Benefits of the Unvented Attic Assembly

Design Note

An unvented attic is a space between the ceiling joists of the top story and the roof rafters where an air impermeable insulation is applied directly to the underside of the structural roof deck and is tied into the insulation located in the walls, such that the roof system becomes part of the insulated building enclosure. This attic space becomes indirectly conditioned space as a result of air leakage, heat transfer and vapor diffusion through the uninsulated attic floor. 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. This paper 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

The US Department of Energy (DOE) promoted the unvented attic assembly 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 under special approval for more than 12 years, and a set of design recommendations has been developed for common use. These recommendations refer to the system as a "conditioned attic assembly", which was adopted by the International Code Council (ICC) in 2004, and is now part of the 2006 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 and soffit areas, such that the roof insulation is tied into the wall insulation. 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

A fundamental requirement of the unvented attic assembly is the use of an air-impermeable insulation. The use of an air-impermeable barrier at the underside of the roof is an effective means of preventing air infiltration and thereby excluding air borne moisture from the attic, reducing latent air-conditioning loads and providing further reductions in energy consumption. An air barrier material is defined as one having and air permeance, when tested according to the requirements of ASTM E283, less than 0.02 $L/s*m^2$. Icynene® meets this requirement. ASTM E2178 can also be used to measure the air permeance of building materials. Icynene® has been tested according to the requirements of ASTM E2178 and has a result less than the 0.02 $L/s*m^2$ requirement. Icynene® is an air impermeable insulation material as required by the code.

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, with relative humidity (RH) up to 90%. Any cool

surface in the attic will provide a condensation plane and with moisture comes the potential for mold and mildew. Cool HVAC equipment and ductwork provide condensing surfaces. Even more moderate conditions can cause moisture issues: the dewpoint temperature for 100°F air at 40% RH is 70°F, well above the temperature of most air-conditioned air. Wrapped and 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 conditioned attic assemblies, the attic space generally remains within about 5 ° 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 significantly reduced, along with the potential for mold, mildew, and 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 and the natural tendency for cool air to fall make attics the best choice for HVAC equipment and duct work. With vented attic systems, HVAC equipment and ductwork systems are exposed to high outdoor humidity levels and highly elevated daytime temperatures. This will reduce the efficiency of the HVAC system and increase the potential for condensation. The common tendency for ductwork to suffer from leakage causes part of the conditioned airflow to be lost to the outdoors or even for outdoor air to infiltrate into the air conditioning network, and the equipment output 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 therefore into conditioned space. In fact, this type of design reduces somewhat the importance of stringent duct sealing practices; any air-conditioned air that leaks from attic ducts will leak through the ceiling plane into the building, 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 a 10% loss of flow due to leakage, enclosing ducts and equipment inside an unvented attic system was found to generate up to 15% reduction in energy consumption. Where ducts suffered from a 15% loss, the reduction in energy consumption increased up to 25%. Field estimates for duct leakage can range anywhere from 5% to well above 35%.

Wind Blown Moisture

In hot humid climates, where hurricanes are prevalent, conditioned attic assemblies provide an advantage over the typical vented attic system. By eliminating vents, wind-driven rain can be kept out of the attic.

Energy Efficiency – in Cold Climates

In cold climates, attic ventilation is a common method to remove warm, humid air from the attic space. The vented attic system is therefore common in cold heating climates. Air leakage up from the living space occurs through cracks and joints in the ceiling, around electrical penetrations, or even around recessed “pot” or “can” lights. 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. In high snow fall areas, snow accumulation can often block ridge vents, increasing the likelihood of damage due to ice damming (roof leaks) or condensation. Vented attic systems, when functioning properly, can

maintain the roofing surface below the freezing point and thereby minimize the potential for ice damming subject to evaluation by an experienced design professional. Icynene® is an ideal insulation material to be used in vented attic systems. Icynene® insulates and air seals the ceiling which minimizes the potential for condensation and ice damming. Icynene® is well suited for vented attic applications.

Unvented attic systems are used in cold heating climates where HVAC systems are located in the attic, scissor trusses make it difficult to insulate the floor of the ceiling or the intent is to turn the attic into living space. The unvented attic system will perform very well in heating climates.

Icynene® will minimize the potential for moisture accumulation in the building envelope because it is an air barrier material and it eliminates convective moisture flow. Icynene®, however, is vapor permeable and therefore a vapor retarder is recommended in climate zones 6 and higher > 7200 HDD. A vapor retarder paint can be applied directly to the inside surface of the insulation. Vapor retarder paint can also be applied to the inside surface of the drywall interior finish where Icynene® full fills the insulated cavity.
Vapor diffusion should also be controlled where the indoor relative humidity is expected to remain in excess of 35% for significant periods of time. This would be true for buildings with interior swimming pools, saunas or other concentrated moisture sources. A vapor retarder paint can be applied directly to the inside surface of the insulation.

Cathedral Ceilings

One benefit that has come from the development of the unvented attic assembly is the improvement in design of cathedral (vaulted) ceilings. In general it has been found that there is a minimal difference in performance between the installation of the interior finish at the floor of the attic and its installation at the underside of the rafters. The details found in section R806.4 (2006 IRC) can be used in the design of cathedral ceilings.

Special Considerations

With any roof system, there should always be a contingency in place to address the possibility of roof leaks, especially with wood roof decks. When employing a conditioned attic assembly, insulation materials should be selected that allow rainwater to drain through the material, thereby ensuring that roof leaks can be located and repaired prior to any long-term damage of the roof sheathing. Similarly, the use of vapor permeable materials is preferred, as these materials will not impede the drying of the wood sheathing to the interior, thereby preventing moisture build up and improving the service life of the roof sheathing.

Historic Buildings

Prior to the introduction of insulation, attic ventilation was not necessary; 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.

The use of a conditioned attic assembly can provide improved thermal efficiency for historic buildings, without requiring attic ventilation. Similarly, a small portion of new building designs cannot accommodate ventilation (complicated hip roofs) or cannot be easily insulated (scissor trusses). Conditioned attic assemblies provide the means for these buildings to be properly insulated and to function properly.

Summary

Under all seasonal conditions, locating HVAC equipment outside the conditioned envelope causes significant increases in energy consumption. Unvented attic assemblies provide the means to reduce energy consumption by encapsulating attic HVAC equipment within the conditioned boundary. Conditioned attic systems have additional benefits in condensation control, snowy climates, historic buildings and buildings with complex roof geometries, and in high wind areas. Regardless of the application, considering a buffered unconditioned attic assembly at the design stage of a project can lead to significant improvements in many projects.