HUNTSMAN
BUILDING SOLUTIONS

Benefits of Unvented Attics

BES-101 - DESIGN NOTE

This Design Note reviews unvented attic construction using spray polyurethane foam (SPF). It briefly discusses its history and reviews the benefits in terms of energy efficiency and condensation control. There are sections on building codes, retrofit applications, cathedral ceilings, and historic buildings.

Attics

There are two types of attic assemblies. One is a vented attic where the insulation is installed in the floor of the attic with soffit vents and ridge or gable end wall vents. The other is an unvented attic assembly where the insulation is applied directly to the underside of the roof sheathing and on all gable end walls. There are no soffit, gable end or ridge vents.

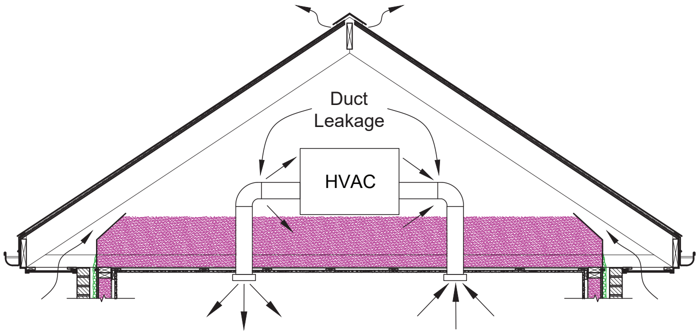
With an unvented attic, HVAC equipment and ducting are installed within the thermal envelope of the building. The unvented attic is more energy-efficient and is "indirectly" conditioned, as some conditioned air from the living space can make its way into the attic.

History

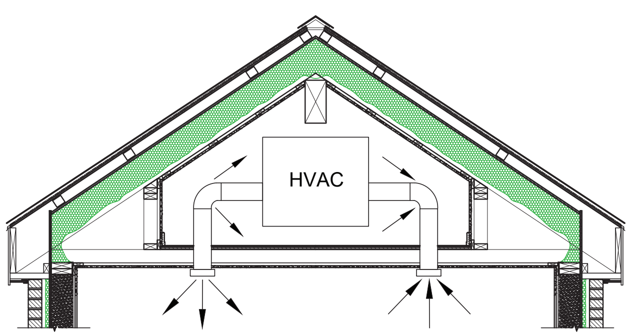
In the late 1990s, the US Department of Energy (DOE) promoted the use of unvented attic assemblies to reduce energy consumption and improve moisture control. Research began in 1996 with computer modeling and soon moved to full-scale testing. As a result, building code adoption occurred, leading to the system being referred to as an "unvented attic assembly", which was first adopted by the International Code Council (ICC) in the 2004 IRC Section R806.4. The section was renumbered in the 2012 IRC as R806.5. The section title was also changed to Unvented Attic and Unvented Enclosed Rafter Assemblies. The unvented attic assembly was adopted into the 2015 IBC, Section 1203.3 Unvented Attic and Unvented Enclosed Rafter Assemblies with the same code language.

Unvented Attic Construction

To construct a typical unvented attic, spray foam, an air-impermeable insulation (definition below), is applied in direct contact with the underside of the structural roof sheathing and on all gable end walls. The result is an attic encapsulated or sealed with SPF which is also sealed to the top of the exterior walls. The insulation layer forms a continuous "air barrier" in the attic to seal the space from outdoor air.
By moving the insulation and air pressure boundary to the underside of the roof deck, temperature & humidity conditions in the attic can be kept reasonably close to those conditions within the occupied interior of the building. There is neither a Class I vapor retarder, nor insulation installed on the attic floor of the unvented attic assembly.



Vented Attic



Unvented Attic

Air-Impermeable Insulation

IRC Section R806.5 and 2015-2021 IBC Section 1203.3 allow the use of an air-impermeable insulation in an unvented attic assembly. An air-impermeable insulation is defined as: "An insulation having an air permeance equal to or less than 0.02 L/s x m² at 75 Pa pressure differential tested in accordance with ASTM E283 or ASTM E2178".

Huntsman Building Solutions spray foam insulation products meet this requirement, making them ideal for use in unvented attics. Independent testing verified in Evaluation Service Reports confirms that they comply with this Code requirement at minimum required thicknesses.

Energy Efficiency

Unvented attic assemblies provide a distinct energy advantage over vented attic systems in all climates. In many climates, it is common to install HVAC equipment and duct work in attics. Especially in cooling climates (ICC Climate Zones 1-4), buildings are more comfortable when cool air is introduced at the ceiling level, as it allows for better mixing with the interior air.

With traditional vented attic designs, HVAC equipment and ductwork systems are exposed to high outdoor humidity levels, highly elevated daytime temperatures and frigid wintertime temperatures. This reduces the efficiency of the HVAC system since it is often operated in severe temperature conditions and increases the potential for condensation. In addition, the generally leaky nature of residential ductwork causes part of the conditioned airflow to be lost to the outdoors through attic venting. In the summer months, hot moisture-laden outdoor air and in the winter months frigid air can enter the HVAC system through return leaks in the vented attic ductwork. The equipment capacity must be significantly increased to compensate for these inefficiencies.

By moving the boundary of the conditioned enclosure to the underside of the roof deck, any duct air leakage within the attic is contained within the attic space. This type of design reduces the need for perfect duct sealing; any conditioned air that leaks from supply attic ducts partially conditions the attic space. If all of the ductwork is within the building thermal envelope, often the residential building code does not require a duct tightness test, which reduces construction costs. By reducing the effect of duct leakage to the outside of the building, there is a considerable improvement in energy consumption without the need for meticulous duct sealing. It has been found that where ducts in a vented attic suffered from a 10% loss of flow due to leakage, enclosing ducts and equipment inside an unvented attic assembly can generate up to a 15% reduction in energy consumption. Field measurements suggest that duct air leakage can range anywhere from 1% to well above 20%.

Condensation Control

One of the benefits of locating HVAC equipment and ductwork inside the thermal envelope is the reduction in condensation potential. In vented attics, temperatures can reach 150°F during the heat of the day in the summer months. In many climates, the Relative Humidity (RH) outdoors in the summer months can be upwards of 90%. When this hot humid air enters the attic space through attic vents and comes into contact with any cool surface, it will condense on that surface. The resulting moisture creates a potential for mold growth.

Wrapped and insulated ducts are not immune to condensation, as pinholes in the vapor barrier can allow the hot air to leak through mineral fiber insulation and contact the cold ducts, where condensation could fill the insulation with water. Supply air duct leakage can also cool adjacent surfaces and thereby provide additional condensing surfaces.

In unvented attic assemblies, the attic space generally remains within about 10-12°F of the directly conditioned living space below the attic, with a relative humidity much lower than ambient, due to the indirect conditioning of the space. The potential for condensation is therefore greatly reduced, along with the potential for other problems such as mold & structural rot.

Energy Efficiency in Wintertime

Unvented attics are also advantageous during the colder months for many of the same reasons that they work in the summer. By bringing the ductwork inside the thermal envelope, it is not subjected to cold wintertime attic temperatures, and any attic duct leakage is contained inside the sealed attic space, which is inside the thermal envelope of the building.

Note that vented attic designs originated in cold climate regions, where attic ventilation construction is used to remove warm, humid air that travels upward from the interior space below into the attic space. Air leakage from the living space below occurs through cracks and joints in the ceiling, around electrical and pipe penetrations, duct chases, attic access panels, pull-down attic stairs and especially around recessed "can" lights. The popularity of can lights has greatly increased the likelihood of moist air leaking into attics in the wintertime and without adequate attic ventilation, condensation will form on the underside of the cool uninsulated roof deck.

The most reliable way to avoid moisture problems in vented attic designs is to minimize the potential for moist air to exfiltrate into the attic space. Huntsman Building Solutions spray foam systems are ideal insulation materials to be used in unvented or vented attic designs because they provide superior control of heat, air, and moisture flows across the building envelope.

Building Codes

The IRC and IBC require only an ignition barrier in the attic space if the space is not used for storage. However, there are fire tests that can be used to allow spray foams to be left exposed without an ignition barrier or an intumescent paint, which provides the equivalent of an ignition barrier.

IRC Section R316.6 Specific Approval and IBC Section 2603.9 Special Approval, for example, allow for foams to be fire tested under various test methods, including End Use Configuration testing and another test method as listed in ICC AC 377, Acceptance Criteria for Spray-applied Foam Plastic Insulation, Appendix X. These test methods allow for testing in attics and crawl spaces with alternatives to code prescribed ignition barriers.

Many open cell foams use End Use Configuration testing. Some open cell and most closed cell foams use Appendix X testing to achieve the necessary approvals be left exposed without an ignition barrier or intumescent coating.

Most Huntsman Building Solutions spray foams are allowed to be left exposed (uncoated) in unvented attics. The specific requirements are detailed in third-party code compliance evaluation reports.

Note: If there is to be storage in the attic space, a 15-minute thermal barrier is required between the spray foam and the attic space. This can be either a ½” gypsum wallboard (prescriptive thermal barrier) or an intumescent paint that has been tested with the specific foam and shown to be an equivalent thermal barrier. The determination for attic storage is typically the presence of plywood/OSB installed on the attic floor, which is above the amount required for safe access to the HVAC equipment for servicing.

Wind Driven Rain

In hot humid climates, where hurricanes are prevalent, unvented attic assemblies provide a significant advantage over the typical vented attic system. By eliminating vents, an unvented attic design keeps wind-driven rain out of the attic, which has shown to be a major water damage issue following hurricanes.

Wind Driven Embers

In areas prone to forest fires, such as hot dry climates, unvented attics provide a benefit over vented attics in that wind driven embers are kept out of the attic space.

Cathedral Ceilings and Flat Roofs

A key benefit that has come from the development of the unvented attic assembly is an improvement in the design of cathedral (vaulted) ceilings. The ability to eliminate venting provides more space for insulation and thereby, higher R-values can be achieved and the potential for condensation is reduced.

The details found in IRC Section R806.5 and 2015-2021 IBC Section 1202.3 can be used in the design of cathedral ceilings. Buildings may also have flat roofs which create an assembly that cannot be effectively ventilated. Such roof designs make unvented attic construction very appealing. The SPF application follows the same methods used in unvented attics with larger volumes.

Retrofit Applications

When converting a vented attic into an unvented attic, the existing insulation along with any vapor retarder and all items in the attic should be removed from the floor of the attic. Doing this minimizes the chance that the attic temperature will be significantly different from the living space temperature. If the existing insulation on the floor of the attic is not removed, it will prevent the foam from providing an air seal between the foam under the roof sheathing and the top of the exterior wall. This will allow moist outdoor air to enter the unvented/sealed attic assembly, creating additional condensation potential. Additionally, when removing the attic floor insulation, dust, dirt, and any rodent residue need to be removed to eliminate odors. Such odors used to be able to escape harmlessly to the outdoors through attic vents, but in an unvented attic assembly, this is not possible.

Other Considerations

Roof Leak Detection

With any roof system, the possibility of roof leaks always exists. Historically, many low-density open cell spray foams have allowed water, subject to sufficient hydrostatic pressure, to travel through the insulation and permit early detection of leaks. Additionally, open cell foams are vapor permeable and allow for the diffusion of moisture from the roof leak to the interior of the building. This early detection can be critical for the rapid drying of wet assemblies.

Combustion Air Considerations

Fuel-fired furnaces and other combustion appliances located in an unvented attic need to be direct vent two-pipe condensing units with an outdoor air supply to a sealed combustion chamber with an exhaust vent to the outside. If a fuel-fired open combustion (atmospherically vented) appliance is located in an unvented attic, it needs to be enclosed in a “utility closet” that is air sealed to separate it from the attic space. An air-tight gasketed door is installed for access to service the appliances. Combustion air from the outside is supplied directly into the utility closet through a sealed duct and exhaust gases travel through a sealed vent to the outside.

High Humidity Applications

In high humidity areas (e.g. swimming pools, saunas, crawlspaces, etc.) vapor diffusion should be controlled with a vapor diffusion retarder. This practice also applies to areas where the humidity drive is relatively constant for long periods such as in cold rooms and freezers.

For the situations noted above, medium density closed cell spray foams meet ICC code requirements for a Class II vapor retarder (< 1 Perm) at thicknesses 1.5" or greater. This eliminates the need for supplemental vapor retarders. One of the principal advantages of using a closed cell foam in these situations is that it provides insulation, an air barrier, and a vapor retarder, all in one product.

Historic Buildings

Prior to the introduction of insulation, attic ventilation was not common. As a result, many historic buildings were constructed without the provision for attic ventilation. Traditional fiberglass batt insulation, when installed on the attic floor, has a dramatic effect on the reduction of attic temperatures and increases condensation potential, which must be mitigated through the use of attic ventilation. However, it is not always possible to achieve this in historic buildings that were never designed to accommodate attic ventilation or that may have complex roof geometries. In historic buildings, the use of spray foams in an unvented attic assembly can provide improved thermal efficiency and moisture control without requiring attic ventilation. Such designs need to consider the drying ability of the assembly with respect to the addition of spray foam.

Summary

Buildings with HVAC equipment and ducts located in a vented attic have excessive energy consumption because of the inhospitable environment in which they are located. Unvented attic systems provide a strategy for reducing energy consumption by sealing the attic and bringing the HVAC equipment and ductwork into the thermal envelope.

Unvented attic systems have additional benefits, such as improved condensation control, limiting wind-driven rain ingress and preventing the entrance of hot embers from a forest fire. They also provide unique opportunities to address difficult building envelope problems in historic buildings, as well as buildings with complex roof geometries.

Unvented attics reduce energy consumption and improve moisture control because:

1. The mechanical equipment and ductwork are placed in a more temperate, semi-conditioned space. The attic temperature is typically within 10-12ºF of the occupied space below.

2. Attic duct leakage remains within the thermal envelope. Energy loss associated with leaky ducts that are outside the thermal envelope in a vented attic is reduced.

3. Penetrations through the top floor ceiling do not compromise the building's airtightness because the building envelope has been moved to the roof deck level. This results in a tighter overall building envelope.

4. Hot humid outdoor air in the summer months does not enter the attic space through attic vents, thus eliminating potential condensation and increased temperature of the attic space where the HVAC equipment and ductwork are located.

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