Benefits of the Unvented Attic Assembly

Unvented attics have been getting popular in recent years. An unvented attic differs from a conventional vented attic in that there is no venting of the space between the roof rafters and the ceiling joists of the top story. The unvented attic is "indirectly" conditioned space since as there are no supply or return vents from the HVAC system located in the unvented attic space.

This design practice benefits situations where space limitations require HVAC equipment and duct work to be located in the attic. In this situation, modifying the attic to create a conditioned attic space has generated significant reductions in energy consumption because:

1. The mechanical equipment is placed in more temperate, conditioned space.
2. Duct leakage remains within the conditioned space.
3. Duct penetrations through the ceiling (immediately below the attic) do not compromise the building envelope air tightness because the building envelope has been moved to the roof deck level.

This Design Note reviews unvented attic construction, briefly discusses its history and reviews the benefits in terms of energy efficiency in hot humid climates and cold climates. Sections on cathedral ceilings, condensation control and historic buildings are also included.

History

In the late 1990's, the US Department of Energy (DOE) promoted the use of unvented attic assemblies in an effort to reduce energy consumption. Research began in 1996 with computer modeling, and soon moved to full-scale testing. As a result of the DOE research work, unvented attic systems have been constructed for more than 14 years, and a set of design recommendations has been developed for common use. These recommendations refer to the system as an "unvented attic assembly", which was adopted by the International Code Council (ICC) in 2004, and is now part of the 2009 International Residential Code (section R806.4).

Unvented Attic Construction

To construct an unvented attic, air impermeable insulation is applied in direct contact with the underside of the structural roof deck and gable end walls & soffit areas, such that the roof insulation is tied into the wall insulation of the occupied space below. By moving the insulation 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 vapor retarder nor insulation installed on the attic floor of the unvented attic assembly.

Air-Impermeable Barriers

Section R806.4.5.1 of the 2009 IRC, Unvented Attics, calls for the use of an air-impermeable insulation. The use of an air-impermeable barrier at the underside of the roof prevents air infiltration and thereby limits the accumulation of airborne moisture in the attic. This helps reduce latent air-conditioning loads providing further reductions in energy consumption.

An air barrier material is defined as one having an air permeance, when tested according to the requirements of ASTM E283 or ASTM E2178, less than 0.02 $L/s{*}m^2$ at 75 Pa. Icynene® spray foam insulation products meet this requirement. Independent testing verified in our ICC-ES Evaluation Reports confirm that they comply with this Code requirement.

Condensation Control

One of the benefits of locating HVAC equipment & ductwork inside the conditioned envelope is the reduction in condensation potential. In vented attics, temperatures will typically range from 140°F – 160°F during the heat of the day in the summer months. In many areas the Relative Humidity (RH) outdoors can

be upwards of 90%. Any cool surface in the attic will provide a condensation plane and with moisture comes the potential for mold.

In conventional vented attics, cool HVAC equipment & ductwork provide condensing surfaces. Even more moderate conditions can cause moisture issues: the dew point temperature for 100˚F air at only 40% RH is 70˚F--well above the temperature of most air-conditioning equipment. Wrapped & insulated ducts are not immune; pin-holes in the vapor barrier can allow the hot air to leak through mineral fiber insulation and contact the cold ducts, where condensation fills the insulation with water.

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 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 Hot Humid Climates

Unvented attic assemblies provide a distinct energy advantage over vented attic systems in hot humid climates. In these climates, slab-on-grade construction is common as is the placement of HVAC equipment and duct work in attics; air conditioned air mixes better and buildings are more comfortable when cool air is introduced at the ceiling level

With traditional vented attic designs, HVAC equipment and ductwork systems are exposed to high outdoor humidity levels and highly elevated daytime temperatures. This reduces the efficiency of the HVAC system and increases the potential for condensation. The generally leaky nature of residential ductwork causes part of the conditioned airflow to be lost to the outdoors and hot, moisture-laden, outdoor air to infiltrate into the air conditioning network. The equipment capacity must be increased to compensate.

By moving the boundary of the conditioned enclosure to the underside of the roof deck, any duct leakage within the attic is contained in the conditioned space. In fact, this type of design reduces the need for duct sealing; any conditioned air that leaks from attic ducts will cool the attic space, helping to cool the building.

By reducing the effect of duct leakage, the unvented attic system can provide a dramatic improvement in energy consumption, without the need for duct sealing. It has been found that where ducts suffered from just a 10% loss of flow due to leakage, enclosing ducts and equipment inside an unvented attic system generated up to a 15% reduction in energy consumption. Where ducts suffered from a 15% loss, the reduction in energy consumption increased to 25%. Field measurements of suggest that duct leakage can range anywhere from 5% to well above 35%.

Wind Driven Rain

In hot humid climates, where hurricanes are prevalent, unvented attic assemblies provide an advantage over the typical vented attic system. By eliminating vents, an unvented attic design helps keep wind-driven rain out of the attic.

Wind Driven Embers

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

Energy Efficiency – in Cold Climates

Vented attic designs originated in cold climate areas. In cold climates, attic ventilation is commonly used to remove warm, humid air from the attic space. The vented attic system therefore became popular in cold heating climates. Air leakage up from the living space occurs through cracks and joints in the ceiling, around electrical penetrations, duct chases, or especially around recessed “pot” or “can” lights. The popularity of these features has greatly increased the likelihood of moist air leaking into attics in colder climates. Without adequate attic ventilation, condensation can form on

the underside of the roof deck, and interior heat can cause snowmelt on the roof surface, leading to ice damming and roof leaks.

But the use of venting to control moisture in cold climate attics is not foolproof. In high snow fall areas, snow accumulation can often block ridge and roof vents, limiting venting and increasing the likelihood of damage due to ice damming (roof leaks) or condensation. The most reliable way to avoid moisture problems in vented attic designs is minimize the potential for moist air to exfiltrate into the attic space. Icynene® spray foam systems are ideal insulation materials to be used in vented attic designs because Icynene® spray foams insulate and air-seal the ceiling and they minimize the potential for condensation and ice damming.

Though vented attic designs are more popular, unvented attic designs are gaining popularity in cold heating climates especially to address problem areas that were previously difficult to address properly (e.g. HVAC systems located in the attic, scissor trusses where traditional insulating materials settle and move or attics are turned into living space.) The increasing popularity has come with the recognition that unvented attic systems can perform very well in heating climates not just cooling climates.

Icynene® spray foams minimize the potential for moisture accumulation in the building envelope because they are air barrier materials and they eliminate convective moisture flow. Icynene® low density spray foams however, are vapor permeable and therefore, by Code, a vapor retarder is recommended on the interior of side of the foam in Climate Zones 5 and higher. Vapor retarder paint can be applied directly to the inside surface of the insulation. Alternately it can be applied to the inside surface of a drywall interior finish where Icynene® fills the insulated cavity.

Notwithstanding Code requirements, vapor diffusion should also be controlled with a vapor diffusion retarder in high humidity areas (e.g. swimming pools, saunas, etc.) and in areas where the humidity drive is relatively constant for long periods of time (cold rooms, freezers etc.)

Icynene® medium density spray foams are much less permeable to vapor. When applied in suitable thicknesses, they meet ICC code requirements to eliminate the need for supplemental vapor retarders. One of the principal advantages of using these materials is that they provide insulation, air barrier and vapor retarder in one step.

Cathedral Ceilings

A key benefit that has come from the development of the unvented attic assembly is an improvement in the design of cathedral (vaulted) ceilings. In general it has been found that there is a minimal difference in moisture performance between vented vs. unvented cathedral ceiling assemblies. The ability to eliminate venting provides more space for insulation and thereby, higher R-values can be achieved. The details found in IRC Section R806.4 can be used in the design of cathedral ceilings.

Other Considerations

With any roof system, the possibility of roof leaks always exists. Icynene® low density spray foams are vapor permeable materials that allow drainage of water through the insulation and allow for the diffusion of moisture from the roof sheathing to the interior of the building. This can be critical to permit early detection of leaks and rapid drying.

In retrofit applications, when converting a vented attic into an unvented attic, the insulation and any vapor retarder should be removed from the floor of the ceiling. This minimizes the potential for the interior temperature of the attic to be at a level that is significantly different from the interior. The potential for condensation is thereby minimized.

Furnaces and any other combustion appliances located in an unvented attic must be high efficiency (two pipe units with air supply to a sealed combustion chamber and an exhaust pipe to the outside.)

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 batt insulation, when installed on the attic floor, has a dramatic effect on the reduction of attic temperature and the increased condensation potential 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; many historic buildings feature complex roof geometries that are not conducive to ventilation.

In such buildings, the use of Icynene spray foams in a conditioned attic assembly can provide improved thermal efficiency for historic buildings, without requiring attic ventilation. Similarly, many new buildings have complicated hip roofs that cannot easily accommodate ventilation or cannot be easily insulated. Unvented attic assemblies provide the means for these buildings to be durable, well insulated and to function properly.

Summary

Buildings across North America, with HVAC equipment located outside the conditioned envelope, generally have excessive energy consumption. Unvented attic assemblies provide a strategy for reducing energy consumption by encapsulating attic HVAC equipment and ductwork within the conditioned envelope. In various climates, unvented attic systems can have additional benefits, such as, improved condensation control, limiting wind-driven rain and snow ingress, and reducing ice damming. They also provide unique opportunities to address difficult building envelope problems in historic buildings and buildings with complex roof geometries. It's no wonder they are increasing in popularity.