Installing High Performance Insulation Part 3:

A Guide to Installing Unvented Attics in Canada

Designers, builders, and homeowners are seeking options to build more energy-efficient, resilient, affordable, and comfortable homes. Building unvented attic (UVA) assemblies, instead of a conventional vented attic, provides a unique solution to improve energy efficiency and helping avoid the ingress of moisture, fire, embers, and other extreme weather in attics while adding flexibility in terms of design options.

An UVA assembly can allow for the normally overlooked open attic space to become usable occupied space (with appropriate interior finish) or a conditioned service space providing a more hospitable environment for placing and servicing electrical fixtures, mechanical equipment, water lines, ductwork, and storage.

Spray polyurethane foam (SPF) provides one of the most proven options for creating an UVA assembly. Builders have created hundreds of thousands of UVAs using SPF in all North American climate zones. To create an UVA, SPF is applied directly to the underside of the roof deck or sheathing and the adjacent structural roof trusses or rafters - similar to the way SPF insulation is applied in walls. In UVAs, SPF provides insulation and an air barrier on the underside of the roof deck or sheathing, which limits air and moisture flow through the assembly. Because attic air is maintained well above the dew point, attic venting is not required. Exterior walls (at gable ends) of the attic are also required to be insulated and air sealed resulting in an attic space completely encapsulated in SPF.

Because the interior space of an UVA is inside the thermal envelope, insulating the floor of the attic is not recommended. The result is a conditioned attic space is contained within the insulated, air-sealed building envelope. If used as occupied living space, the attic may be directly conditioned with HVAC and finished accordingly. However, if used only for the purposes of keeping the ductwork and mechanical systems in conditioned space, the attic may be indirectly conditioned; in this case conditioning is provided by heat exchange through ductwork and mechanical equipment, and via duct leakage and via heat exchange with the living spaces below though the uninsulated attic floor. In either case, UVA assemblies move the insulation and air barrier from the floor of the attic to the roofline.

Advantages of Unvented Attic Assemblies with Spray Foam

UVA assemblies, insulated and air sealed using SPF, offer numerous performance advantages versus vented attics:

- **Fewer Thermal Envelope Penetrations:** The roof plane becomes the top edge of the building envelope for the home. At this location, there are fewer penetrations to make airtight than at the attic floor. In the winter, the roof sheathing and shingles are protected from heat loss and moisture by the SPF. As a code-compliant air impermeable material, SPF can encapsulate framing as well as sheathing to deliver a continuous insulation layer and air barrier.

- **Simplified Installation:** UVA assemblies accommodate roof plans that are complex or difficult to vent properly. Homes with limited side-yard setbacks, roofs with complex slopes, and gables can be difficult to vent properly. UVA assemblies can simplify or eliminate complex insulation, air sealing, and vapour barrier requirements that may be problematic in the field. Continuous application of air-impermeable insulation at the roofline and exterior walls reduces the potential for compromises to the thermal envelope. Because the roofline is part of the thermal envelope, penetrations in the attic floor for pot lights, exhaust fans, piping, and HVAC ducting and equipment do not impact the integrity of the thermal envelope and they aid the indirect conditioning process for the attic as well.

UVA assemblies, sometimes called unventilated, "cathedralized" attic roof assemblies, typically feature a sloped roof system. However, UVA assemblies can be created with cathedral ceilings or with flat roof assemblies as well.

- **Freeze Protection for HVAC and Plumbing in the Attic:** Moving the thermal envelope to the roofline helps to ensure service water connections, condensate lines, pumps and other equipment located in the attic are no longer in danger of freezing. The need for associated heat tracing, maintenance, repair, or upgrading activities can be virtually eliminated.

- **Avoidance of Placing Ducts in Unconditioned Spaces:** UVA assemblies can help minimize the energy losses associated with leaky ductwork in the attic. UVAs create a more hospitable environment for ductwork making it possible to easily condition rooms in remote corners of the home with duct accessibility challenges. For example, "bonus rooms" over garages can be conditioned from the UVA above thereby avoiding potential heat loss, occupant discomfort, and safety issues associated with running ducts through garages and/or other exposed locations.

- **Simplified Creation of Additional Occupied Space:** The attic space can be turned into occupant space which potentially enhances the value of the house.

- **HVAC Location Options are Increased:** Furnaces with a sealed combustion (direct venting) systems and ventilation systems, can be located in a hospitable attic environment without fear of freezing condensate lines. Ductwork associated with such equipment would not be subject to extreme exterior temperatures and duct leakage compromising its performance.

- **Reduced Exposure to Extreme Weather:** UVA assemblies also offer protection from the ingress of blowing snow, rain, and burning embers (in areas where wildfires are a risk). In parts of the country where the construction abuts the wildland-urban interface, burning embers entering vented attics can be a significant risk to homeowners and their insurers. In some forested regions of North America, vented attics are not allowed because of the risk of attic fires from burning embers.

- **Cost Savings Related to Provision of Attic Venting:** UVA assemblies potentially offer construction cost savings because attic venting detailing can be eliminated or significantly reduced in scope.

Code Considerations for Unvented Attics

The National Building Code (NBC) and Provincial Codes modeled on it, specifies vented attics in Sentence 9.19.1.1.1 but allows unvented attics as a specific exception:

> *"Except where it can be shown to be unnecessary, where insulation is installed between a ceiling and the underside of the roof sheathing, a space between the insulation and the sheathing, and vents shall be installed to permit the transfer of moisture from the space to the exterior".*

NBC Appendix A provides a discussion of situations where venting might be unnecessary, however, the structure of this part of the Code assumes that the default will be a vented attic assembly. This makes approval of UVA assembly subject to the approval of the Authority Having Jurisdiction (AHJ). Designers and builders need the approval of their building official BEFORE proceeding.

The wording "where it can be shown to be unnecessary" suggests that it is necessary for someone to demonstrate there is no need for venting the attic. Some progressive jurisdictions have examined the issue and have arrived at their own determinations of when UVA assemblies are appropriate. Other jurisdictions require a designer (architect or engineer) to take responsibility and approve the UVA assembly. Unfortunately, some jurisdictions are not prepared to allow the use of UVA assemblies in their jurisdiction due to a lack of guidance on how they should be built. This guide is intended to provide detailed guidance on how to successfully build an UVA using SPF such that the rationale and practical detailing of such designs are better known.

One rationale for Canadian code acceptance is the extensive experience with UVA construction in the US. The U.S. model building code – the International Residential Construction Code has featured UVA assemblies since 2006, with some state approvals occurring several years prior. The requirements apply to all U.S. climate zones including cold and very cold climate zones (e.g. Alaska and mountain states in the Pacific Northwest). This has given rise to extensive experience with successful UVA assemblies, sealed with SPF in all North American climate zones—they have been built by the thousands annually in residential and commercial buildings across the United States. In Southwest U.S. the UVA assembly is advantageous since many buildings don't have basements—UVA's are a straightforward, more energy-efficient solution for dealing with performance inefficiencies associated with locating HVAC equipment and ductwork in the attic.

In Canada, UVA assemblies are not as well-known due to the difficulty of obtaining approvals without a prescriptive code clause. Nevertheless, numerous UVA assemblies are found across Canada as well. Designers and builders have found several key design features that must be considered to successfully implement UVA assemblies. Use of air-impermeable insulation, such as SPF, and proper assembly design are important to ensure the successful construction of an UVA assembly. SPF is particularly suited to application in UVA assemblies because it adheres to surfaces where it is sprayed, meet the required R-values, and can help form an effective, continuous Air Barrier and Vapour Barrier in areas where it is professionally applied.

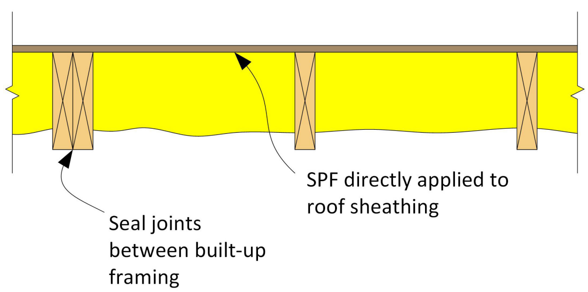
UVA Assembly Key Aspects and Details

The key features of UVA assemblies featuring SPF are:

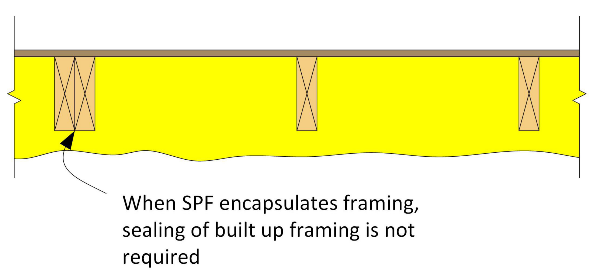
1. The SPF material needs to be installed in direct contact with the underside of the exterior sheathing for the roof, roof gable ends or other assemblies that make up the attic exterior envelope. Ideally, the SPF encapsulates framing but if this is not possible, joints between built-up framing members must also be sealed to provide a continuous Air Barrier. (See Figure 3.1) Note that NBC 9.9.1.1.(1) requires a gap between the insulation and the sheathing for venting, but in the case of the UVA, the gap can be eliminated as "unnecessary".

Figure 3.1 Typical SPF UVA Applications

Option (a) Between Rafters



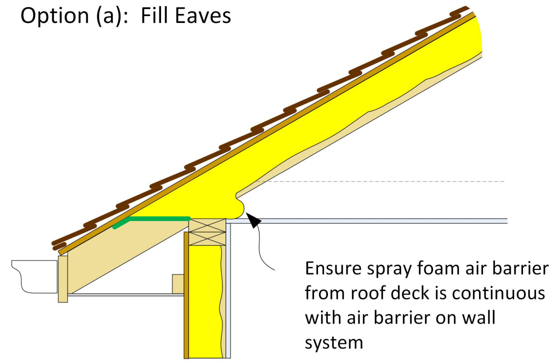
Option (b) Encapsulating Framing



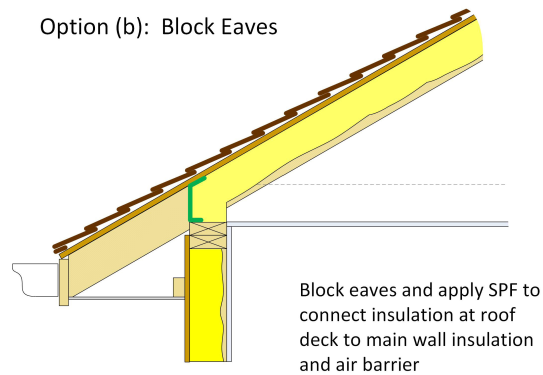
2. The SPF layer needs to completely encapsulate the interior UVA space so there are no gaps in the insulation or airtightness. In practical terms, this means that SPF must extend down and connect to the air barrier for above-grade walls such that discontinuities do not exist at eaves and projecting roof assemblies. (See Figure 3.2)

Figure 3.2 Eave Detail

Option (a): Fill Eaves



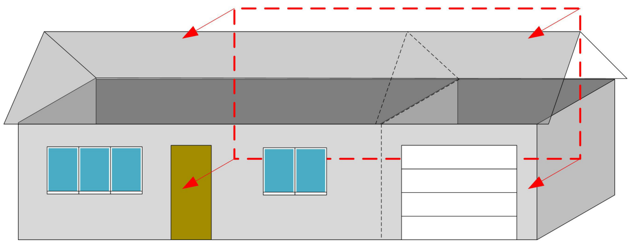
Option (b): Block Eaves



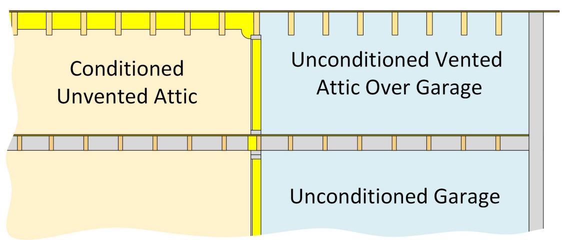
3. The UVA space must be completely contained within and tied into the adjacent building thermal envelope for the rest of the building (e.g. walls below. If the attic for an unheated attached garage is directly connected to the attic for the main part of the house, the two attics need to be either fully separated by an insulated and air-sealed wall assembly separating the two spaces. Alternatively, the two attics can be joined together so that the combined attic space is completely contained within the building thermal envelope—this would make it necessary to apply SPF not only to the roof and walls of the attic but also the floor of the attic (i.e. in the area over the unheated garage) because the attic of the garage would be part of the conditioned space. (See Figure 3.3).

4. Either Medium(MD) or Light Density (LD) SPF can be used in an UVA assembly. LD SPF is not a code-compliant Vapour Barrier so it would require a supplemental Vapour Barrier to be applied to control vapour diffusion—this may be accomplished with a Vapour Barrier coating applied directly to the foam, a conventional

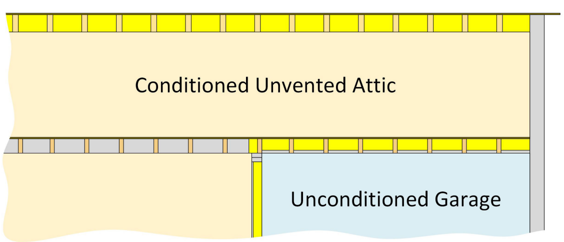
Figure 3.3 Separate Attics over Heated/Unheated Spaces



Option (a)



Option (b)



vapour barrier film behind drywall, or a Vapour Barrier primer on the interior drywall. (Note, the Vapour Barrier should not be applied on the attic floor as Vapour Barrier protection is needed directly in the insulated assembly which is now at the roofline.) Medium-density SPF meets code-compliant levels of vapour control to be classed as a vapour barrier at thicknesses over 50 mm (2.0 in.) so a supplemental Vapour Barrier is typically not required when MD SPF is used.

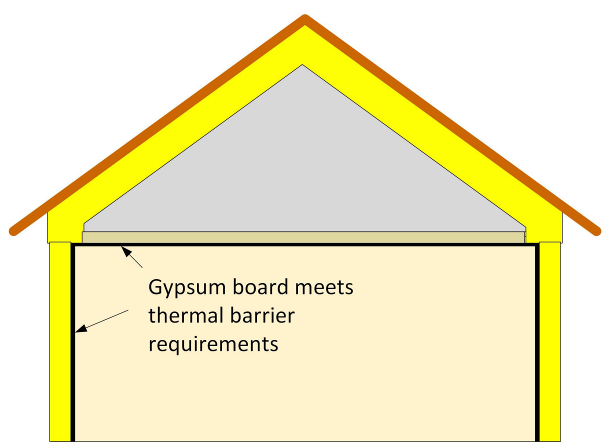
5. For retrofit, all roof venting should be eliminated, blocked, or otherwise rendered inoperable. The correct use of SPF in the UVA minimizes condensation occurrences making roof venting unnecessary.

6. In an unoccupied attic, the UVA interior space is typically indirectly conditioned. In such applications, the attic temperature normally stays within 3 degrees Celsius of the temperature of the adjacent, occupied conditioned area. For effective indirect conditioning, it is necessary to remove vapour barriers and insulation in the floor of the attic. Otherwise, the temperature in the attic may fluctuate more than 3 degrees Celsius, thereby raising the risk of condensation in the attic. If the attic floor insulation cannot be removed, the solution is to provide a small amount of air discharge to the exterior to prevent moisture accumulation in the space.

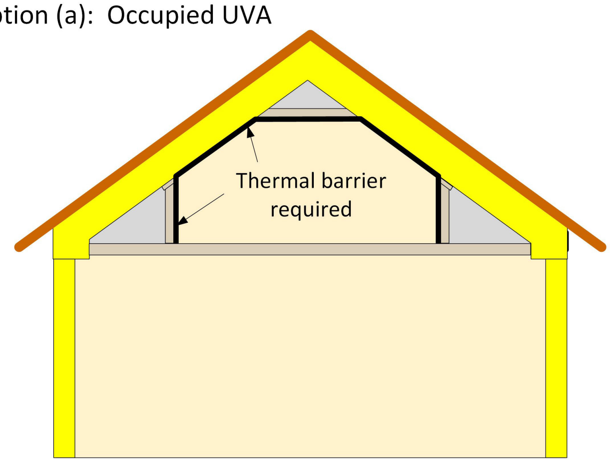
7. In an unoccupied attic, the attic must be separated from the occupied zone by a finish complying with the NBC Article 9.10.17.10. That finish (typically gypsum wallboard) usually exists within the attic floor/ceiling assembly and is typically considered to meet the Code requirement for separating SPF from occupied space(s) (See Figure 3.4 a.)

Figure 3.4 Thermal Barrier Locations per NBC Article 9.10.17.10

Option (a): Unoccupied UVA



Option (a): Occupied UVA



8. In an occupied space (in finished rooms or rooms used for storage) NBC Article 9.10.17.10 requires that SPF be separated from occupied spaces by a finish such as gypsum board at least 12.7 mm thick. (See Figure 3.4 b.) Other thermal barrier material options exist as well. (See factsheets 1 and 2 in this series for more information on other options) If the use of alternate thermal barrier finish material is planned, the local Authority Having Jurisdiction (AHJ) should be contacted as to their local acceptance of other thermal barrier options.

9. If a fuel-fired furnace or mechanical equipment is installed in the UVA, the furnace must be a sealed combustion (direct vent) unit. Comply with all Codes (e.g. Building and Gas Codes) with respect to providing needed make-up/ combustion air. Leakage through a well-sealed UVA must not be relied upon as source of combustion air.

10. It is important to maintain all code-required clearances / separations between all combustible materials (such as sprayfoam) and heat-producing appliances and devices such as unrated pot lights, fireplaces, water heaters, furnaces, and chimneys.

UVAs have been widely studied in both the U.S. and Canada. The research has compliment code requirements and has helped define recommended practices.

The SPF UVA assembly may be a new construction approach in some Canadian jurisdictions, but as previously indicated, it has performed well in hundreds of thousands of North American applications across the full range of climate zones. It is fully recognized in U.S. codes and is widely used in cold climate locations as well as warm climates. The SPF UVA assembly has gone through extensive building science research to understand its performance and substantiate that it is a durable construction approach in a cold climate when constructed properly. Anecdotal experience has also shown SPF UVA's offer numerous construction and design advantages and can aid the retrofitting of unused attic space to occupied space, provided the requirements outlined above are properly addressed.

Building Science Research on How Unvented Attic Designs Perform

The following general building science findings and site observations on unvented attic construction have emerged concerning Canadian climate conditions and US cold climate locations:

- All interior surfaces in the attic should be continuously covered with a layer of SPF at a thickness that meets building code insulation requirements for the appropriate climate zone. Framing members that are coated with SPF on their interior face help control thermal bridging and condensation.[1]

- There should be no gaps in insulation at the inboard side of the roof sheathing as these could be susceptible to condensation and resulting moisture problems.[2] Particular attention is needed in an SPF application around roof penetrations (e.g. plumbing and fan vents) and where the attic connects with exterior walls.

- In a UVA, the first condensing surface becomes the interior surface of the SPF.[3] In general, during the winter the greater the SPF thickness, the higher the interior SPF surface temperature will be. The SPF is also an air barrier that prevents moist interior air from reaching the roof sheathing.

- The UVA becomes an indirectly conditioned air space within an enclosed building space since it operates near the conditions of the living space without active conditioning.[4] The attic floor/ceiling assembly should not be insulated Specific air sealing or a vapour barrier at this location is also not recommended because vapour control and air leakage control elements are moved to the roofline. Interior humidity levels are typically low (less than 35%) during the heating season so small amounts of conditioned air leaking into the attic usually do not cause moisture issues. But, caution is necessary to ensure that moisture from bathrooms and kitchens is not directly deposited into the attic – they should be vented directly to the outdoors.
- Vapour barrier requirements need to be met for UVA assemblies. MD SPF meets the requirement at typical application thickness. Exposed LD SPF requires a vapour barrier coating or material at its interior surface according to local building code approvals.[5]
- Though some manufacturers expressed concerns, typically, peak increases in roof shingle temperatures caused by insulating at the underside of roof sheathing were found to be slight—in the range of 1.7 to 3.9ºC, and therefore not a major concern. (The impact is comparable to that of a radiant barrier.) Shingle colour, roof orientation, and roof slope cause shingle temperature elevations of an equal or greater magnitude.[6]
- Adhesion characteristics of SPF to roof trusses appear to create a uniform structural unit.[7] This has led some researchers to propose building retrofits utilizing spray foam to improve resistance to wind and hurricane uplift taking advantage of spray foam adhesion to fortify roof sheathing attachment.
- A test hut (field exposure test facility) in Coquitlam, BC included an UVA light density, open-cell SPF application with and without a ceiling vapour barrier to research the feasibility of the approaches in milder climates. After 9 years of operation, an examination revealed no visible mold in any of the assemblies which appeared to provide acceptable service. The roof sheathing in the unvented roof assemblies was observed to have a moisture content below 19% which is commonly accepted as a safe moisture content level for wood building products. Indoor humidity levels below 35% during the winter months are still recommended.[8]

For further information on the research, consult the following documents:

1,4 Rudd (2004). Unvented-Cathedralized, Conditioned Attics: A Comprehensive Update. Building Science Corporation. Westford, MA.

2 Straube, Smegal & Smith (2010). Moisture-Safe Unvented Wood Roof Systems. The University of Waterloo and Building Science Corporation. Waterloo, ON.

3 Schumacher (2007). Unvented Roof Assemblies for All Climates. Building Science Consulting. Westford, MA.

5 Lstiburek (2006). Understanding Attic Ventilation. Building Science Corporation. Westford, MA.

6 Less, Walker & Levinson (2016). A Literature Review of Sealed and Insulated Attics—Thermal, Moisture and Energy Performance. Lawrence Berkeley National Laboratory, Berkeley, CA.

7 Prevatt (2007). "Wind Uplift Behavior of Wood Roof Sheathing Panels Retrofitted with Spray-applied Polyurethane Foam", University of Florida, Gainesville, FL.

8 Schumacher (2016). Research Summary – Field Performance of ocSPF-insulated Unvented Roof Assemblies in the Climate of Vancouver, British Columbia, Canada. Building Science Consulting Inc.,Waterloo, ON.

For additional information on LD SPF, see:

https://www.spraypolyurethane.org/

https://nrc.canada.ca/en/certifications-evaluations-standards/canadian-construction-materials-centre

https://canada.ul.com/ulcstandards/

https://nrc.canada.ca/en/certifications-evaluations-standards/canadian-national-master-construction-specification

https://www.caliberqa.com/

https://www.cufca.ca/

https://www.buildingprofessionals.ca/

http://foamexperts.ca/

American Chemistry Council
700 2nd Street, NE
Washington, DC 20002
(202) 249-7000
americanchemistry.com
blog.americanchemistry.com
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