INDEX

Benefits of the Unvented Attic Assembly 2

Cold Floors – Bonus Rooms and Beyond 6

Controlling Sound with Icynene®. 8

Design Assumptions for HVAC & Ventilation 11

Healthy Indoor Air Quality and Ventilation. 13

Hotels and Nursing Homes. 16

Insulating Cavity Walls During Renovation. 19

Insulating Steel Roofs 22

Mold and Mildew: Causes and Cures 24

Mold Abatement and Rehabilitation 27

The Economic Thickness of Thermal Insulation. 29

Vapor Retarders: Qualifying for Removal 33

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 dewpoint 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.

Cold Floors – Bonus Rooms and Beyond

Cold floors are not just found in bonus rooms (rooms over garages) anymore; today's home designs are becoming more ambitious, with new opportunities for cold floors to develop over such unconditioned spaces as porches, crawl spaces, or even floors cantilevered beyond the exterior wall of the building. The push for more durable floor finishes like hardwood and tile are making the problem even more noticeable because these materials have a low R-value.

Most builders understand that bonus room floors require substantially more attention, if these rooms are to be made as comfortable as the rest of the house. In reality, standard construction practices simply do not provide a sufficient level of performance or durability to justify the additional cost. The end result is a compromise; the builder does his best to keep the job affordable for the homeowner, and the homeowner accepts that the bonus room will not be as comfortable as the rest of the house.

Why the Floors are Cold?

Even with building codes in many areas dictating that these floors be insulated to R-25 (R_{SI}-4.3), it is common to find floors that are 10° F (5.5° C) cooler than the room. Why? Because it is virtually impossible to install an insulation batt so that it is in contact with, and stays in contact with, the floor above.

Unless continuous contact can be maintained, void spaces will exist between the batt insulation and the floor above. These void spaces can range in size from small pockets to, in some cases, the entire length of the room. Cold air that penetrates the insulation can flood the void space between the insulation and the floor, rendering the insulation ineffective. Complicating matters is the necessity to accurately install the insulation around bracing and bridging between joists. The use of air permeable friction fit insulation system relies on an effective air barrier material being installed on both the underside of the insulation and at the exterior wall, at a cost that most builders cannot justify.

Heated Plenums

Some designers and builders have tried to overcome the weaknesses of this system through the use of a heated plenum space; a dropped ceiling is installed in the garage and insulated with a fiber batt. Heated house air is then ducted into the space created under the floor. While this is a more reliable means to keep the floor warm, experience proves it does not address all related problems. When water pipes are run within the plenum, frozen pipes are still commonplace. One common reason is there is no code requirement for the proper insulation and air-seal at the exterior wall of the heated plenum, allowing cold air to infiltrate under certain weather conditions.

In the plenum failure to properly air-seal the insulation allows the heated humid air to move through the insulation and come in contact with the exterior plenum wall. This can result in condensation in the insulation and on the cold exterior plenum wall, creating the potential for a long-term structural problem. To compound the issue, if a return air duct is installed to recycle the heated air, it runs the risk of conveying glass-fiber particles to the house.

While it is possible to design the heated plenum system to prevent these problems, the amount of labor involved makes the solution cost-prohibitive. Instead, builders may opt to ignore the additional detailing necessary in order to get the system to work. The inferior design will cost the building owner in higher energy bills for the life of the building.

Air barrier materials

The ideal means to supply occupant comfort to bonus rooms is to install a combined insulation and air barrier material in direct contact with the underside of the floor, while the insulation prevents conductive heat loss from the room above. And unlike the use of a heated plenum, this system does not require a continuous source of heat, or risk either condensation damage or reduced air quality.

Icynene®

Icynene® is a perfect solution for bonus room and floors exposed to cold air. It is a low-density (0.5-lb/ft^3) combined air barrier and insulation material that forms a continuous, reliable bond without sagging, settling, shrinking, or de-bonding from the substrate. Icynene® eliminates the possibility of short-circuiting and the need for heated plenum systems. Thousands of floors over porches, garages, crawl spaces and cantilevers have been successfully insulated and air-sealed with Icynene® and many more existing cold floor issues have been resolved by an Icynene® retrofit.

Icynene® is a low-density soft foam insulation, which is sprayed into/onto walls, crawlspaces, underside of roofs, attics and ceilings by Icynene Licensed Dealers. Sprayed as a liquid, it expands to 100 times its volume in seconds to create a superior insulation and air barrier. Every crevice, crack, electrical box, duct and exterior penetration is effortlessly sealed to reduce energy-robbing random air leakage. Icynene® adheres to the construction material and remains flexible so that the integrity of the building envelope seal remains intact over time. Icynene® is ideal for residential, commercial, industrial and institutional indoor applications. **Information about Icynene® can be obtained by visiting Icynene.com or contacting your local Icynene Licensed Dealer.**

Urban planning and home usage trends are generating a substantial increase in the need for improved sound attenuation in today's home. Surround sound and home theater systems are becoming more prevalent, even as more families are choosing to live in multi-unit dwellings constructed closer to major sources of noise pollution. Responding to the discriminating demands of this new generation of homeowners can be frustrating, if not downright impossible. A comprehensive solution to sound attenuation must include the right materials, the right design, and of course proper execution. Icynene® is a spray in place two-component liquid material that expands into low-density foam insulation, and provides a significant contribution to a consistent, cost-effective, and comprehensive solution to homeowners demand for sound attenuation.

STC & NRC Ratings

In construction, Noise Reduction Coefficient (NRC) and STC (Sound Transmission Class) ratings are used to measure how absorptive a particular material is. The NRC rating is representative of the ratio of sound that is reflected back into the area where the sound has originated. It is generally an appropriate tool for the selection of interior finishes, such as when designing auditoriums or gymnasiums. Where insulation is installed behind an interior finish for sound attenuation, the NRC of the exposed insulated cavity is not applicable, and NRC rating gives little indication of how sound is transmitted through an assembly. In these situations, STC rating gives a more appropriate - even if still imperfect - indication of performance.

The STC rating of a building assembly is a reasonable measure of how effective a wall assembly is at preventing sound transmission through the assembly. However, it is important to note that the frequency range for the STC testing is limited to 125 Hz - 4,000 Hz. This range of frequencies is the common set for human speech, and was selected because traditionally speech attenuation was the primary concern. The difficulty arises due to the fact that human hearing has a range that varies from 20 Hz - 15 kHz, and modern stereo equipment can generate sound at a range of 10 Hz – 48 kHz. Exterior noise can be generated even further outside this range. As a result, the STC rating does not give an accurate representation of performance in all situations, and against all frequencies.

Field Performance

A second fundamental difficulty in sound design comes from the differential in performance between an assembly as designed and its performance in the field. These deficiencies can be the result of poor workmanship, unforeseen circumstances, or the choice of insulation, and in combination, can cause a significant drop in the performance of a wall. Even simple penetrations such as light switches and electrical outlets can contribute to a dramatic loss of performance.

To quantify the typical performance loss, the Canadian Building Code actually notes that builders often design for STC ratings 5 dB higher than the code requirement in order to overcome "construction deficiencies, penetrations, and flanking paths". This is actually a fairly dramatic upgrade, and usually at considerable expense; an increase in STC rating by 5 dB should provide the ability to attenuate sound at more than twice the intensity.

In order to encourage a higher construction standard, the Canadian Code actually grants an alternative standard for compliance by testing in the field. Field-tested assemblies need to meet a rating that is substantially lower than the laboratory rating, based on the poor reliability of laboratory results. This type of provision is not yet available under the U.S. national building codes.

Icynene®

Sound can travel through a variety of mediums, but the most common means of transport is through air. The most effective way to reduce the transmission of airborne sound is therefore to effectively control air movement. As a combined air barrier and insulation, Icynene® is an effective means of reducing sound problems that are the result of air leaks, penetrations and alternative (flanking) sound paths. The best practice is to partially fill the cavity, sufficient to provide an air seal but also to provide an air gap discontinuity for the transmission of sound. Moreover, its flexible structure is designed to provide a durable, reliable air-seal for the life of the building.

Icynene® fills every gap and crevice in the building cavity while adhering to all adjoining components for a tight seal. By greatly reducing airborne sound transfer, flanking sound, and the effect of drywall penetrations, wall assemblies insulated with Icynene® generally do not suffer from the typical performance difference between laboratory and field STC ratings. The overdesign that is typically necessary to guarantee performance can be reduced; the savings in terms of both material and cost are considerable.

Structural Vibration & Impact Noise

Certain types of sound transmission cannot be resolved through the use of insulation materials, even when using a combined air-barrier and insulation material. This can be either because of the frequency at which the sound is transmitted, or because of the nature of the sound itself. Very-low frequency sounds have the ability to be transmitted through the building structure, bypassing any insulation materials in assembly cavities.

Impact noise, specifically, is not transmitted through air, and rather causes vibrations through the building structure itself. Adding insulation will not dampen those sounds effectively; and providing sufficient mass can become very costly. Instead the solution relies on properly addressing the issue at the design stage.

For the best possible performance, Icynene® should always be combined with other sound attenuation practices, including structural dampening, structural breaks, and point source isolation. Further reductions in sound transmission are achieved by adding mass to the wall or ceiling; low cost and ease of installation make adding gypsum board or drywall the preferred method to significantly increase STC values. Additional measures can also include the use of resilient channel systems, mounting mechanical equipment on pads, or ensuring point sources (speakers and subwoofers) are not directly in contact with walls or floors.

Summary

The evolving habits of modern homeowners are constantly generating new challenges for designers, and sound attenuation is no exception. These challenges are further compounded by the use of testing procedures that do not universally reflect field conditions.

No matter the application, Icynene® provides a reliable air-seal for the duration, reducing the effect of airborne sound leakage and alternative sound paths. Alongside structural dampening and point source isolation, Icynene® is a necessary addition to any comprehensive sound design strategy. Icynene® also reduces the need for costly overdesign by bridging the gap between laboratory ratings and performance in the field.

Icynene® is a low-density soft foam insulation, which is sprayed into/onto walls, crawlspaces, underside of roofs, attics and ceilings by Icynene Licensed Dealers. Sprayed as a liquid, it expands to 100 times its volume in seconds to create a superior insulation and air barrier. Every crevice, crack, electrical box, duct and exterior penetration is effortlessly sealed to reduce energy-robbing random air leakage. Icynene® adheres to the construction material and remains flexible so that the integrity of the building envelope seal remains intact over time. Icynene® is ideal for residential, commercial, industrial and institutional indoor applications. **Information about Icynene® can be obtained by visiting Icynene.com or contacting your local Icynene Licensed Dealer.**

Design Assumptions for HVAC & Ventilation Design Note

The use of Icynene® in a building offers the opportunity for dramatic improvements in energy efficiency and comfort. By minimizing air leakage, Icynene® changes the way buildings fundamentally perform, and the demands on the HVAC system. In each structure, variations in climate, orientation, window areas, etc will determine the extent of the impact Icynene® can have on the overall building. Because each situation is different, it is impossible to use a rule-of-thumb to determine the specific heating and cooling loads. Instead, it is more important to understand how the use of Icynene® changes a building's performance and then use a standard HVAC design software package to calculate the loads.

Increased Performance

There's no denying that installing Icynene® in a building can substantially reduce heating and cooling loads. This improved performance can be entirely attributed to the fact that Icynene® is both an air barrier and insulation material. Blower Door diagnostic air leakage test results for residential buildings insulated and air-sealed with Icynene® consistently test at less than 1.5 Air Changes per Hour (ACH) @ 50 Pa of pressure (ACH_{50}). When converted to leakage rates based on natural pressure, well-built houses insulated with Icynene® typically range from 0.05 ACH to 0.1 ACH at natural pressure (ACH_{nat}). Basing HVAC design for space conditioning on a design infiltration / exfiltration number of 0.1 ACH_{nat} provides a conservative means to address field variability, and is therefore recommended. This compares very favorably to conventionally constructed residential buildings that often test at 5 to 7 ACH_{50}, or 0.6 – 0.7 ACH_{nat}.

In the interest of customer satisfaction and to ensure that desired interior design conditions can be met at all times, there is a natural tendency to add considerable extra heating and cooling capacity when selecting equipment. This common trend to oversize is understandable with typically constructed (leaky) buildings, due to the unpredictability of performance. However, oversizing equipment in predictably tight buildings leads to equipment short-cycling, resulting in elevated humidity levels, and therefore, added liability for the HVAC designer in the event that moisture/mold problems develop in the building.

Mechanical Ventilation

Many new structures are excluded from requiring a dedicated mechanical ventilation system because the natural infiltration rates exceed the delivery volume of the mechanical ventilation system – it is assumed that the natural ventilation provides sufficient ventilation. However, natural ventilation is unreliable, and can often transport humidity into locations where moisture problems can result. Homes that are air-sealed and insulated with Icynene® do not rely on natural infiltration for ventilation. Instead, a mechanical ventilation system is required, in order to meet the code requirement for ventilation and to ensure the proper function of the home.

HVAC in a Conditioned Attic or Crawlspace

In regions where standard construction practice involves the location of HVAC equipment in typically unconditioned spaces like attics or crawlspaces, the conversion to unvented attic or unvented crawlspace systems can lead to substantial reductions in energy consumption. Note that because most attics and crawlspaces can add a considerable amount to the volume of conditioned space, unvented attic or crawlspace systems can only reduce energy consumption in situations where duct losses to the outdoors are significant. Unvented attic and crawlspace systems should therefore not be used indiscriminately.

Depending on the jurisdiction, these assemblies can be referred to as conditioned space, indirectly conditioned space, or even buffered unconditioned space. In any case, the decision to locate HVAC and distribution systems in an unoccupied, indirectly conditioned space requires that special provisions be met. For attics, the HVAC and distribution system should be accommodated as follows:

1. The volume of the attic is added to the conditioned volume of the house.
2. Ducts and equipment should be specified as "within the conditioned envelope", with duct losses back into the conditioned space. The duct loss percentage should remain representative of the actual duct losses.
3. No supply or return terminals or registers are to be installed in the attic, as this area will not be directly conditioned.
4. Combustion appliances are to be sealed combustion units, and fitted with an outdoor air intake. Combustion units are to exhaust directly to the outdoors.
5. Vents originally intended to exhaust into the attic (plumbing stacks, dryer vents, etc) shall be continued through to the outdoors.

The decision to locate HVAC and distribution systems in an unoccupied, indirectly conditioned crawlspace should be accommodated as follows:

1. Ventilation is to be provided in accordance with the requirements of 2004 IRC Section R408.3.
2. The volume of the crawlspace is added to the conditioned volume of the house.
3. Ducts and equipment should be specified as "within the conditioned envelope", with duct losses back into the conditioned space. The duct loss percentage should remain representative of the actual duct losses.
4. Combustion appliances are to be sealed combustion units, and fitted with an outdoor air intake. Combustion units are to exhaust directly to the outdoors.
5. Vents originally intended to exhaust into the crawlspace shall be continued through to the outdoors

Field Reliability

Today's buildings are far more vulnerable than those built even 50 years ago. Building practices have changed; it is now too expensive to build as we once did. As a result, small design errors can lead to condensation problems. A properly sized space conditioning system, coupled with a dedicated mechanical ventilation system, is required to controlling moisture issues and providing performance for the life of the building.

Proper design has to start with tried and proven concepts based on the results of years of comprehensive field experience. These design recommendations have been developed through the guidance of many of the US's top building science engineers, and based on years of field-testing. The net result is designs that can achieve an average of 30 to 50% reduction in space conditioning loads, and a similar reduction in energy costs.

Ventilation is a necessary requirement for the proper operation of any home. Many existing homes rely on natural ventilation to control interior humidity, odors and combustion products. Natural ventilation is wind dependant and therefore unreliable. The quality of construction, however, is improving, and homes are becoming tighter and more energy efficient. These houses cannot rely on natural ventilation and as a result new residential buildings are developing a need for mechanical ventilation.

The Drive to Energy Efficiency

In older buildings, uncontrolled air leakage can be responsible for 50 % to 60 % of the heating and cooling energy consumption and 40% of the overall energy consumption, prompting many energy conscious homebuilders to focus their efforts on reducing air leakage.

The local building code sets the minimum level of ventilation air required to maintain the health of both homeowners and their home itself at approximately 0.35 ACH_{nat}[1]. Typically the average house is sufficiently drafty, that this minimum level of ventilation air can easily be met by air leakage. New energy-efficient homes are able to reduce air leakage rates to a level that are far less than the minimum required for ventilation. A dedicated mechanical ventilation system is therefore a necessary component in any energy-efficient home and is highly recommended for all homes. The mechanical ventilation system assists in control of interior humidity, odors and chemical pollutants, emissions of combustion appliances, and indoor microenvironments.

Interior Humidity

Interior humidity is generated by normal human activities, such as showering, cooking, cleaning and breathing. In fact, any activity where an item or surface has to dry causes an increase in interior humidity levels. Ineffective management of interior humidity leads to complaints of reduced occupant comfort, pollutants and increased potential for both mold and condensation damage particularly in hot/humid climates. In northern climates, excessive air exfiltration and infiltration due to stack effect causes uncomfortably low indoor relative humidity levels, and humidification is needed to compensate. Supplemental humidification, such as from a portable humidifier unit, does not always supply an even distribution of humidity throughout a home. As a result, problems from high humidity can even occur in houses with very low overall humidity conditions.

Interior Odors and Pollutants

It is important to note that anything that has an odor is emitting pollutants. This includes everything from cleaning compounds to food odors, to trash and even the perfumes we use to mask them. In a new house, this also includes many of the building materials, such as plastics, paints, carpets, and furniture. <u>Indeed, every product must meet a strict set of emissions specifications in order to be approved for household use.</u> However, where a single product may not generate a substantial amount of emissions, a whole house full of new paint, furniture, and carpet can be well above the safe limits.

Smells are transmitted through diffusion, and continue to spread until their concentration is uniform throughout an entire house. Although this process may dilute a pollutant sufficiently to eliminate the odor, it does not mean that the chemical has disappeared. With many chemical compounds, even low concentrations can be detrimental to occupant health, especially in cases

[1] International Mechanical Code: Table 403.3

of prolonged exposure, such as in the case of elderly or young occupants. The effect is further increased when the occupant is in poor health or sensitized.

Combustion Appliances

What many homeowners do not realize is that there are some heating appliances that actually rely on the available air within the living space for the supply of combustion air. This includes unvented heaters, kerosene heaters, and other combustion appliances that also vent combustion products into the indoors. Of course, it is typically the most drafty homes that require these supplemental heat sources, creating a fairly good match. However, if the home is insulated and the air tightness increased, then these appliances are polluting the home and should be vented to the outside.

Combustion devices should not only be fitted with a direct exhaust, but also with a dedicated intake, in order to supply the unit with combustion air. The dedicated intake is necessary in order to prevent conditioned air from being continually drawn into the mechanical room. Without a dedicated intake, the house can become negatively pressurized; drawing cold air in through the envelope and increasing heating loads, or even causing the chimney to backdraft.

Microorganisms

Ambient outdoor air presents a significant contribution to indoor air quality. Ambient air contains mold and mildew spores, bacteria, pollens, dust, etc. In addition, air leakage through structures carries water vapor with it, which can condense on colder surfaces. This condensation can cause wood decay and contributes to the set-up of microenvironments that are suitable for the development of mold and mildew. Mold, mildew and dust mites feed on organic materials such as the cellulose in paper and pet or human skin dander. Dust mite life cycles produce dried carcasses and feces that often become airborne and are known to trigger asthmatic attacks.

Ventilation Requirements

Traditionally, building ventilation concentrated on removing combustion products. Ventilation provisions further developed to remove large sources of moisture and odors through the use of fans in kitchens, washrooms, and even closets. The balance of ventilation occurs through either stack effect or wind pressures. Stack effect is the natural tendency for hot air to rise until obstructed. When outdoor temperatures are lower than indoor temperatures, stack effect causes warmer, humid indoor air to rise though joints and penetrations in the ceiling plane and escape through the attic. Cold, dry outdoor air enters at the base of the house to replace the outbound volume of air. Wind pressures act under any climate conditions to replace indoor air with outdoor air.

Although the initial cost is appealing, relying on natural ventilation can lead to a lack of adequate ventilation during the summer (minimal stack effect), and on windless days. In reality, all buildings should have some type of ventilation system so as to provide adequate air exchange during under-ventilated periods. With a few exceptions, building codes do not adequately address the requirement for mechanical ventilation in residential buildings.

With the emergence of energy efficient construction, stack effect and wind pressures can no longer be relied upon to supply adequate levels of ventilation. Indeed, energy efficient construction necessitates the use of a dedicated mechanical ventilation system. In air tight homes, only a dedicated mechanical ventilation system can provide adequate protection from the effect of indoor humidity, odors, pollutants, combustion appliances and microorganisms.

Often the decision to use a dedicated mechanical ventilation system is influenced by cost. In practice, energy efficient construction provides substantially lower heating and cooling loads, resulting in dramatic reductions in the required equipment capacity and operating costs. The use of lower-capacity HVAC equipment for space conditioning provides a large reduction in first cost. The end result is that the combined capital cost of the entire mechanical system remains roughly the same, but with a substantial increase in energy efficiency, condensation and mold minimization, and occupant comfort.

Icynene®

Icynene® is a combined air barrier and insulation material that is both flexible and durable, thereby ensuring that air-tightness can be achieved for the life of a building. A building envelope that is both insulated and air-sealed with Icynene® typically tests for peak air leakage at 1.5 air changes per hour (ACH) or less, at 50 Pascals (Pa) of pressure. In comparison, blower door depressurization tests on older homes have recorded 10 ACH @50 Pa. With the adoption of air barrier and insulation materials, typical new housing air leakage rates are now 5 to 7 ACH @ 50 Pa during peak leakage tests. Builders who provide extra attention, labor, and many sealing materials provide structures that test for peak air leakage at 3 to 4 ACH @ 50 Pa.

Because of its ability to provide a complete air-seal to the entire building envelope, the difference in performance between a house insulated and air-sealed with Icynene® and even a well built new house is dramatic. Natural air-change rates are typically 0.05 ACH to 0.1 ACH, with 0.1 ACH used as a conservative estimate for the design of the HVAC system.

Any house insulated with Icynene® should be equipped with a mechanical ventilation system that is sized to continuously deliver the full ventilation requirement, with no reliance on natural ventilation.

Emerging residential ventilation standards such as ASHRAE 62.2-2003 provide a comprehensive strategy for taking advantage of high-performance construction techniques, including the use of Icynene®. The end result is a healthier indoor environment, superior energy efficiency and ultimate comfort.

Like any specialized facility, hotels and nursing homes place demands on buildings that do not exist in basic residential or commercial structures. Hotels and nursing homes especially should provide feelings of comfort and establish an aura of quality, all without breaking the bank. Critical considerations in the design of hotels and nursing homes are:

- Maximize occupancy rates, referrals, lengths of stay and repeat visits;
- Keep guests comfortable, rooms are draft free, cool in summer, warm in winter;
- Reduce sound transmission between rooms and bathrooms and limit exterior noise transmission from planes, highways and the street;
- Control moisture and mold both inside wall cavities and room interiors;
- Provide high quality indoor air to accommodate guests with allergies, etc;
- Minimize energy cost;
- Minimize maintenance cost;
- Minimize construction time; and
- Minimize mechanical and electrical equipment costs.

With enough heat or air conditioning, even poorly insulated buildings can stay comfortable. The fundamental purpose for properly insulating a building is therefore to minimize energy costs. The most effective way to cost-effectively insulate a building is with Icynene®. Buildings insulated and air-sealed with Icynene® achieve a reduction in heating and cooling consumption between 30% - 50%. In addition, there are many additional benefits to be derived from eliminating air leakage.

Guest Comfort

In general, hotel guests have high expectations for their stay in any quality hotel, often far in excess of the comfort they expect from their own homes. No matter how discriminating their tastes, guests will feel the difference that proper insulating and air sealing makes over standard insulation techniques:

- No drafts;
- No cold spots on walls or ceiling in winter;
- Less humid rooms in summer;
- Less day-night temperature swing;
- Quieter rooms; and
- Improved interior air quality.

Moisture Protection

In hot and humid climates, mold and mildew are a primary concern for any hotel operation. Mold remediation is costly, and often requires that large portions of a building remain unavailable for guest occupancy for extended periods of time. Although not a major consideration in colder climates, in hot and humid climates the determining factor in whether or not a hotel can continue to operate can be its ability to prevent the formation of mold growth. Major mold remediation projects have even led to ambitious undertakings like the development documents like "*Preventing Indoor Air Quality Problems in Hot, Humid Climates: Design and Construction Guidelines*", and other similar contingency design manuals.

Icynene® is an integral part of any comprehensive mold attenuation strategy. Properly installed, Icynene® provides a means to reduce the potential for condensation and mold from forming, thereby protecting the structure, the interior finishes and furnishings, and above all the health of guests and employees:

- Airborne moisture and humidity are kept from entering the building and forming condensation in cold cavities;
- Reduced temperature differentials between rooms and corridors;
- Reduced transport of mold spores and better overall air quality;

- Assembly designs can be used that eliminate materials which impede natural drying cycles;
- Reduced moisture-related structural problems, increasing building life expectancy;
- Reduced cleaning frequency and prolonged life for carpeting, bedding and soft furnishings; and
- Replace individual room fans with direct mechanical exhaust and conditioned make-up air supplied to corridors.

Quieter Rooms

All sound barriers have the potential to be compromised by air leaks, which allow airborne sound to penetrate. By eliminating air leakage, assemblies air sealed with Icynene® are able to meet their laboratory-rated performance levels. There are many ways in which Icynene® makes it affordable to lower sound levels in rooms:

- Reduced wall thickness (from 2x6 to 2x4 construction);
- Reduced interior finish thicknesses;
- Reduced noise from interior fans and smaller, quieter A/C units; and
- Reduced bathtub and plumbing noise

Construction Efficiency

Employing Icynene® to insulate and air-seal projects can generate cost savings during construction by reducing site scheduling complications and material requirements. A single truck has an installation capacity of 15,000 board-feet per material set, with many trucks carrying multiple sets. This, combined with a wide coverage area (each truck is equipped with up to 300 ft of hose) contributes to substantial reductions in site clutter, and scheduling conflicts. As well, designs that include Icynene® allow the elimination of both the installation time, labor costs, and storage of materials associated with:

- interior vapor barriers;
- exterior building wrap;
- soundboard;
- preformed mechanical pipe insulation;
- glass fiber batts;
- individual room fans; and
- all associated fasteners & electrical work.

Electrical System Downsizing

In hot, humid climates, ambient outdoor air adds a considerable latent load to the air conditioning system, which is also responsible for dehumidification. By reducing the volume of humid outdoor air that enters the building envelope, air sealing has a dramatic effect on the air conditioning load, and on the associated electrical systems:

- Reductions in space conditioning requirements by 30% – 50%;
- Reductions in total and peak electrical energy consumption;
- Room circuits can be lowered to 110-120 volts;
- Reductions in room distribution panel sizing;
- Reductions in interior power distribution circuit sizing;
- Downsized power supply lines from the utility grid; and
- Reduction in service entrance transformer sizing.

Hotels and nursing homes continually present new challenges for design and construction. Regardless of whether a building is residential, commercial, institutional, or industrial, Icynene® provides an affordable and effective solution to energy efficiency and mold control. Given the choice, it is always more efficient to ensure that Icynene® is included at the design stage than to attempting to retrofit a building once the project is found to be suffering from issues of mold and moisture damage.

Icynene® is a low-density soft foam insulation, which is sprayed into/onto walls, crawlspaces, underside of roofs, attics and ceilings by Icynene Licensed Dealers. Sprayed as a liquid, it expands to 100 times its volume in seconds to create a superior insulation and air barrier. Every crevice, crack, electrical box, duct and exterior penetration is effortlessly sealed to reduce energy-robbing random air leakage. Icynene® adheres to the construction material and remains flexible so that the integrity of the building envelope seal remains intact over time. Icynene® is ideal for residential, commercial, industrial and institutional indoor applications. **Information about Icynene® can be obtained by visiting Icynene.com or contacting your local Icynene Licensed Dealer.**

While many older and historic buildings are beautiful examples of architecture, they tend to suffer from the same problem: they are not energy efficient. Old inefficient buildings cost much more to heat and cool than newer efficient ones, are drafty and uncomfortable, and allow outside noise and pollutants to enter through the building envelope. One of the single biggest improvements that can be made to older buildings is the addition of thermal insulation into empty wall cavities.

But insulating wall cavities brings new challenges in that the walls tend to be more susceptible to moisture accumulation and condensation problems. Cavity spaces play an important role in how a building manages rainwater penetration and interior humidity. The challenge faced by renovators is therefore how to insulate cavity walls in older buildings in a way that protects against moisture accumulation, without having to fully dismantle the wall.

Pour-Fill Solutions

The most common materials for cavity fill applications are cellulose, rock wool, or vermiculite. These materials are blown into the cavity through holes made through either the exterior cladding or the inside plaster. In heating climates, however, the addition of insulation prevents heat from reaching the exterior sheathing of the cavity, resulting in exterior sheathing that is very close to outside ambient temperature. This leads to an increased likelihood that the exterior sheathing will act as a condensation plane for any interior humidity that reaches this surface. While these cavity insulation materials can supply a sufficient level of R-value to the wall, their use does not supply an adequate level of protection from condensation, or even address issues of energy losses that are not due to conduction.

Beyond the fundamental issues of energy efficiency and moisture protection, traditional solutions are also susceptible to issues of installation. It is often impossible to guarantee complete filling of the cavity due to interior obstructions, with the solution typically involving hammering of the wall in the hope that this will shake the material down. Similarly there is the possibility that these materials can settle in time, leaving a void at the top of the cavity. These workaround solutions can often add significant time and cost to the project, without any guarantees of long-term performance or overall effectiveness.

Combined Insulation / Air barrier materials

Condensation in wall systems is generally a result of moisture movement by either diffusion or air leakage. However, it is generally accepted in the industry that air leakage is a far more significant mechanism for moisture transport than diffusion, due to the fact that air can carry very large volumes of water in the form of water vapor / humidity. As a result, insulation materials that also supply an air barrier to the wall cavity can dramatically reduce moisture movement and the resulting exterior wall condensation problems.

Icynene® Pour-Fill Formula

Icynene® is a combined air barrier and insulation material, and is therefore able to both insulate and prevent convective moisture accumulation. It provides a monolithic barrier against heat loss & air leakage, and will not shrink, degrade, or settle over the life of the building.

Although Icynene® provides convective (airborne) moisture protection to the exterior condensation surfaces, the insulation is not a vapor retarder, and therefore an interior vapor retarder may be required in cold heating climates where the interior relative humidity is high (high vapor drive). The vapor permeability of Icynene® does not impede drying of other building materials in the event of pipe/roof leaks or rainwater intrusion.

While moisture is free to diffuse through the insulation, continuous contact with the exterior sheathing ensures that this moisture remains in a vapor state and passes through the assembly without condensing on exterior or interior surfaces. Rain penetration is generally not a problem either, because Icynene® has a high perm rating, and does not exhibit any capillary action.

Installation

Icynene® cavity fill formulation is installed by injecting a liquid into closed wall cavities, though small holes ranging in size from a ½-inch (13 mm) to 1-inch (25mm) diameter. As a two-component liquid material, Icynene® runs to the bottom of the cavity, filling every void and bonding to the interior surfaces. Over a 2-3 minute period, the foam expands to approximately 40 times the volume of the original liquid. As the foam expands to fill the cavity, it remains in a pliable state, setting into an inert, soft, fine-celled foam plastic. By remaining flexible and bonding to the interior surfaces, Icynene® is able to supply a durable air-seal for the life of the building, regardless of how the building expands and contracts due to wind loading, thermal cycling, or seasonal changes in moisture content.

Site Assessment & Installation

An assessment of the building envelope is the first step in deciding if Icynene® is suitable.

1. Existing insulation materials interfere with the proper expansion of Icynene®, and must be removed prior to installation.
2. Uninsulated wiring (knob and tube wiring) must be removed, as it is generally incompatible with any type of insulation.
3. The building envelope should be leak free, the cavity space should not be integral to the drying of the exterior cladding.
4. The interior plaster/drywall must be able to resist the expansion of the insulation. While plaster in good condition can easily satisfy this requirement, plaster that is damaged or in poor condition should be repaired prior to the application of insulation.

The width and depth of the cavities are measured (using a probe) so that the amount of insulation to be injected may be determined. The location of diagonal cross bracing is detected this way, and additional holes are made below so that the foam may be injected into the space below the bracing.

Injection of insulation can be made from the inside or outside of the building. The method employed often depends on whether interior or exterior surfaces and finishes are to be renovated. Injections are timed so that there is minimal risk of bowing or blowing off interior finishes. Any excess material that oozes through the application holes is easily trimmed by hand.

Because it is installed as a liquid, there is minimal risk of Icynene® getting "hung-up" on plaster keys or nails. During expansion, the foam rises upward from the bottom of the cavity, completely filling the space through which it moves. However, if the style of construction indicates that there might be large obstructions within the wall (cross-bracing, etc), infrared thermography can be used to locate any pockets under large obstructions so that they can be filled. Once the insulation process is finished, the refinish of application holes is generally the responsibility of the finishing contractor or homeowner.

Better Performance: Old Buildings

In most climates, installing Icynene® in cavities as small as 1½ inch (38 mm) deep can result in a 90% reduction in heat flow through the cavity, while improving a building’s ability to manage moisture. Installing Icynene® pour fill material is one of the most effective ways to reduce excess energy consumption and improve the performance of old buildings. When combined with a mechanical ventilation system, the interior space will be quieter, more comfortable, and more energy efficient than ever before.

Icynene® is a low-density soft foam insulation, which is sprayed into/onto walls, crawlspaces, underside of roofs, attics and ceilings by Icynene Licensed Dealers. Sprayed as a liquid, it expands to 100 times its volume in seconds to create a superior insulation and air barrier. Every crevice, crack, electrical box, duct and exterior penetration is effortlessly sealed to reduce energy-robbing random air leakage. Icynene® adheres to the construction material and remains flexible so that the integrity of the building envelope seal remains intact over time. Icynene® is ideal for residential, commercial, industrial and institutional indoor applications. **Information about Icynene® can be obtained by visiting Icynene.com or contacting your local Icynene Licensed Dealer.**

Insulating Steel Roofs

The critical considerations in the design and insulation of flat or low pitch steel roofs are:

- Simplicity of installation
- Thermal performance
- Initial cost
- Life expectancy
- Maintenance cost
- Lifetime cost

Conventional insulation Approaches

Low-rise commercial and industrial buildings typically have metal roofs; these roofs have very large surface areas when compared to the rest of the structure. Because of this, a substantial portion of the heat loss and gain is expected through the roof. However, this also means that properly insulating and air sealing the roof can have considerable impact on reducing the building's heating and cooling bills.

A New Approach

Icynene® offers a superior, proven alternative to conventional air permeable roof insulation systems. The difference can often be a significant reduction in heating and cooling bills, even over traditional built-up exterior insulation systems. Additionally, installing Icynene® on the underside of the roof assembly provides a large reduction in condensation potential when compared to interior air permeable batt systems.

Air Leakage Control

Substantial reductions in energy consumption are achievable with Icynene® because it is a combined air barrier and insulation material. In cold weather conditions, the primary source of heat loss in insulated buildings can be hot air leaking up through cracks & joints in the roof assembly. By reducing the volume of air that leaks through the roof, annual heating bills can be dramatically reduced.

Condensation Control

Proper air sealing can also contribute to considerable reductions in condensation potential; hot air can hold a large amount of moisture, and can generate serious problems when this moisture is allowed to contact cold roof surfaces. Humid air can penetrate vapor retarders through gaps, around joints & penetrations, or at poorly taped seams; condensation that forms on the roof deck can saturate the suspended batt insulation, eventually requiring the replacement of the insulation.

As a qualified air-barrier, Icynene® inhibits the movement of humid indoor air up to the underside of the steel deck. This prevents the formation of condensation on the underside of the roof deck. Icynene® is flexible and will not shrink or de-laminate with dimensional changes in the surface to which it is adhered, providing a reliable air-seal and protection from condensation. Additional vapor retarder protection may be required where high interior humidity or extreme climate conditions exist.

Design

When using Icynene®, the roof deck is installed on purlins mounted above open web joists or red iron framing. Weather sealant is applied on the steel deck. The depth of the purlins must be adequate to accommodate the thickness of insulation specified, plus 2 inches. A spacer is installed over the top of the purlins prior to laying the roof to provide a thermal break between the purlin and the roof. The preferred thermal break material is isocyanurate strip fastened with adhesive. The choice of roofing deck profile is governed by the goal to provide as little contact between the decking and the purlin as possible. Icynene® will fill the spaces between the purlins and the roof deck, creating an additional thermal break.

Installation of Icynene®

Site installation centers around the truck or trailer on which the application equipment is mounted. The equipment consists of spray equipment, electrical power, compressed air, and up to 300 ft of hose. Although a man-lift is required from which to work, all additional equipment is contained in the standard truck or trailer. Application rates are about 15,000 board feet per day.

Upon application, the insulation adheres to the substrate, is self-supporting, and requires no additional support system. It adheres well to steel. Icynene® can be installed in any climate zone, even extreme cold (Alaskan installations have been as low as 40 °F/C temperatures) when proper application techniques are employed.

After installation, the Icynene® is usually covered by an interior finish material. The choice of the interior finish will be dictated by appearance, maintenance and fire rating requirements. Interior finish options include, but are not limited to: a gypsum board or cementitious thermal barrier coating; suspended acoustical tile; or steel sheeting. In some situations, such as agricultural buildings, it may be possible to leave Icynene® exposed without a thermal barrier. Prior approval should be obtained where the insulation is left exposed to interior, occupied space. The insulation can be painted, but should never be power washed.

Roof Leak Management

One of the most important features of insulating a roof with Icynene® is the way in which roof leaks can be managed. Although Icynene® is designed as a complete air barrier, it allows for the drainage of water in the event of a roof leak. Water drains straight down through the material, simplifying the leak location process. Once the leak has been found and repaired, the insulation dries quickly, with no deformation or degradation in insulative or air sealing performance.

Icynene®

Icynene® provides a roof insulation solution to issues of energy efficiency and condensation control with less labor, faster installation and no dependency on good weather conditions. The insulation contains no CFCs, HCFCs, HFCs, or HFAs to cause corrosion of the metal deck or fasteners with which it is in contact. Additionally:

- Site traffic and material handling is reduced
- Roof leak maintenance costs are reduced
- Low insulation weight leads to thinner purlins
- Purlins do not require painting
- Simplified end-of-life roof replacement
- Paintable interior finishes
- No maintenance or replacement required of insulation, even under roof leak situations

Mold and Mildew: Causes and Cures

Mold and mildew are a major problem in warm, humid climates such as the U.S. southeast where as many as 70% of all homes are reputed to eventually suffer from mildew problems. Mildew increases the risk of making the building occupants sick and gives rise to expensive and frequent repairs and redecorating. Mildew is a mold that grows under warm, humid conditions. Optimal growth conditions are from 77° to 86° F (25° to 30° C), and between 62% and 93% relative humidity.

Sources of humidity in homes

Relative humidity (RH) inside buildings can be greatly increased by adding moisture to the air in many different ways. In houses, human activities such as preparing meals, washing dishes and clothes, steam baths, whirlpool tubs, showers, aquariums, plants, and even breathing add a lot of moisture to the air. A 15-minute shower can add 1.7 pounds (0.75 kg) of moisture to the air; a cord of uncured wood drying out can add 600 pounds (272 kg) of water; the infiltration of humid air can add 360 pounds (163 kg) of water a day to a typical home.

Moisture also enters from outside - through open doors and windows and by infiltrating the building envelope. Natural ventilation through cracks, crevices and chimneys will cause some air infiltration, but this is accelerated by makeup air entering the building to replace air that has been "exhaled" by exhaust fans. Infiltration can change the air 24 to 48 times a day, and when moisture laden outside air is brought in it throws a tremendous load on air-conditioning equipment. This moisture can amount to hundreds of pounds a day. With 100% relative humidity, clothing, paper products, wood and some textiles can absorb up to 20% of their weight in water.

Another source: oversized air conditioners

Improperly sized air conditioning units can also greatly increase the humidity inside buildings as well. The role of air conditioning in humid conditions is twofold: remove moisture from the air, and reduce the temperature. Removing moisture from air requires a far greater amount of energy than simply lowering the temperature. Thus, it is vital that A/C units run constantly in humid conditions to keep the RH below 60% (the level at which mildew mentioned previously begins to grow)

Unfortunately, A/C units are often oversized in humid climates for the load requirement of the building. In these cases, the units only run long enough to reduce the air temperature, and do not actually remove much moisture. The result is a lower indoor temperature, but actually a higher RH (colder air cannot hold as much moisture as warmer air). To the occupants, this environment feels clammy or “cave-like” and less comfortable. This causes the occupants to turn down the thermostat further, which can make the problem worse, and wastes energy keeping the building cooler than it needs to be.

Oversized A/C units are commonplace in humid climates because of building practices of the past. Older buildings had high rates of random air leakage. Ductwork for systems was typically placed in unconditioned spaces (i.e. attics and crawl spaces), and there was a loss of conditioned air into these spaces due to leaks in the ducts (see design note titled: *Insulating and sealing Ductwork*). These practices led to a great uncertainty for the A/C contractor, who had to design a system to make up for the shortcomings. The result was over-designed, oversized units.

Solving the problem: control air-leakage and correct A/C sizing

The only way to avoid mildew is to control the interior RH through reduced air leakage and proper sizing of A/C equipment. Building an air-tight structure accomplishes two things: it limits the amount of moisture-laden air that gets inside, and it makes life easier for the A/C contractor, who can size a system that does not need to account for all that random infiltration. A properly sized A/C unit runs for longer periods, removing more moisture from the air and lowers the RH as a result. Further reduction in A/C sizing can be achieved by sealing ductwork and/or installing ductwork within the conditioned space of the building (see design note titled: Benefits of the *Unvented Attic Assembly*). Unfortunately, constructing buildings in humid climates that are free from high RH and mildew has been difficult to achieve in the past.

Vapor barriers are NOT the solution

Most air leaks into buildings through sill plates, electrical outlets, duct systems, and penetrations through attics, floors, and around windows and doors. One attempt to combat the moisture problem has been to apply a vapor barrier placed against the inside of the interior wall. This is the wrong place for a vapor barrier in a humid climate. The vapor barrier, at this relatively cool location, provides a surface for condensation to occur as outdoor air moves inside. Placing the vapor barrier on the inside of the exterior wall creates another problem in the winter, when interior vapor is trying to move outside.

The solution is a monolithic air barrier with Icynene®

The recommended solution was first proposed by the School of Building Construction at the University of Florida: eliminate the use of a vapor barrier and instead use an air-retarder in the wall to inhibit the passage of airborne moisture into the building. While an air barrier inhibits the entry of air it must be slightly vapor permeable to allow building materials to dry.

Icynene® is a site-installed cellular foam material that provides an excellent air barrier throughout the entire building envelope. By expanding into cracks and crevices and adhering to other building materials, this soft flexible foam ties all other building assembly materials together into a monolithic continuous envelope.

No other sheet-type air barrier material or method can match Icynene®'s performance when applied to an entire building situation. With the air-sealing ability of Icynene® in place, preventing outdoor moisture from entering the building the A/C contractor can select a system that is sized appropriately for the cooling load. Experience has shown that typical A/C size can be reduced by 30 to 50% in humid climates. The smaller unit(s) run for longer periods of time keeping the indoor RH lower while consuming less energy.

Additional tips for occupants

- Set air-conditioner temperature higher when using a ceiling fan.
- Set heating thermostat lower when they are away from the house.
- Keep the interior temperature below 75° F (24° C) and RH below 60%.
- Wipe-dry any thing that gets wet after use - things like shower doors, wet floors and tiles, counter-tops, sinks, and spills in general. And hang wet towels, mops and clothing outside to dry. By doing this, the amount of moisture that will be evaporated inside the home will be drastically reduced.
- Operate exhaust fans sparingly.
- Close the fireplace damper when not in use.
- Keep doors and windows closed in the morning or after a rainfall, when the humidity is high.

Tips for builders

- Build a tight building easily using Icynene® insulation.
- Install mechanical ventilation that also dehumidifies incoming air.
  - Ensure that shower stalls and baths drain properly and don't puddle.
  - Waterproof and seal exterior block walls.
  - Do not install a vapor barrier on exterior walls, except for earthen crawl space floors.
  - Comply with local building codes.

Mold Abatement & Rehabilitation

There are a considerable number of mold remediation contractors and experts working in buildings throughout North America. Questions have been asked as to how spray foams fit with strategies to avoid mold. The purpose of this Design Note is to identify where and how the use of Icynene spray foams might dovetail with effective mold abatement and control strategies.

Mold

To be able to control mold it is necessary to understand what mold is & how it forms. Mold is a family of naturally occurring organisms that exist in nature to break down organic matter. Mold species can grow almost anywhere if the conditions are right. Basically, mold growth requires:

- Mold spores
- A food source (organic matter)
- Moist conditions—generally above 80% relative humidity
- Favorable temperatures—generally above 40° F (5°C)

Mold spores are common throughout our environment so they are very difficult to control.

Many construction materials, such as wood framing, sheathings and trim, the paper facing on drywall and other finishes are organic but they are difficult to eliminate. Even if organic materials could be eliminated, a lot of household dust is organic so food sources would still be common in buildings.

Therefore, the most effective strategies for controlling mold focus on controlling moisture and surface temperatures. Given that spray foam insulation can help control both issues, the usefulness of Icynene spray foams begins to become obvious.

Moisture Sources

Moisture can enter the building envelope by several mechanisms. The primary transportation mechanism is water or snow infiltration. Groundwater or rainwater typically enters a building through construction or detailing that is improperly designed or installed. Water infiltrating the building via this mechanism can be substantial. *Spray foam insulation materials typically should not be used to stop such leaks, rather they should be corrected by selecting and installing flashings, claddings, roofing, exterior-grading or other details before other aspects of the building such as insulation are put in place.*

Moisture can also accumulate or move through building assemblies through capillary action—many construction materials such as wood and concrete are porous so they can absorb and move moisture into concealed areas causing problems. The most effective means of controlling these sources of moisture involve providing barriers (e.g. waterproofing) or gaps (drainage planes) to deflect moisture away from moisture-sensitive materials.

Often such problems are easily identified yet difficult and costly to correct. For example, it is typically very costly and difficult to excavate a foundation wall to provide waterproofing or a drainage layer to control moisture. If this is not done, it becomes necessary to provide other paths for drying. Many designers specify Icynene low density open cell foams specifically to allow drying to take place. *Care should always be taken to ensure that there are no pre-existing bulk water leaks to deposit large quantities of water, interstitially, in moisture sensitive areas. Also, always consult local Building Codes and/or Icynene Engineering personnel to determine if a vapor diffusion retarder/barrier is needed in a particular assembly in your climate zone.*

Air Leakage & Diffusion

One of the most important reasons for choosing to use a spray foam product in a mold abatement/retrofit project will be to control air leakage. Air leaking through assemblies will often be cooled to the point where condensation can occur (i.e. at the "dewpoint" temperature.) This can result in moist conditions on vulnerable materials…the ideal conditions for mold.

Spray foam tends to be helpful in controlling such problems for two reasons:

1. It controls air leakage.
2. It insulates the surface exposed to moist conditions so surface temperatures are maintained above the dew point temperature and surfaces stay drier.

Additionally, depending on climate zone and assembly type, it may be necessary to consider whether diffusion control is required. In colder climates (ICC Climate Zone 5 and above) a vapor retarder may be required. This may be provided by the foam itself (check permeance data in Evaluation Reports) or by use of a separate vapor diffusion retarder / barrier. If in doubt, consult Icynene Engineering support for recommendations.

Mechanical Systems: Helping or Exacerbating the Situation?

Another factor affecting humidity levels in buildings is the design and sizing of the HVAC equipment and the way it is used. Some common issues typically encountered after significant building envelope retrofit work include the following:

1. Over-sizing of the Heating or Cooling equipment: In a building where significant improvements are made in heat loss/gain the existing equipment may be oversized resulting in a loss of efficiency. More important for cooling systems is the effect oversizing has on moisture removal. If a cooling system is oversized it is no longer operating long enough to be effective at removing moisture from the air. The result can be a "clammy" indoor environment prone to humidity and mold problems.
2. Air tightness effects on Combustion Venting and / or Combustion Air: Air tightening and sealing work can significantly reduce the combustion air available for conventional naturally-vented combustion devices (e.g. furnaces, water heaters and fireplaces.) The safety of these devices can be simply checked—contact a Building Performance Institute, Certified Auditor or Combustion Appliance Zone qualified HERS rater for more details.
3. Changes to the natural ventilation rate of the building: Reduced air leakage results in less natural ventilation. In heating climates, this can bring about higher humidity levels in interior environments. Mechanical ventilation may be required—contact a HERS rater or BPI Certified Auditor for assistance.

Additional Considerations?

All building envelopes have the potential at some time to get wet. It is highly beneficial for the building envelope system to have the potential to dry quickly and energy efficient buildings especially require special care in order to achieve this. Once wetted the components should have the potential to dry quickly and should not impede the drying of the other components (should have a high perm rating). At the same time, the components of the building should resist wetting.

Designers and building owners are also increasingly concerned about durability and therefore value the other benefits spray foam insulation can bring to the table.

Why Icynene®

Icynene spray foam products have been tested and found not to be a food source for mold. The air barrier characteristics of the foam also help to prevent the ingress of mold spores into the foam.

Icynene® low density foam insulations resist moisture absorption and are flexible materials with a high Perm rating. They resist getting wet and dry quickly without impeding the drying of other building materials. Wetting has no detrimental effect on the air-sealing or insulation performance after the insulation has dried.

Where additional structural rigidity or resistance to vapor permeance might be required, Icynene medium density foams and coatings can be used to produce assemblies that correct fundamental flaws that may have existed in the original building design.

Regardless of type, all Icynene spray foam insulation products qualify as insulation and air barrier materials that provide a durable and reliable air-seal for the life of the building.

With more than 25 years experience producing durable, energy efficient foams for the residential and commercial building construction industry, Icynene is the most respected name in the spray foam industry. It is the leader in low Global Warming Potential, non Ozone depleting, PBDE free, spray foam.

Once a building has been made water tight and any existing mold problems have been remediated, the superior performance characteristics of Icynene® foams make it the material of choice for builders, remodelers and architects dedicated to energy efficiency & mold prevention.

The Economic Thickness of Thermal Insulation

Designers frequently ask questions like "what is the optimum level of insulation to provide?" Others are interested only in cost so they look for the economic thickness or "payback" on increasing insulation levels. Still others want an insulation level to achieve a certain level of performance (e.g. 50% of Code-level energy consumption). If the answer was simple there would be one common insulation level for all components of all buildings in a given climate. That is not the case so what is going on? Some variables argue in favor of increasing wall and attic insulation levels such as:

- Attic and wall cavities are easier to insulate than windows and doors so that makes it possible to achieve higher thermal resistance versus other components.
- The savings in energy brought about by insulation might bring about the ability to reduce sizing (and cost) of mechanical systems, thus justifying higher insulation costs.
- Above-grade elements are more exposed than below-grade elements so insulation provides an even greater benefit above grade.

Some variables argue against increasing insulation:

- Measures that thicken wall assemblies eat into available floor space which comes at a cost.
- Thicker walls might require thicker foundations and modifications to windows adding cost.
- If measures are not taken to air tighten an assembly, the effect of added insulation may be negligible.
- Some insulation materials are more costly per unit of R-value so they do not provide sufficient pay back to justify high levels of insulation.

Beyond the building and site-related variables are issues like:

- Energy costs: With historically low energy prices there has not been as much incentive to conserve energy. Clearly that is changing and will continue to change in the future.
- Non-energy benefits: Typically, better insulated and air sealed buildings are more comfortable and more durable so building owners may be willing to pay a premium for such benefits.
- Some buyers are willing to pay a huge premium to be "energy independent" or off-the-grid.
- Borrowing costs: If the money to make an improvement is borrowed, it comes at a cost which must be factored against energy savings.

This Design Note is not intended as a recommendation of a particular R-value or method of designing buildings. Rather, if a designer has formulated an opinion on what type of building(s) he is building (built to minimum Code or some standard above Code i.e. LEED, NAHB Green, etc.) it suggests alternate ways of justifying/ achieving equal or better performance.

Code Minimums

In any design project, it is necessary to consider what is the minimum, Code-prescribed, level of insulation that should be installed.

In the US, the International Residential Code prescribes the following levels of insulation in various climate zones:

Table 1: Prescriptive Insulation Levels in the IRC 2009.

Zone	Ceiling	Walls	Basement
1	30	13	0
2	30	13	0
3	30	13	5/13*
4	38	13	10/13*
5	38	20 or 13+5**	10/13*
6	49	20 or 13+5**	15/19*
7	49	21	15/19*
8	49	21	15/19*

Notes: * Continuous vs. Cavity insulation only
** Cavity insulation + Continuous insulation

Anyone looking for one specific R-value as a *minimum* might find this table confusing--it suggests that continuous insulation at a lower R-value is equivalent to cavity fill insulation at a higher R-value--but there are good reasons for the Code to be written in this way.
As we insulate wall and ceiling cavities to higher levels, we find that the remaining heat flow through structural elements becomes a much higher percentage of the total. Rather than increasing insulation levels in the cavity

spaces, it becomes much more important to provide continuous insulation over structural features that otherwise act as "thermal bridges" through the insulation.

That is one of the areas where Icynene® spray foams can be used to greatly improve heat loss/gains. Continuous spray foam insulation applied over structural elements can help eliminate thermal bridging through structural elements, controlling heat loss/gains. For example the underside of roof rafters can be insulated in an unvented attic application. This also makes buildings more comfortable.

"Equivalent" Assemblies

The arguments of "equivalent" Code minimum levels also apply to higher levels of insulation. Table 2 provides groupings of wall assemblies that are *roughly equivalent in terms of **conductive** heat loss.*

Table 2
Roughly Equivalent Wall Assemblies

Group A 2x6 Wall 24" OC with R-20 Cavity 2x4 Wall 16" OC with R-13 Cavity + R-5 Continuous
Group B 2x4 Wall 16" OC with R-12 Cavity + R-10 Continuous 2x6 Wall 24" OC with R-20 Cavity + R-5 Continuous 2x6 Wall 24" OC with R-30 Cavity
Group C 2x6 Wall 24" OC with R-20 Cavity + R-10 Continuous 2x4 Wall 16" OC with R-13 Cavity + R-15 Continuous
Group D 2x6 Wall 24" OC with R-20 Cavity + R-15 Continuous 2x4 Wall 16" OC with R-13 Cavity + R-20 Continuous

As can be seen in the insulation levels identified as Group B in this table, it takes a very high insulation level in a wall cavity (R-30) to be equivalent to a wall assembly with continuous insulation over the studs (R-12+R-10 Continuous.)

One might also expect that a wall insulated to a very high level such as those listed in Group D might have reduced energy use by a very high percentage. But in reality, once wall cavities are filled, conductive heat loss through walls is a small percentage of the total heat loss of a building so the impact of adding R-value alone tends to diminish as insulation levels increase.

Consider the conductive heat flow equation:

$$Q = \frac{A \times \Delta T}{R}$$

Where:
Q = Rate of heat flow (BTU/hr)
A = Area (ft^2)
ΔT = Difference in Temperature (°F)
R = Resistance to conductive heat flow (hr.ft^2 °F/BTU)

Even a 300% increase in R-value only reduces conductive heat loss through walls 75%. If you consider that heat loss/gains through walls is a fraction of the total heat loss/gains of a building, the effect might be in the range of a 10% saving on *total building energy use*.

Adding insulation to walls follows a pattern of diminishing returns. As an example, consider 1000 ft^2 of insulated area with a temperature differential of 40°F. We will start with a 1" layer of Icynene® increasing the insulation thickness by 1" increments at R-3.7/inch up to 14" and that is R-51.8. The heat flow rates are shown in Figure 1.

Figure 1
Conductive Heat Flow Reduction

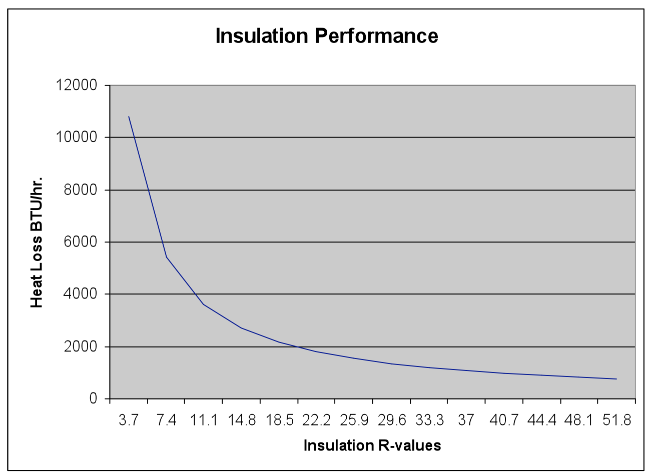


Figure 1 illustrates how heat flow is reduced as R-value is increased. Around R – 20, the curve beings to flatten and diminishing returns are gained from increased insulation thickness. At that point it makes much more sense to begin to provide continuous insulation over the wall to address thermal bridging.

Reduced Air Infiltration

Thus far, the discussion on heat loss/gains has focused on conductive heat loss but heat transfer occurs by other means as well. In many buildings, uncontrolled convective heat loss accounts for as much as 40% or more of total energy consumption. Icynene® spray foams are able to fill any number of irregular shaped cavities and they adhere to most construction materials, thereby, forming an insulation layer with very low air permeance.

Conventional fibrous insulation materials are air permeable, so they cannot control air flow. Furthermore, the air sealing details required to control air flow with fibrous insulation products can be very time consuming, labor intensive and costly. Icynene® spray foams are a more reliable way to consistently deliver a building with exceptional energy performance.

Combined Effects

Oak Ridge National Laboratory (ORNL) conducted an experiment[1] to determine the efficiency of a roof assembly insulated with low density, loose-fill fiberglass insulation and discovered that up to 50% of the heat loss occurred as a result of convection; air circulation through the insulation. This study showed that convective heat transfer had a significant negative impact on insulation performance.

In Canada, the National Research Council Institute for Research in Construction (NRC-IRC) conducted a series of research projects to assess the overall performance of insulated wall assemblies.

Wall assemblies insulated with low density and medium density polyurethane foam insulation consistently out performed fibrous insulation assemblies when they were tested when air pressure was applied. NRCC produced a Wall Energy Rating factor that compared the performance that was delivered during testing versus the expected performance based on Nominal R-value. Spray foams consistently performed at more than 90% of nominal R-value where as fibrous insulation had performances in the range of 35% to 65% of nominal R-value.

[1] ORNL's Building Envelope Center
Fighting the Other Cold War
URL: http://www.ornl.gov/ORNLReview/rev26-2/text/usemain.html

Computer Simulations

The selection of the optimal level of insulation can be complicated but software tools such as REM/Design, HOT 2000 and EnergyGuage can be a powerful way of simplifying trade-off analysis. Such analyses are useful for allowing designers to examine how adding insulation and air sealing reduces required capacity in heating and cooling systems.

The following evaluation was generated using the REM/Design energy analysis software as reflected in the charts (2.1 – 2.4). This evaluation deals with three identical houses, located in different North American cities with three different levels of insulation and air-infiltration. A fully detached, approximately 3,500 ft², two storey house with a conditioned basement was studied in 10 different cities. The analysis considered the merits of increasing insulation versus increasing air tightness. The comparable data used in the computer analysis was as follows:

Table 3
Specifications for Comparison Houses

	Nat. Air Infilt.	**R-Value Wall**	**R-Value Ceiling**
1. Base Case	0.55	19	30
2. Higher R-value	0.55	19	43
3. Icynene	0.10	11	18

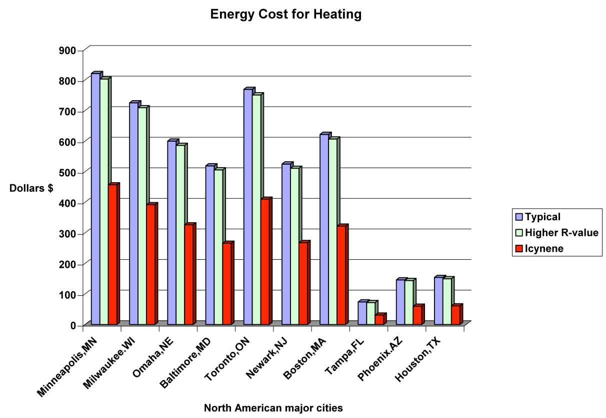
Both the base case and upgraded mineral fiber insulation case used an air infiltration rate of 0.55 ACH at natural pressure. A recent study by NAHB indicated this was the average value for newly constructed residential buildings in the U.S.[2]

The **Icynene®**, *house used Lower R-values than even the base case or the upgraded insulation house. The key difference was the use of Icynene light density spray foam--an air-impermeable insulation*. An air infiltration rate of 0.1 ACH at natural pressure was used for Icynene® based on its air sealing capability, as determined by NAHB[2].

Heating and cooling costs and the required heating and cooling equipment capacities were estimated for each set of house specifications in 10 different cities.

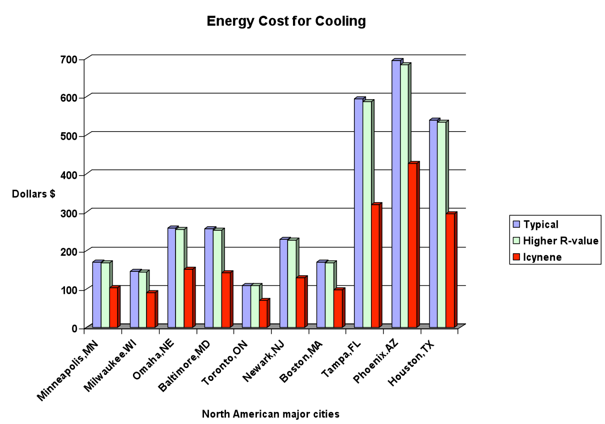
[2] NAHB Research Center, November, 2007;
Air Infiltration Data Analysis for Newly Constructed Homes Insulated With Icynene Spray Foam. The efficiencies of heating and cooling systems were 92 AFUE for the furnace and 13 SEER for A/C unit respectively with utility rates set at $0.10 per kWh for electricity and $1.50 per Therm for natural gas.

Figure 2
Annual Heating Cost by City



Savings on heating costs were up to 30%-40% with Icynene® compared to the **"Base Case"** and even when compared to the **"Higher R-Value"** insulation systems. The colder the climate, the greater the heating cost savings are with Icynene®.

Figure 3
Annual Cooling Cost by City



Icynene® provided similar savings in cooling. Savings of 20%-35% were noted versus the **"Base Case"** and **"Higher R-Value"** insulation systems. In terms of cooling, cities in a hot and humid climate show greater savings because of the higher cooling demand and latent load.

Figure 4
Heating Equipment Size by City

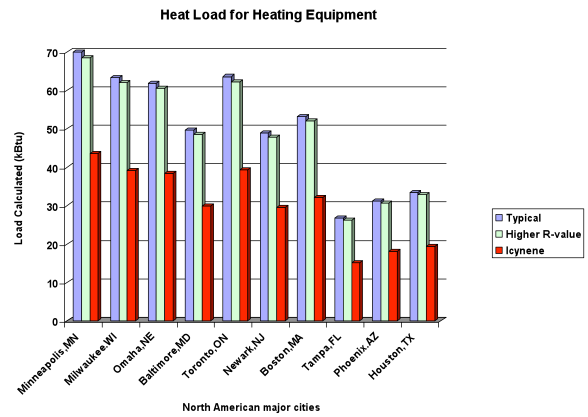
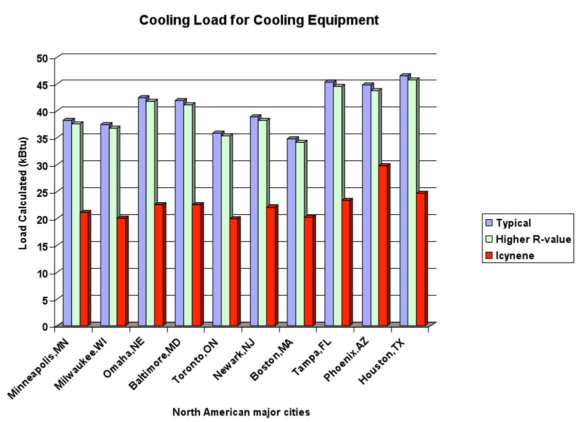


Figure 5
Cooling Equipment Size by City



As far as the sizing of heating and cooling equipment is concerned, the use of Icynene® provides a significant opportunity to reduce the capacity of both heating & cooling systems. Load reduction for both heating & cooling equipments can reach up to 35%.

Why Icynene

Whether you are looking to meet Code or go off-the-grid, Icynene®'s air-sealing capability virtually eliminates convective heat transfer within the insulation and reduces unwanted air leakage through the building envelope.

The on-site spray applied application of Icynene® spray foam creates an excellent air seal that provides a low air infiltration rate through the building envelope for years of durable, energy efficient comfort. For more than 20 years Icynene has set the standard for spray foam insulation.

Vapor Retarders: Qualifying for Removal

The build up of moisture in insulated building envelopes resulting from condensation continues to demonstrate that the standard practice of including a vapor retarder is not a fail safe means of preventing moisture problems. The elimination of the vapor retarder in air conditioned buildings can allow for drying to the interior during the cooling season. With the removal of the vapor retarder, moisture can diffuse through the interior cladding into the interior air space where it can be removed by the air conditioning system. The benefit of vapor retarder removal has been recognized in the 2006 IRC which now allows for vapor retarders to be optional in climate zones one through four.

Although, Icynene® is not a vapor retarder, it can be used as the primary resistance to airborne moisture transport. The air seal capability of Icynene® controls convective moisture flow which can be the primary moisture transfer mechanism through the building envelope. In many applications, where the rate of diffusion is low, Icynene® provides the opportunity to eliminate vapor retarders from the assembly and thereby improve the drying capability of the building envelope. In applications where vapor protection is required, standard polyethylene vapor retarder can be replaced through the use of a vapor retarder paint.

Although the use of Icynene® can qualify a project for the elimination of the vapor retarder, a number of other conditions must also be met:

1. Climate must not exceed 7200 Heating Degree Days (HDD) on a 65 °F basis
2. Interior relative humidity must not exceed 35% RH for a significant period of time during the heating season
3. Subject to approval by the design authority and the local code office

Climate Zones

Historically, our standard recommendation with Icynene® has been that a vapor retarder is not necessary in the average home except in areas colder than 7500 Heating Degree Days on a 65 °F basis (such as Madison, Wisconsin) or in high humidity applications (indoor swimming pools, etc). Since then, The International Code Council (ICC) has defined new Climate Zones; maps and definitions of these zones can be found in both the International Residential Code (IRC) and the International Energy Conservation Code (IECC). Under the new zoning system, 7500 Heating Degree Days (HDD) roughly corresponds to Climate Zones 6 (7200 HDD) and above. For construction projects in Climate Zones 6 and higher, polyethylene can be replaced by the use of a vapor retarder paint. Projects in Climate Zones 4 or 5 can further eliminate the need for vapor retarder paint by controlling interior humidity.

Interior Relative Humidity

In Climate Zones 4 and 5, the reversal of vapor drives between the summer and winter seasons is best served by assemblies that are breathable (vapor permeable) and allow for drying to the interior in the summer and the exterior during the winter. The prevalence of air conditioned buildings makes it even more important to be able to eliminate vapor retardant materials in assemblies. In these climate zones, the need for vapor protection can be made unnecessary by controlling interior relative humidity levels.

In terms of building durability, maintaining humidities lower than 35% RH are preferred, but low humidity levels are generally not comfortable to occupants. For example, static shocks on door handles, nose bleeds, etc begin to occur below 20% RH. Maintaining interior humidity levels at around 35% RH provides both comfort and a reasonable assurance of building durability.

Maintaining the interior relative humidity at no more than 35% RH will require the use of an appropriately sized mechanical ventilation system. All houses insulated and air-sealed with Icynene® should have a mechanical ventilation system to supply fresh air. The building code sets a minimum standard for supplying fresh air to a building, and, in an airtight house, this can only be supplied through mechanical ventilation.

Vapor Retarder Recommendations

In some buildings, vapor protection is absolutely necessary. Fortunately, these are also applications where the vapor drive is consistently from one side of the wall to the other, making it less likely that the vapor retarder would ever act as a condensation plane; for example:

1. extremely cold climate
2. extended high humidity levels
3. special applications such as coolers or freezers

In the event of a pipe or roof leak, vapor retarders can impede the drying of the assembly. The vapor protection should therefore be selected so as not to impede the drainage of liquid water in the event of this type of water intrusion. In these applications, it is therefore highly recommended that vapor protection be supplied through the use of a vapor retarder paint, as opposed to polyethylene. This paint can be applied directly to the insulation, prior to the installation of gypsum drywall.

Extreme Cold Climates

In extreme cold climates, climate zones 7 and 8, winter conditions consistently drive indoor moisture into the insulation. Additionally, a limited warm season provides very little opportunity for the wall system to dry to the interior. As a result, it is highly recommended that vapor protection be included on the inside face of the insulation.

In these climates, the use of air conditioning is also significantly reduced, or even excluded from many projects. This results in a reduced opportunity for condensation due to the use of an interior vapor retarder.

Elevated Interior Humidity

There are many applications where the demands of the living space require interior humidity levels to be above 35% RH. This can include areas around swimming pools, saunas, greenhouses, showers, etc. For most of the year the indoor humidity levels will be higher than those outdoors, and moisture drive will be consistently from the interior of the building into the insulation. In these cases, a vapor retarder should not be removed from the assembly, and should be installed on the interior face of the insulation.

Coolers & Freezers

Like indoor pools, coolers and freezers present a special situation whereby moisture is always traveling in one direction. However, unlike pool rooms, moisture is typically traveling *into* a cooler or freezer from the outside. This situation presents both special advantages, and special design considerations.

One of the special advantages with these specialized structures arises from the fact that many coolers / freezers are entirely located within a conditioned building. As well, moisture that enters the freezer is often managed by the mechanical system that handles cooling. In this situation, it is important to ensure that no major obstructions to moisture flow exist on the interior finish of the cooler. If the cooler is insulated from the inside, moisture that penetrates the Icynene® is conveyed into the cooler/freezer, where it is removed from the interior air by the cooling system.

Many coolers are framed with cold-formed steel cladding. If the Icynene® is installed by spraying the outer face of the steel cladding, the cladding acts as a cold-side vapor barrier. In this case, moisture that enters the insulation can accumulate on the outside of the steel skin. In this case, vapor protection should be applied to the outer face of the insulation.

Where any wall of the cooler is also an exterior wall, the wall can be exposed to reversals in vapor drive. In this case, the inclusion of a vapor retarder and its location is at the discretion of the designer, depending on local climate.

Icynene®

Icynene® is also an air barrier material that will prevent the flow of airborne moisture into the building envelope. With Icynene® there is no need for a sealed poly vapor retarder to act as an air barrier to prevent convective moisture flow into the building envelope. As a result, the requirement for a vapor retarder with Icynene® occurs where substantial vapor drive exists, a large temperature difference across the building envelope or high humidity levels. By preventing air leakage, Icynene® is able to eliminate the need for a vapor retarder in many climate zones and living conditions. This will allow for drying of the building envelope to the interior of the building, thereby improving the overall quality and durability of the structure.

At the same time, vapor retarders remain a necessary part of many projects. Although initially the removal of the vapor retarder may reduce the cost of the project, improperly eliminating the vapor retarder can end up costing a lot more to fix down the road.