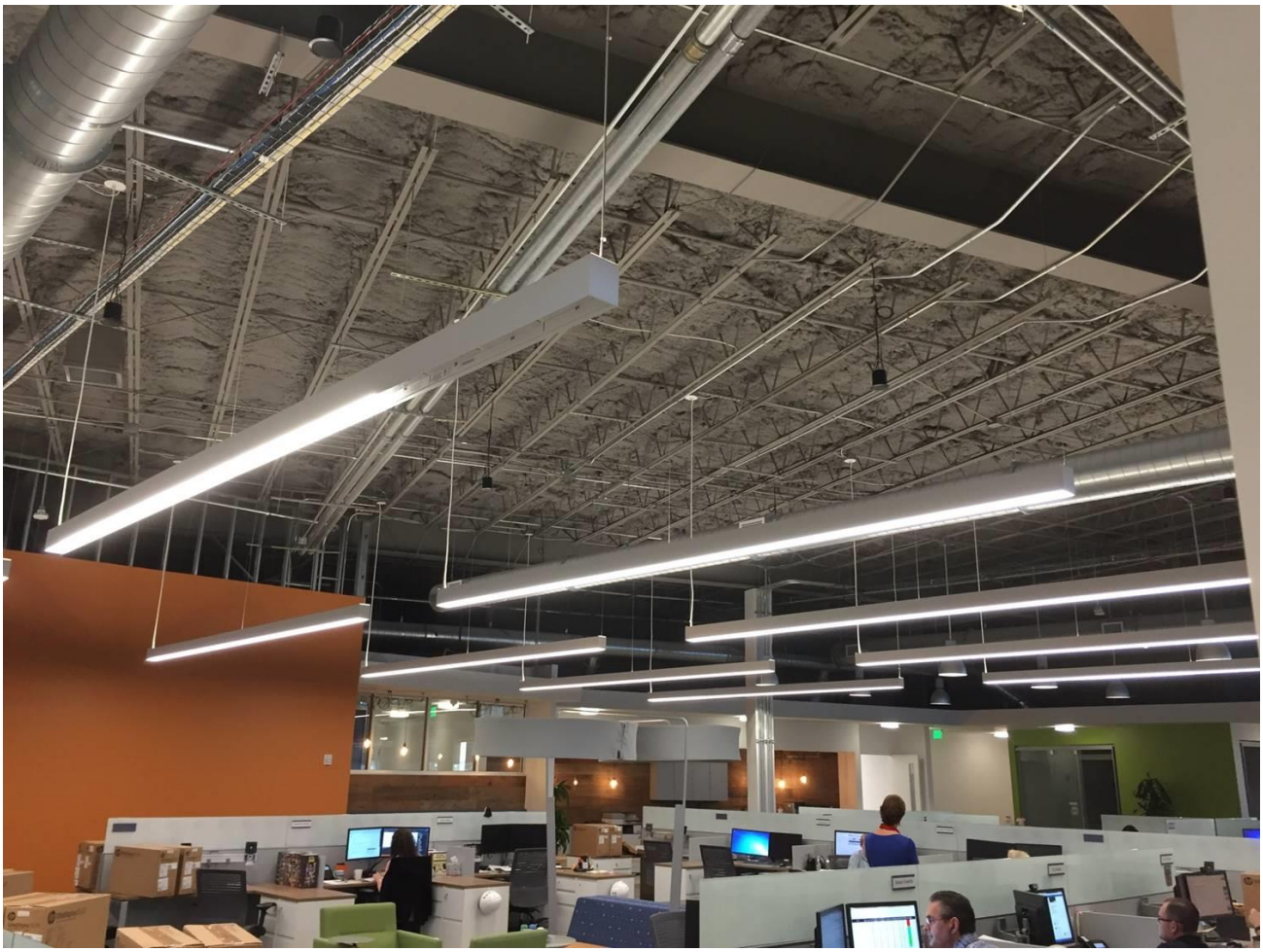

Figure 3: Gaining in popularity is the design approach of insulating on the underside of the roof deck and leaving the spray foam exposed to the occupants below. This variation on the unvented attic design requires a thermal barrier, such as an approved intumescent coating. As shown in this workplace setting, painting of the foam is possible to make it less obvious. Image Courtesy of Icynene Inc.

Moisture Concerns

The issue of moisture ingress (i.e. water leakage) from the exterior is sometimes raised as a concern. From a design perspective, attic venting is not provided to address roof leaks. The basic design assumption regarding all roofing systems is that the roof system deflects water away from moisture-sensitive materials. If it does not do this, it has failed.

Some materials will perform better, given differing design intents:

- Open cell foams will tend to leak closer to the point of entry making leaks easier to identify and locate.
- Closed celled foams will perform better in terms of deflecting water away from interior elements but may allow leaks to go undetected longer.

As with all construction products, installation is critical to the performance of the product. Spray foam installers that have successfully gone through manufacturer or trade-association delivered application training are more likely to deliver the installation needed. For unvented attics having the spray foam layer applied continuously from the roof/wall intersection, at the specified thickness, to encapsulate the entire interior surface area of the attic will hinder airborne moisture entry while providing an energy efficient environment.

Unvented attics that contain HVAC equipment and ductwork will benefit from unintended supply and return air leakage occurring in the space with respect to moisture control. If a dedicated supply or return register in the unvented attic is desired to enhance moisture control, note that the spray foam would now be subject to 15 minute thermal barrier requirements for fire protection.

Figure 4: The recessed lights in attic floor of this unvented attic construction didn't need to be made airtight. By not performing such airtightness measures construction costs savings can be realized even if no HVAC equipment and ductwork are located in the attic – a situation common for many cold climate locations. Image Courtesy of Icynene Inc.

Temperature Concerns

Among the significant issues that get raised pertaining to unvented attics is concern over asphalt shingle temperature/durability. Generally, it has been found by researchers that the net impact of eliminating venting is to raise shingle temperatures only by 5-8˚F. Furthermore, it was found that shingle temperature was affected more severely by factors such as geographic location, roof slope and orientation, and shingle color. The effect on roof sheathing temperatures in unvented attic was similarly shown to be of negligible concern.

But, the lack of understanding of these issues has prompted some manufacturers to reduce or eliminate their warranty on shingles applied to unvented roof assemblies. Were warranties based on scientific evidence, it would be logical that they should also be altered based on geographic

location—one should expect to get a different warranty in Las Vegas versus Minneapolis. In any event, a growing number of manufacturers are offering competitive warranties for roofing over unvented attic assemblies recognizing a significant marketing opportunity for their products.

The advantages of unvented attic construction using spray foam insulation are numerous. It is a proven, cost effective approach to creating a more energy efficient building particularly when the HVAC system is located in the attic space. It can be used in all climate zones where it is has been shown to work well provided appropriate climatic design considerations are utilized.