Building Science

Building Ventilation and Air Quality

History of Construction Issues

For years, changes in North American housing construction requirements have been introduced with the intent to help reduce energy consumption. Many older buildings with hollow exterior walls were not built with dedicated air barrier, vapor barrier or insulation materials and thus experience serious air-leakage. Blower Door depressurization tests on older homes have recorded 10 complete air-changes per hour (ACH) or more @ -50 Pa (- 0.2" w.c.), the standard pressure difference to estimate simulated peak building air leakage conditions.

During the heating season, large temperature differences between indoor-air and ambient-air cause leaky buildings to act like chimneys and this "stack" effect alone causes significant air leakage. Wind also creates pressure differentials between exterior surfaces that cause air leakage. Finally, mechanical systems and other fans inside the building lead to air pressure differentials that also cause air leakage. All three pressures cause conditioned air to leak out of (exfiltration) or unconditioned air to leak into (infiltration) the building, depending on the climate and season. This leakage occurs through holes in the building envelope where the air barrier is incomplete, improperly installed, or damaged. In northern winters, humidification is needed as excessive air exfiltration causes uncomfortably low indoor relative humidity levels. In humid summer conditions, excess infiltrated moisture must be removed from the interior of the building with air conditioning and/or dehumidifiers.

Other air quality problems are present as ambient air contains mold and mildew spores, bacteria, pollen, dust, etc. In addition, air leakage through structures carries moisture vapor with it, which condenses on colder surfaces. This condensation causes wood decay and contributes to the creation of microenvironments suitable for the development of mold and mildew.

In older buildings, uncontrolled air leakage can be responsible for 50 to 60% of the heating and cooling energy consumption, and large capacity heating and air conditioning equipment is required.

Today's Standards

With the adoption of air barriers and insulation requirements, 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 good sealing materials provide structures that test for peak air leakage at 3 to 4 ACH @50 Pa.

Building Code changes and extra tightening efforts by custom builders have been implemented to improve energy efficiency and comfort. Savings from reduced heating and air conditioning equipment requirements are realized.

Under Ventilated Buildings

Virtually any building is likely to experience under-ventilated periods unless controlled ventilation is employed. Until recently, little attention has been devoted to varying weather conditions in relation to indoor air quality. Although most residential building codes require point-source exhaust fans for spot use, few specify make-up air for combustion appliances and so, with few exceptions, they do not address under-ventilated conditions in residential buildings.

BioBased Insulation
1315 N. 13th Street
Rogers, AR 72756

Phone: (800) 803-5189
Fax: (479) 636-5810

Email: info@biobased.net
Website: www.biobased.net

Add to this an indoor environment that is a chemical and biological soup. Many building materials such as carpets, furniture, plywood, particle board and flooring off-gas VOC's (volatile organic compounds). Cleaning solvents and solutions vaporize. Smoking and cooking odors are often present. Oxygen is consumed. Human activities and related processes produce moisture vapor that helps create microenvironments suitable for biological growth. Mold and mildew feed on organic materials like the cellulose in paper and pet or human skin dander. Dust mite life cycles produce dried carcasses and feces that often become airborne (these allergens are known to trigger asthmatic attacks). Dust mite digestion processes also produce gasses such as aldehydes, alcohols and ketones (perceived as moldy odors).

During under-ventilated conditions a myriad of pollutants are introduced to the indoor air, building up to unhealthy levels. The U.S. Environmental Protection Agency has performed studies indicating that average indoor air is 10 to 70 times more polluted than outdoor air. The U.S. EPA also estimates that people typically breathe in two tablespoons of particulate-type contaminants and chemicals each day.

Ventilation - Doing it Right

The solution is to build buildings as tight as possible and take full control of fresh air requirements with controlled mechanical ventilation. This minimizes unwanted air and moisture movement through the structure, and allows the intake and cleansing of the correct amount of air for the specific building. Buildings are complicated and, when using conventional insulation and air/vapor barrier materials, extremely tight construction is difficult and expensive to achieve.

A Healthy Home with BioBased 501 Insulation™

A *BioBased 501*™ insulated thermal envelope coupled with minimal caulking typically tests for peak air-leakage at 1.5 ACH @50 Pa or less.

Into this tightly controlled indoor environment, a properly designed controlled mechanical ventilation system is installed. The choice of system (exhaust, supply, or balanced) depends on the type of building, and cost. Extra ventilation may be needed to compensate for large point source exhaust fans (i.e. kitchen cook top fans, clothes dryer fans). Ventilation systems that are installed with *BioBased 501*™ operate much more efficiently because of greatly reduced random air leakage through the exterior walls, roof and floors. The result is a healthy indoor environment, superior energy efficiency and ultimate comfort.

HVAC System Sizing Considerations

Typical Practice

A good Heating, Ventilation and Air Conditioning (HVAC) contractor will use one of the standard methods for determining heating and cooling loads on buildings, such as Air Conditioning Contractors of America's (ACCA) Manual J and Manual N. These methods take into account specific building characteristics including orientation, dimensions, and thermal performance of exterior components (walls, ceilings, basements, windows and doors). Averaged local weather data as well as summer and winter peak design temperatures are also considered. Then, a building is placed into an air leakage category based on construction tightness estimates and a generalized wind shielding description to estimate how the building will perform in breezy or windy conditions.

In the interest of customer satisfaction, to insure that desired interior design conditions can be met at all times, an HVAC contractor will often add considerable extra heating and cooling capacity equipment. This fairly common desire to oversize is largely due to the unpredictability of performance that is expected from typically constructed "leaky" building. Extra heating and cooling capacity adds significant extra cost and additional HVAC system space requirements.

This is particularly true on the cooling side. Humid summer conditions coupled with oversized A/C units lead to short cycling that cools without dehumidifying adequately. This produces a cold clammy environment with high relative humidity which is a breeding ground for mold and mildew. Building occupants are faced with poorer indoor air quality and higher energy costs due to ineffective oversized systems.

How To Do it Right

Build tight and ventilate right is the answer to minimizing guesswork involved in HVAC equipment selection. Tight construction drastically reduces the significance of air leakage and its effect on HVAC system sizing. Also, tight construction coupled with mechanical ventilation ensures proper air quality during all weather conditions. Unfortunately, constructing tight buildings that are increasing in complexity with conventional materials and methods has proven to be a difficult and costly challenge.

Dealing with the “Tightness” Challenge

BioBased 501 Insulation™ handles the "tightness" challenge easily. Using a blower door diagnostic air leakage test, *BioBased 501*™ insulated residential buildings regularly test at less than 1.5 ACH @50 Pa (1.5 Air Changes per Hour at -50 Pascals of internal pressure). This compares very favorably to conventionally constructed homes that often test at 5 to 7 ACH @50 Pa. In addition to air sealing, flexible *BioBased 501*™ provides thermal insulation to R-3.83 per inch (RSI-0.66 per 25 mm) of thickness throughout any size cavity. Without convective airflow within the cellular material, the insulating value of *BioBased 501*™ remains virtually the same in all conditions of temperature and air pressures.

The Bottom Line

Sizing HVAC systems for buildings is now far less of a challenge than ever before with *BioBased 501*™. *BioBased 501*™ ties together all other building assembly materials creating a monolithic envelope that is extremely airtight and thermally efficient in all weather conditions. The HVAC contractor no longer needs to guess at air leakage levels or compensate for shortcomings in air barrier and insulation materials. The net result for the consumer is an average of 30 to 50% reduction in heating and cooling system size and a similar reduction in energy costs.

Building Moisture and Air Quality

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 eventually suffer from mildew problems. Mildew increases the risk of occupant sickness and causes 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.

Moisture Generation in Homes

Relative humidity inside buildings is greatly increased by the addition of moisture to the air in many different ways. In houses, human activities such as preparing meals, washing dishes and clothes, bathing, using whirlpool tubs or showers, maintaining aquariums and plants, or 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 and just the infiltration of humid air can add 360 pounds (163 kg) of water a day to a typical home.

External Moisture Infiltration

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 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. With 100% relative humidity, clothing, paper products, wood and some textiles can absorb up to 20% of their weight in water.

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. Thus, it is vital that A/C units run a significant amount of the time in humid conditions to keep the relative humidity below 60% (the level at which mildew begins to grow).

Unfortunately, in humid climates A/C units are often oversized 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 relative humidity (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 common in humid climates because of building practices of the past. Older buildings had high rates of random air leakage. Ductwork for systems were 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. 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.

Build an Airtight Structure

The only way to avoid mildew is to control the interior relative humidity. Along with proper practices that reduce generation of moisture by the occupants, reducing air leakage and proper sizing of A/C equipment will reduce relative humidity.

Building an airtight structure limits the amount of moisture laden air that gets inside, as well as allowing the use of smaller A/C systems which run for longer periods, removing more moisture from the air and lowering the relative humidity 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 Building Science note title: Insulating Unvented Attics and Cathedral Ceilings).

Vapor Barriers are NOT the Solution

Most air leaks into buildings occur through sill plates, electrical outlets, duct systems, and penetrations through attic and floors, and around windows and doors. One attempt to combat the moisture problem has been to apply a vapor barrier 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.

Solution: Monolithic Air Barrier

The solution is a monolithic air barrier with *BioBased 501 Insulation*™

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. While an air barrier inhibits the entry of air it must be slightly vapor permeable to allow building materials to dry.

BioBased 501™ is a site-installed semi-open-cell 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 the performance of *BioBased 501*™ when applied to an entire building situation. With the air-sealing ability of *BioBased 501*™ in place, preventing outdoor moisture from entering the buildings, 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 relative humidity lower while consuming less energy.

Air Quality Tips for Occupants

- Set air-conditioner temperature higher when using a ceiling fan.
- Set heating thermostat lower when away from the house.
- Keep the interior temperature below 75°F (24° C) and relative humidity 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. Hang wet towels, mops and clothing outside to dry. By doing this, the amount of moisture evaporating inside the home will be drastically reduced.
- 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.

Building Tips

- Build a tight building easily using *BioBased 501 Insulation*™.
- Install mechanical ventilation that also dehumidifies incoming air.
- Ensure that shower stalls and baths drain properly and do not puddle.
- Waterproof and seal exterior block walls.
- Do not install a vapor barrier on exterior walls.

Insulating Unvented Attics and Cathedral Ceilings

Roof Ventilation History

Before the introduction of insulation, moisture was not a problem in roof spaces. Roofs were exposed to warm, humid interior air. This warm air raised the interior temperature of the roof space and decking materials. The roof itself, made of vapor-permeable natural materials, allowed water vapor to pass through it to the outside without condensing on the interior surface.

With the introduction of insulated roof spaces (attic and cathedral ceilings), the temperature in attics was reduced and water vapor passing through the ceiling to the attic encountered decking materials that were now colder than before. Condensation resulted, causing moisture problems and, in winter, a build-up of ice.

The solution was to install a vapor diffusion retarder (VDR) on the warm side of the insulation, and to ventilate attics to remove any water vapor that succeeded in passing through the VDR and the insulation.

Also with cathedral ceilings, designers and builders faced similar moisture problems. Their solution was to leave an air space between the roof deck and the insulation material. Vents at the soffits and ridges allowed outside air through the space. The function of the air space in a cathedral ceiling is exactly the same as the function performed by attic vents.

Today's Technology for Attics and Cathedral Ceilings

BioBased 501 Insulation™ provides architects and builders with a new tool. While this modern material may be used with ventilation in the same configuration as glass fiber, it also allows us to roll back the clock and build as our forefathers did. There is no longer a need for ventilation or air spaces. This is accomplished with spray-in-place, air sealing *BioBased 501*™ foam insulation.

Conventional Roof Space Ventilation Practice Objectives

Objectives for ventilation and the air spaces in roof spaces are:

- To remove moisture.
- To lower the temperature of the roof to impede the buckling of roof shingles.
- To prevent temperature rise in the roof deck, which could result in ice damming.

Moisture problems and ice damming in roof spaces are caused by air leakage from within the conditioned building and vapor diffusion, which allow moisture to pass through fibrous insulation materials and condense on the nearest cold surface. It is well documented that, in most situations, diffusion accounts for only 1% of moisture transfer, while movement of air accounts for 99% of the total moisture load on roof spaces and materials. Thus, controlling air leakage virtually eliminates moisture problems.

Scientific Testing

Scientific research (University of Illinois Small Homes Council and Florida Solar Energy Center) has determined that the maximum exterior roof temperature for roofs without ventilation or air spaces is virtually the same as those with ventilation and air spaces. The tests, conducted over six months, found

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that, in the critical high-temperature range above 140°F (60°C), there was only a 3° to 5°F (1.6° to 2.8°C) difference in the non-vented roof. They concluded that any effect of the ventilation was far outweighed by the solar gain, so that no difference could be expected to occur to shingles, with or without ventilation.

Snow Country History

In Montana, a mountain state with heavy snowfall, insulating cathedral ceilings with spray foam without ventilation or air space has been standard practice for many years. There is no evidence of an ice dam problem in those homes. Similarly, foam-core, stress-skin panels (SIP panels), without ventilation, have been used as roofing for decades, with no evidence of problems. Unvented roofs are now widely accepted in humid climates like Florida.

Why BioBased 501™ Does Not Require Ventilation

Air leakage control.

BioBased 501™ has a low air permeance - low enough to be classed as an air barrier. Therefore moisture movement through *BioBased 501*™ foam by air transfer is virtually none.

Vapor diffusion permeance.

Five inches (125 mm) of *BioBased 501*™ foam has a vapor permeance of 10 perms (565 ng/m2/s). This property allows low rates of moisture diffusion to occur, just enough to allow breathing of adjacent framing and decking materials to prevent moisture entrapment. The minimal diffusion that does occur through *BioBased 501*™ foam will pass through the material without condensing, provided that the substrate to which it is attached is equally (or more) vapor permeable.

A Final Word

Spray-in-place foam insulation has been applied in unvented roof spaces in all climatic extremes for many years. However, the building code in your community may dictate that ventilation and air spaces are still required. The final authority may not be the building code, but a professional consultant. Many jurisdictions allow for alternative installation techniques provided they have been reviewed and approved by professional architects or engineers. Finally, many building codes have been amended in recent years to allow for unvented roof installations. This is a promising sign that this approach to insulating attics and cathedral ceilings may be universally adopted in the future.

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Steel Roof Insulation Practices

Considerations

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

The Conventional Approach

Low-rise commercial/industrial buildings typically have metal roofs with very large surface areas in relation to the rest of the structure. It is vital to properly insulate these roofs to conserve energy and to control condensation. *BioBased 501 Insulation*™ offers an alternative to the conventional insulation systems commonly used. The most common conventional systems are built up exterior insulation and interior glass fiber systems.

BioBased 501 Insulation™

BioBased 501 Insulation™ is a two component, spray-in-place insulation system. It is a semi-open-celled low-density (0.5 lb/ft3 or 8.0 kg/rn3) product. It is installed by spraying the materials in liquid form on the underside of the roof deck. The liquid immediately expands into foam at a rate of 100:1 in a matter of 10 seconds. *BioBased 501*™ forces itself into every corner and crevice and adheres to everything it touches. *BioBased 501*™ has a thermal resistance of R-3.83 per inch (RSL-0.66 per 25 mm). *BioBased 501*™ provides a continuous barrier to the movement of humid indoor air, protecting the steel deck from condensation. When using *BioBased 501*™ the roof deck is installed on purlins mounted above open web joists or red iron framing, as usual. 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 an isocyanurate strip fastened with adhesive. The choice of roofing deck profile is governed by the goal of providing as little contact between the decking and the purlin as possible. *BioBased 501*™ will fill all the spaces between the purlins and the roof deck, creating an additional thermal break.

The maximum thickness of *BioBased 501*™ recommended in most areas of the country is 5.5 inches (140 mm) or R-20 (RSL-3.4). At this level the heat-flow through the roof is reduced by about 95%. Increasing thickness to 8.5 inches (216 mm) or R-30 (RSL-5.3) will increase cost by about 30% but reduced heat-flow by only 1.7% to a total of 96.7%. This is rarely justified.

BioBased 501™ is delivered to the site in liquid form in steel drums, each set of two drums containing 15,000 board feet of insulation. Site traffic and site clutter is reduced. In addition to the greatly reduced raw material requirements, *BioBased 501*™ can be installed in all weather conditions. This limits weather related interruptions of construction schedules that plague conventional insulation systems. When *BioBased 501*™ is specified, the building can be closed in sooner and interior work can proceed more quickly.

Installation

The licensed dealer comes fully equipped with spray equipment, electrical power and compressed air. All equipment is mounted on a truck or trailer that comes with up to 300 ft. of hose, allowing the installer, from one location, to insulate a wide area before moving. The only additional on-site equipment requirement is a man-lift from which to work. Application rates average about 15,000 board feet per day.

BioBased 501™ adheres well and permanently to steel, even if it has an oil-based coating or moisture is present due to condensation.

BioBased 501™ is flexible and will not shrink or de-laminate with dimensional changes in the surface to which it is adhered.

BioBased 501™ is an inert material. It contains no CFC's or HCFC's to cause corrosion of metals and fasteners with which it is in contact.

BioBased 501™ is an excellent air barrier and eliminates the problems resulting from the movement of airborne moisture. It prevents moist air from coming in contact with the roof deck.

BioBased 501™ is self-supporting, requiring no additional support system.

After installation, an interior finish usually covers *BioBased 501*™. 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: gypsum board, suspended acoustical tile, vinyl-faced material and steel sheeting. In some situations, such as agricultural buildings, it may be possible to leave *BioBased 501*™ exposed. It can be painted, but cannot be power washed.

Advantages of BioBased 501™ Versus Exterior Insulation

- Installation is not weather dependent. No delays because of rain, cold, heat, wind or snow.
- Materials and installation are less expensive.
- Installation is faster, because *BioBased 501*™ is installed in one step.
- Overall construction proceeds faster.
- Site traffic and material handling is reduced
- Purlins do not require painting.
- Roof maintenance after leaks is less expensive.
- At the end of its life, roof replacement is much simpler

Advantages of BioBased 501™ Versus Interior Insulation

- Site traffic and material handling is reduced.
- Purlins do not require painting.
- Purlins are thinner.
- Roof maintenance after leaks is less expensive.
- Energy performance is superior and energy costs are lower, due to perfect fit.
- Moisture/condensation problems are eliminated.
- No need to maintain or replace insulation.
- Interior finish can be repainted to maintain appearance.

Building Insulation Specification Sheet
BioBased Systems No-Burn Ignition Barrier

Test Summary

The test performed was a crawl space evaluation of *BioBased 501*™ (0.5 lb/ft3) spray foam polyurethane open celled insulation coated with *No-Burn® Plus* fire retardant, conducted in general accordance with SwRI (Southwest Research Institute) test procedure 99-02 *Crawl Space Fire Test*, 1999. This test is to show that this system meets or exceeds the requirements for an ignition barrier according to ICC code number R314.2.3 2003 IRC.

The SwRI test report was issued in April 2005 under project number 01.10934.01.406a.

Manufacturers

BioBased 501™ spray foam polyurethane is manufactured by *BioBased Systems, LLC,* which is based in Rogers, Arkansas. *No-Burn® Plus* fire retardant is produced by *No-Burn, Inc.* located in Wadsworth, Ohio.

Product Description – BioBased 501™

BioBased 501™ spray foam insulation is a two-part, soy-based product installed by Certified Dealers using custom designed application equipment. When installed, *BioBased 501*™ expands to completely fill all voids to effectively seal against air infiltration – often the major source of heat/cooling loss. *BioBased 501*™ also provides superior acoustical and thermal performance when compared to other insulation products. While offering superior performance in conventional construction, it is especially effective in steel-framed structures, older homes and metal buildings.

BioBased 501™ is applied by spraying liquid chemical components onto open wall, ceiling, and floor surfaces; or into wall and other cavities. When applied, the components quickly expand to make a foam layer of millions of air pockets—covering surfaces and filling cracks and voids. The foam adheres to almost all surfaces, and when cured can be trimmed off to provide a surface that is ready for drywall or other finishing.

Product Description - No-Burn Plus

In most structures, the interior walls that cover the framing are the first line of defense against a fire that weakens the structural integrity of a building. To aid in this defense, *No-Burn® Plus* was developed. *No-Burn® Plus* is an interior latex paint product that can be used as a base primer or tinted to match the finish coat. *No-Burn® Plus* is not a fire retardant paint, but rather an intumescent fire reactant that when introduced to heat or flame, foams up, providing a protective char barrier that shields the underlying materials from heat and fire. This protective barrier "swells", creating an intact "cocoon" that can withstand a tremendous amount of heat and fire. Because *No-Burn® Plus* does not allow the treated surfaces to be readily used as a fuel source for the fire, it can actually reduce the production of deadly toxic smoke by up to 80 percent. In new construction, *No-Burn® Plus* works very well as a primer coat, applied directly to new drywall or wood. *No-Burn® Plus* provides a solid, semi-gloss surface for the application of finish

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coats. It accepts all colors and paint types very well, including flats, enamels, semi-gloss, gloss and others. In existing homes and businesses, *No-Burn® Plus* can be tinted and used as a finish coat for those who want to paint on the protection. *No-Burn® Plus* can also be used on the framing of a structure, giving the entire structure a Class A rating on all the structural components. Having a Class A rating gives the structure the best possible protection against fire, especially in areas where a high fire hazard exists - such as urban areas with homes in close proximity or in woodland areas.

No-Burn® Plus Burn Characteristics

- Test Standard..ASTM E84
- Average Flamespread Index.................................... <5
- Average Smoke Developed Index....................10 to 60
- Wall and ceiling finish class rating*............................A
- Number of Coats of Preliminary Paint........................0
- Number of Coats of No-Burn Plus..............................2
- No-Burn Plus Coverage Rate (ft2/gal)....................300
- Number of Coats of Overcoat Paint............................0

NOTE: Refer to Product Specification - *BioBased 501*™ for insulation testing information.

Containers

No-Burn® Plus is available in the following size containers:

- 1 gallon cans
- 5 gallon cans
- 55 gallon drums

Storage

Store *No-Burn® Plus* between 40° and 90°F (5° and 32°C).

NOTE: Refer to Product Specification - *BioBased 501*™ for insulation chemical component storage information.

Installation

BioBased 501™ is installed by certified technicians that specialize in the installation of soy-based spray foam. Application of the product can generally occur independent of environmental conditions—it can be installed in hot, humid, or freezing conditions—and surface preparation is generally not necessary. Once *BioBased 501*™ has been sprayed, curing takes only a few seconds.

No-Burn® Plus is applied much the same as any other paint - it must be properly mixed and then applied to a clean surface. The surface must be cleared of all deposits - including dust, dirt, oil, paint flakes, scale, wax, and any other contaminant that will affect the adherence of *No-Burn® Plus* to the material to be painted. In addition, the *No-Burn® Plus* temperature, the ambient air temperature, and the surface temperature should all be above 55°F (13°C).

***No-Burn® Plus* Install Specifications**

- Mixing.............power mixer only: 15–18 minutes min.
- Application Temperature...........................55°F (13°C)
- Surface Preparation...............................clean and dry
- Application..............................sprayer, roller, or brush
- Thinning..not recommended
- Coverage...250–300 ft2/gal

NOTE: Refer to Product Specification - *BioBased 501*™ for insulation installation information.

Abstract of Testing

The objective of this test was to evaluate the fire performance of insulation board materials when tested in a simulated crawl space module to determine if the insulation could be considered for use in attic or crawl space areas without a thermal barrier. This test program provides a comparison of fire performance characteristics between a baseline spray-applied foam insulation, covered with a nominal 1/4" thick plywood sheathing system, and an exposed spray-applied foam insulation (comparative) coated with an ignition barrier. The spray-applied foam insulation was coated with 10 mils (wet) of *No-Burn® Plus* fire retardant coating (rim joists only). This system is intended for use in attics or floor crawl spaces.

For the baseline test, the SPF insulation was spray-applied 6" thick (nominal) on the cubicle cement block walls between a nominal 2x6 wood stud framework lining the module interior and 8" thick around the perimeter of the rim joist. A 1/4" thick plywood sheathing was applied over the 2x6 walls in the module interior covering the exposed SPF insulation. The SPF foam insulation installed around the interior rim joist was with a fire retardant coating.

For the comparative test, the insulation was spray-applied at a nominal density of 0.5 lb/ft^3 and a nominal thickness of 6" on the inside cubicle cement block walls between the nominal 2x6" wood stud framework, and at nominal thickness of 8" around the perimeter of the rimjoist. The SPF insulation was then coated with 10 mils (wet) of *No-Burn® Plus* fire retardant coating to the walls and rim joist of the deck. In addition, the *No-Burn® Plus* was sprayed onto the underside of the exposed 15/32" thick plywood sub-flooring extending 24" from the left, back, and right walls toward the center of the crawl space. A 22 lb. wood crib, located in a rear corner, was used as the ignition source for both tests.

Two main criteria were established for evaluation prior to testing:
- The time when flames exited the front of the test structure.
- The occurrence of burn-through of the 15/32" thick, 4-ply, A-C graded plywood floor/deck system.

The results of the baseline assembly test were compared to the results for the comparative assembly test. During the baseline test, flames exited the cubicle at 3 minutes, 29 seconds; and burn-through of the plywood deck was observed at 8 minutes, 46 seconds. For the comparative test, flames first exited the test structure at 3 minutes, 46 seconds; and burn-through of the deck assembly was observed at 9 minutes, 33 seconds.

Warranty

BioBased Systems warrants that *BioBased 501*™ spray foam insulation, when installed according to *BioBased Insulation*™ certified installation instructions and by a BioBased Insulation Certified Dealer, will perform as indicated in the current product specification sheet.

Technical Support

BioBased Systems Insulation Dealers and *BioBased Insulation*™ both provide information for technical and regulatory issues.

Disclaimers

- *BioBased Insulation*™ does not endorse open combustion appliances located in attic space.
- *BioBased 501*™ must be separated from living areas by a 15 minute thermal fire barrier.
- For proper use of this insulating material, refer to *BioBased Insulation*™ application information and any of the following codes or guides:
  ***** ICC, International Building Code, Section 2603
  ***** ICC, International Residential Code, Section R314
  ***** API publication AX-230: Fire and Safety Guidelines for Use of Rigid Polyurethane and Polyisocyanurate Foam Insulation in Building Construction
- Wall and ceiling finish Class A rating is defined by the International Building Code, Section 803.1.

Insulating for Sound Control

Controlling sound in single and multi-unit dwellings is an important design consideration today. Selecting the right materials, including insulation, will determine how effective sound control measures will be. *BioBased 501 Insulation*™ is a spray-in-place two component liquid material that expands into low density foam. *BioBased 501*™ provides sound deadening properties in buildings.

Reducing Airborne Sound

Sound can travel through a variety of mediums, but most commonly through air. Loud stereos, highway and city noise, and human speech are common sources of airborne sound. Sounds propagate through the air at many different frequencies, but it is the mid-range frequency noises that are most noticeable.

Reducing Flanking Sound

Often, reducing airborne sound by providing an air barrier material is not enough. Every possible pathway that sound can travel through to another room must be eliminated. This is called flanking sound. To have a reasonable chance of eliminating it, a site-applied material that fills every gap and crevice must be used. It is a known fact that flanking sound can reduce STC (Sound Transmission Class) ratings by up to 5 or more. This is why STC requirements for sound barrier construction are high, because designers know these values will not be achieved in the field.

BioBased 501™ fills every gap and crevice in the building cavity while adhering to all adjoining components for a tight seal. This greatly reduces flanking sound, and can produce STC ratings similar to theoretical design values in a smaller cavity thus using less material and saving money.

Reducing Noise Caused by Plumbing

Running water can cause the pipes behind walls and above ceilings to vibrate, and transfer that sound into the structure of the house. Once the vibrations get into the structure, the sound can be transmitted to other parts of the building. This is a big issue in apartment dwellings when the shower is turned on at 6 o'clock in the morning. *BioBased 501*™ is a flexible, semi-open-cell material that can be applied around these pipes. The vibrations will then be greatly dampened, and structure borne noise reduced. Properly securing the piping inside the wall or ceiling and good design will minimize the vibration and water hammer sound even more.

Impact and Structural Vibrations

BioBased 501™ is a great insulator to airborne sounds, and can also be combined with other materials to reduce impact and structure borne vibrations. Impact noise is not being transmitted through the air, rather it is causing vibrations within the building assembly itself. Adding insulation will not dampen those sounds effectively; the floor must be isolated from the rest of the structure.

Combined with drywall mounted on resilient channels, *BioBased 501*™ provides a structural break between two parts of a structure, isolating the vibration or impact noise from the people on the other side. Insulating equipment rooms with *BioBased 501*™ and mounting the equipment on isolating pads reduces both low frequency vibration sounds, and the airborne noise transmitted by such machinery.

BioBased Insulation
1315 N. 13th Street
Rogers, AR 72756

Phone: (800) 803-5189
Fax: (479) 636-5810

Email: info@biobased.net
Website: www.biobased.net

Controlling Radon with Tight Construction

The U.S. Surgeon General has warned that radon is the second leading cause of lung cancer in the United States. It is estimated that 1 in 15 homes in the U.S. experience elevated radon problems. The U.S. Environmental Protection Agency and the Surgeon General recommend that all homes be tested for radon. They also recommend reducing elevated levels through isolation and sub-slab depressurization if necessary.

Sources of Radon

Radon is a radioactive isotope that occurs naturally in soil and rock. It is created through the natural decay of uranium in soil, rock and ground water. As a gas, radon moves up through the ground to the atmosphere via fractures and fissures in rock and porous soils. Radon gets into buildings through seams, cracks and penetrations in foundation floors and walls. Not all areas are equally prone to radon; the U.S. EPA publishes maps on those regions that have the highest concentrations.

With conventional construction methods, stack and wind effects cause significant air leakage producing negative pressures at lower levels in buildings. Negative pressures in basements and crawl spaces allow soil gasses including radon into buildings below grade. Once inside, radon moves freely up through the building into the living spaces, affecting the occupants.

The U.S. EPA recommends solving this health hazard by installing a gravel layer below a sealed basement floor or slab that is directly vented through the roof of the building. Radon accumulating in the gravel layer is passively vented directly to the atmosphere with a stack that runs up through the roof. In those regions where radon concentrations are very high, an attic-mounted fan may be required.

This approach is sound in theory but it requires an airtight structure. With the air-sealing capabilities of The *BioBased 501 Insulation*™, a cost-effective approach to radon control can be taken with the shell of the building itself.

The Solution

Since radon infiltrates buildings due to negative pressure differences caused by air leakage, it follows that a tightly constructed, positively pressurized building is far less likely to draw radon gas from the soil around it. Ventilation requires a tight structure in which to operate properly. This is where *BioBased 501*™ comes in. In areas of particularly high radon concentrations, passive sub-slab depressurization consisting of vent pipe as previously described may be all the control that is needed. It should only be in extreme cases that fan forced sub-slab depressurization system is required.

Radon Reduction with Tight Construction

Many builders go to considerable extra costs for material and labor to reduce air leakage in new structures. This is most commonly done to reduce heating and cooling costs and to improve comfort levels. It has been known for some time that tight construction reduces energy consumption, but buildings are complicated, and air tightness is difficult to achieve with conventional materials.

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Unlike other types of insulation, *BioBased 501*™ is multi-function, providing excellent insulating value and superior air sealing. *BioBased 501*™ eliminates the need for an air/wind barrier (house wrap and associated taping). This approach has been used on homes that, for energy efficiency program requirements, must test below 1.5 ACH @50 Pa (air-changes/hour at -50 Pascals pressure) with a blower door air leakage test. Some of these homes have actually tested below 1.0 ACH @50 Pa. With tight construction and positive pressure ventilation, buildings are not affected to the same degree by wind or stack effects as those without these systems.

Elevated Radon Levels in Existing Buildings

Where living space exists over an unconditioned crawlspace or basement, an isolation technique can be employed using *BioBased 501*™. When applied to the floor and joists from below, *BioBased 501*™ effectively isolates the living area from the radon source. The unconditioned area can then be ventilated to the atmosphere using wall vents or a passive vent pipe up through the building. In cold climates, care must be taken to prevent plumbing from freezing below insulated floors.

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Advantages for Hotels and Nursing Homes

Considerations

Critical considerations in the design of hotels and nursing homes are:

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

BioBased 501 Insulation™ offers the opportunity to accomplish all these goals with its one step thermal envelope/acoustical system. This foam material allows a general contractor to create a virtually air tight building envelope in one step.

Combining air sealing with *BioBased 501*™ low-density foam insulation and properly designed mechanical ventilation and heating/cooling system produces a building that is healthier, quieter, more comfortable and energy efficient. *BioBased 501*™ applied to the entire building envelope offers many benefits:

Improved Guest Comfort

- Elimination of drafts.
- Elimination of convection inside wall cavities and reduction in air exchange between outdoors, attic, and the interior. This results in interior wall temperatures close to ambient room temperature and reduced radiant cold/heat experienced by guests.
- Better dehumidification in summers due to more frequent operation of smaller A/C units.
- Less fluctuation in interior temperatures in any season.

Reduced Air Changes

Natural air leakage through walls and the attic can be reduced to 0.15 ACH or less resulting in:

- Eliminating moisture and mold formation in interior walls.
- Reducing the heating/cooling load on the building by 40%.
- Reducing outdoor sound transmission by having a virtually air tight wall assembly.
- Reducing electrical energy consumption.
- Reducing peak electricity demand.

Simplified Exhaust and Makeup Air

Direct from room mechanical exhaust and conditioned makeup air supplied to corridors can result in:

- Elimination of individual room exhaust fans and electrical circuitry.
- Improved air quality and reduced temperature differentials between rooms and corridors, resulting in a reduction in mold formation inside rooms.

Construction Time and Costs are Reduced

- Eliminates or reduces many steps and materials, including interior vapor barriers, exterior building wrap, soundboard, preformed mechanical pipe insulation, glass fiber batts, individual room fans and electrical work.
- Reduces site traffic by an estimated 30 truckloads of materials in a 100 unit motel, and storage and handling of these goods through the corridors, enhancing the productivity of other trades.
- Results in a superior structure with net capital cost savings to the owner.

Maintenance Costs are Reduced

- Elimination of moisture and mold spores inside wall cavities stops the growth of mold behind wall finishes and prolongs the life of vinyl interior wall finishes.
- Reduction of mold growth in room interiors reduces routine cleaning and prolongs the life of carpeting, bedding and soft furnishings.
- Elimination of moisture related structural problems increases building life.
- Decreases utility costs for the life of the building.