INSULATION SYSTEM AND METHOD

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ABSTRACT

An insulation system for a cavity of a building structure, including: a layer of plastic foam insulation present on a substrate of the cavity, and a layer of blown-in fiberglass insulation in substantial contact with the layer of plastic foam insulation, wherein the layer of plastic foam insulation is present between the substrate and the layer of blown-in fiberglass insulation.
INSULATION SYSTEM AND METHOD

BACKGROUND

[0001] In the construction of residential and commercial buildings, the use of an unvented attic can provide enhanced energy efficiency performance and an improved resistance to adverse weather conditions. In an unvented attic, the thermal and moisture control boundary is typically present at the plane of the roof deck, as opposed to the ceiling of the living space as in a conventional attic. Since the unvented attic constitutes a part of the conditioned area of the building, thermal leakage emanating from HVAC equipment and/or ductwork present in the attic is transferred to and from the conditioned space. As such, energy losses due to thermal leakage in the HVAC system can be reduced or eliminated by the use of the unvented attic.

[0002] In the construction of an unvented attic, a polyurethane spray foam insulation can be used to provide thermal insulation and management of air infiltration and/or moisture migration. Use of such polyurethane spray foam facilitates construction of the unvented attic, and the spray foam typically can be applied to the interior surface of the roof deck. However, polyurethane spray foam is generally a flammable material.

[0003] It has been proposed that an ignition barrier or thermal fire barrier over the polyurethane spray foam insulation is typically not required in situations where the unvented attic is accessed only for maintenance purposes. However, unvented attics may find use as additional storage space, and therefore such unvented attics may be accessed more frequently, thereby increasing the fire originating in the attic.

SUMMARY

[0004] According to one aspect, an insulation system for a cavity of a building structure is provided, comprising:

[0005] a layer of plastic foam insulation present on a substrate of the cavity;

[0006] a layer of blow-in fiberglass insulation in substantial contact with the layer of plastic foam insulation;

[0007] wherein the layer of plastic foam insulation is present between the substrate and the layer of blow-in fiberglass insulation.

[0008] According to another aspect, a method of insulating a cavity of a building structure is provided, comprising:

[0009] forming a layer of plastic foam insulation on a substrate of the cavity; and

[0010] forming a layer of blow-in fiberglass insulation such that the layer of blow-in fiberglass insulation is in substantial contact with the layer of plastic foam insulation,

[0011] wherein the layer of blow-in fiberglass insulation is arranged at an interior side with respect to the layer of plastic foam insulation.

DETAILED DESCRIPTION

[0012] The methods and systems can be used to insulate any building structure or feature including, for example, a cavity such as a cavity of a wall, attic or crawl space. The cavity can constitute a space defined by two adjacent supporting members of a building such as studs or trusses, and a backing substrate arranged between such supporting structures. For example, the supporting members can include, but are not limited to, natural lumber, engineered wood, metal, and composite building products of various dimensions. The backing substrate substrates can include, but is not limited to, oriented strand board, plywood, hardboard, metal decking, corrugated metal panels, natural lumber, poured concrete or prefabricated concrete.

[0013] Attics can be built using various techniques and the shape and structure of attics can vary widely. For example, attic cavities can be regularly or irregularly shaped and in an exemplary embodiment, use of the methods and systems can facilitate the insulation and sealing of irregularly shaped cavities and structures typically found in attics.

[0014] A plastic foam layer is formed on a substrate of the wall or attic cavity. The plastic foam layer can provide thermal and/or acoustic insulation, and optionally function as a moisture vapor retarder and air barrier. The plastic foam can be semi-rigid or rigid and can include a foam insulating board such as Dow Styrofoam insulation board, or a polyurethane spray foam. In an exemplary embodiment, the plastic foam includes a polyurethane spray foam.

[0015] For example, the polyurethane spray foam can be applied to the substrate by any suitable method, for example, by the on-site mixing of at least two foam components, spraying the mixture at the substrate and generating a foam. The polyurethane foam can be open-cell or closed-cell foam, and in an exemplary embodiment is closed-cell foam. For example, closed-cell foam can exhibit enhanced moisture vapor retarder and air barrier characteristics. An exemplary polyurethane spray foam and techniques for applying such foam to a substrate are described in U.S. Pat. No. 7,160,920, the contents of which are herein incorporated by reference.

[0016] The layer of plastic foam can be of any thickness that is suitable for providing an air barrier and optionally a barrier to moisture vapor. For example, the thickness of the plastic foam layer can be from about 0.5 inch to about 10 inches, preferably from about 1 inch to about 6 inches. In one embodiment, the thickness of the plastic foam layer present in a wall or deck is about 2 inches or less. The plastic foam can have any suitable density for providing the desired insulation and barrier characteristics. For example, in exemplary embodiments, an open-cell foam can have a density of from about 0.3 to about 0.7 pcf, and a closed-cell foam can have a density of from about 1.5 pcf to about 2.5 pcf.

[0017] The plastic foam layer can include an optional primer coating present at its outer surface to enhance adhesion between the plastic foam layer and the layer of a blow-in fiberglass insulation. When employed, the optional primer coating constitutes a part of the plastic foam layer. For example, the primer coating composition can employ the same binder as that used in the blow-in insulation material. The primer coating can be a substantially thin coating in comparison with the overall thickness of the plastic foam layer.

[0018] A layer of a blow-in fiberglass insulation is formed above and in contact with the plastic foam layer, and can function as a thermal and/or acoustic insulation. In an exemplary embodiment, the layer of blow-in fiberglass insulation substantially covers the entire layer of plastic foam. The layer of blow-in fiberglass insulation is arranged on an interior side with respect to the layer of closed-cell polyurethane foam. In the case where there will be access to a sealed attic, for example, to performance maintenance on HVAC equipment present in the attic and/or to employ the attic as a storage area, the risk of fire in the attic increases. In view of the increased fire risk, the blow-in fiberglass insulation can function as an ignition barrier.
Suitable methods and systems for forming a blown-in fiberglass insulation are described in U.S. Patent Application Publication No. 2007/0234649, the contents of which are herein incorporated by reference. The use of blown-in fiberglass insulation can provide substantial advantages over conventional fiberglass materials such as fiberglass batts, boards and blankets. For example, blown-in fiberglass can facilitate the installation of insulation in and around irregularly shaped cavities and structures which would normally be cumbersome to fill using conventional fiberglass mats. Additionally, the blown-in fiberglass is can be substantially self-adhering to the plastic foam layer, whereas the use of conventional fiberglass materials typically necessitates the use of pins, staples or other means for affixing same to the plastic foam layer.

For example, particles of fibrous insulation can be blown using a blowing machine, and an aqueous binder mixture can be sprayed onto the particles while in air suspension. A blowing machine that can be used, for example, is a Unisul VOLU-MATIC machine made by Unisul Company of Winter Haven, Fla. The particles sprayed with binder can then be directed into a cavity to form a thermal and/or acoustic insulation.

The fibrous insulation can be provided in any suitable shape and size such as, for example, in the form of nodules and/or clumps. The average diameter of the fibrous insulation particles can be, for example, from about 0.25 to about 1 inch, more preferably from about 0.25 to about 0.375 inch. Nodules are relatively small diameter, fibrous insulation particles of about 0.25 inch diameter and smaller. Clumps are defined as particles having diameters greater than the diameter of nodules, and up to a conventional size of clumps in the blowing insulation industry, for example, less than about 0.5 inch in diameter. The majority of clumps and/or nodules are smaller than 0.5 inch in diameter, but larger sizes can be used. The clumps and/or nodules can be produced by running mineral fiber insulation such as virgin fiber glass insulation or fiber glass insulation containing a cured binder through a hammer mill, slicing/dicing machine, or other device for reducing material to small clumps and/or nodules as is common in the industry.

For example, the particles can be formed by passing virgin fiber or scrap resin bonded fiber product through a perforated plate in a hammer mill. In addition to glass fibers, the insulation can include other inorganic and/or mineral fibers such as, for example, mineral wool, slag wool or a ceramic fiber. The loose fill particles of fibrous insulation can be made by running virgin fiber or fiber product scrap through a conventional hammer mill, a slicing/dicing apparatus, or an equivalent material processing machine. A slicing/dicing apparatus cuts or shears blankets of fibrous insulation into small cube like or other three dimensional pieces, while a hammer mill tears and shears virgin fiber glass or fiber glass blanket into pieces, collecting only pieces below a preselected size through use of an exit screen containing the desired hole size. Virgin fiber is a fiber web or blanket made specifically for spray insulation and typically contains no resin binder.

Any type of fibrous insulation product can be processed in a hammer mill, e.g., fibrous blanket in which fibers, including glass fibers, are bonded together with a cured, usually thermoset resin, or a blanket of virgin fiberglass containing only de-dusting oil, silicone, anti-static agent, etc. The binder used to bond glass fibers together in the blanket may also contain one or more functional ingredients such as IR barrier agents, anti-static agents, anti-fungal agents, biocides, de-dusting agents, pigments, colorants, etc., which may be applied to the fibers either before, or during processing in the hammer mill or other reducing device. The size of the hammer mill exit screen openings can be varied to produce the desired size of clumps and/or nodules. The typical size of exit screen openings range from about one half inch to about three inches, for example, about 1 inch.

The clumps and/or nodules of mineral fiber such as fiberglass can also derive from what is called “virgin blowing wool.” This is achieved by making insulation fiber in a conventional manner except that no resin or binder is applied to the fibers. Instead, only a conventional amount of de-dusting oil and/or an anti-static agent is applied to the fibers and the resultant fibrous blanket is then run through the hammer mill. Other agents can also be applied to the fibers such as a fungicide, a biocide, filler particles and/or IR reflecting particles.

The fibers of the insulation can be of any suitable dimensions, for example, such fibers can have an average diameter of about 2 microns or less. The average fiber diameter can be 6 microns or smaller, but typically is less than about 3 microns or smaller, more typically about 2 microns or smaller, and most typically 1.5 microns or smaller.

The particles of inorganic fibrous insulation can also contain conventional amounts of one or more biocides, anti-static agents, de-dusting oils, hydrophobic agents such as a silicone, fire retardants, phase change material, particulate aerogel, coloring agents and IR blocking agents. The other additives, when present, are also preferably included with the clumps or nodules.

To install thermal insulation using an aqueous adhesive, the aqueous adhesive can be supplied by the manufacturer at the proper concentration without further mixing or dilution, or aqueous adhesive can be made up by adding the proper amount of water to a tank, and then adding the proper amount of a resin, preferably a concentrated solution of the resin, to the water in the tank while optionally stirring to insure proper mixing. If a powdered resin is used, more time and stirring will be required to obtain a relatively homogeneous solution. Also, particularly when the water in the tank is cool, it may be advantageous to heat the water to at least room temperature before adding the resin, or using a heated adhesive cart. Any suitable water-soluble resin can be used in the present method, such as a polyester resin, preferably a hydrolyzed polyester resin in concentrated solution in water, such as a concentration of about 10 to 50%. The most typical resin for use in the present invention is a water-soluble, partially hydrolyzed polyester oligomer such as SA-3915 available from Henkel Corporation of Greenville, S.C. Another resin option is a polyvinyl alcohol resin available from Parachem Corporation, Simpsonville, S.C.

An adjustable-rate pump connected to the adhesive tank supplies the aqueous adhesive at the desired rate and pressure to spray jet(s) through one or more flexible hoses to properly coat the particles of fibrous insulation with the desired amount of aqueous adhesive. Many different types of spray jets can be used, and one that performs well is Spray Systems Co. 65 degree flat spray nozzle with an orifice size ranging from 0.067 to 0.017 in capacity size.

The blown-in glass fiber insulation can have any density that is suitable for providing adequate insulation and ignition barrier characteristics, for example, from about 0.8 to about 3.5 pcf, more preferably from about 1.5 to about 2.5 pcf, more preferably about 1.8 pcf. The blown-in glass fiber insulation layer can have any thickness that is suitable for providing adequate insulation and ignition barrier characteristics, for example, at least about 1.5 inches, preferably at least about 2 inches, and more preferably from about 2 inches to about 14 inches.
The layer of a blown-in fiberglass insulation can, for example, substantially cover the layer of plastic foam. In an exemplary embodiment, the layer of blown-in fiberglass insulation can be in substantial contact with the plastic foam layer. As used herein, the term “substantial contact” between the layer of blown-in fiberglass insulation and plastic foam layer means that at least one contact point exists between such layers in each square inch of area of the plastic foam layer. In an exemplary embodiment, at least five contact points exist between such layers in each square inch of area of the plastic foam layer. In an exemplary embodiment, in any areas where the layers are not in contact, for example, due to the substantially spherical or irregular shape of the particles constituting the blown-in fiberglass insulation layer, the gaps present between the layers is about 0.125 inch or less.

The layered configuration and substantial contact between the blown-in fiberglass insulation and the plastic foam insulation layer can provide improved ignition barrier characteristics. For example, installation of building materials in overhead spaces such as those existing in an attic can give rise to unique challenges due to the non-uniform structures and cavities which are typically present in the attic, as well as the force of gravity acting on the materials installed overhead. While not wishing to be bound to any particular theory, it is believed that such substantial and intimate contact between the plastic foam layer and the layer of blown-in fiberglass insulation can enhance or maintain adherence therewithin during a fire, which in turn can provide consistent and improved ignition barrier characteristics of the insulation system. In addition, the combined use of such layers can enable reduction of the thickness of the spray foam layer. Since spray foam is typically a relatively expensive material, this can contribute to reducing the overall cost of installing the insulation system. The combined use of plastic spray foam and blown-in fibrous insulation facilitates installation of the insulation system in areas that are typically challenging or problematic, such as overhead spaces in attics, bonus room floors present over garages, rim joists, cantilevered floors, etc.

The use of a blown-in glass fiber insulation can also provide the advantage of reduced installation time and costs in comparison with employing conventional glass fiber batts, boards and blankets. In an exemplary embodiment, the blown-in glass fiber insulation is adhered to the plastic foam layer solely by the adhesive of the binder present in the blown-in glass fiber insulation with the optional use of the primer coating of the plastic foam layer. In an exemplary embodiment, the blown-in glass fiber insulation is not mechanically attached to the plastic foam layer or the surrounding cavity structure. This can reduce installation time and costs and result in a more intimate contact between the blown-in glass fiber insulation and the plastic spray foam layer.

Aspects of the present insulation systems and methods will now be illustrated and exemplified in greater detail with reference to the following examples, but it will be understood that the invention is not necessarily limited thereto.

EXAMPLES

Various comparative and exemplary insulation systems employing a spray foam layer and an ignition barrier layer thereon, were installed in a simulated attic/crawl space structure and tested in accordance with the standard set forth in Southwest Research Institute (SwRI) Test Procedure 05-01, “Test Method for the Evaluation of Polyurethane Foam Spray-Applied Onto Walls and Ceilings on an Attic/Crawl Space Configuration,” which is also referred to as the SwRI-09-02 test criteria. In such tests, a fire source was introduced in a corner of the simulated attic/crawl space structure, and the time it takes for flames to exit the front of the structure (flashover time) and the time it takes for burn-through of the top surface of the plywood deck to occur (burn-through time) were measured.

The framing dimensions (walls and joists) of each of the examples is set forth in Table 1. Each of the examples employed a two component polyurethane spray foam having a density and thickness set forth in Table 1. Comparative examples 1 and 2 and Examples 4 and 5 employed water-blown, 0.5pcf polyurethane spray foam. Example 3 employed a 0.9 pcf closed-cell spray foam.

Comparative Examples 1 and 2 employed conventional intumescent coatings as ignition barriers. Comparative Example 1 employed Firefree 88 intumescent coating available from International Fire Resistant Systems, Inc., and Example 2 employed Andek Fireguard intumescent coating available from Andek Corp. Both intumescent coatings were applied using an airless paint sprayer and the coatings were applied to the walls in two coats. The first coat was applied in an amount of 1 gallon per 100 sq. ft and allowed to dry for two or more hours, and the second coat was applied in an amount of 0.5 gallon per 100 sq ft.

Examples 4 and 5 employed a blown-in glass fiber insulation as an ignition barrier at a density of 1.8 pcf.

The flashover time (i.e., the time it takes for flames to exit the front of the test structure) and burn-through time (i.e., the time it takes for burn-through of the top surface of the plywood deck to occur) were measured for each example, and the results are shown in the following Table 1.

<table>
<thead>
<tr>
<th>Example 1 (comparative)</th>
<th>Example 2 (comparative)</th>
<th>Example 3</th>
<th>Example 4</th>
<th>Example 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framing (walls)</td>
<td>2 x 4</td>
<td>2 x 4</td>
<td>2 x 4</td>
<td>2 x 4</td>
</tr>
<tr>
<td>Framing (joists)</td>
<td>2 x 8</td>
<td>2 x 12</td>
<td>2 x 8</td>
<td>2 x 12</td>
</tr>
<tr>
<td>Density of Spray foam (pcf)</td>
<td>0.5 pcf</td>
<td>0.5 pcf</td>
<td>0.5 pcf</td>
<td>0.5 pcf</td>
</tr>
<tr>
<td>Thickness of Spray foam (inches)</td>
<td>3.5 inches</td>
<td>5.5 inches</td>
<td>1 inch</td>
<td>2 inches</td>
</tr>
<tr>
<td>Thickness of Spray foam (inches)</td>
<td>6.0 inches</td>
<td>10 inches</td>
<td>2 inches</td>
<td>2 inches</td>
</tr>
<tr>
<td>Ignition barrier</td>
<td>Firefree 88 intumescent coating</td>
<td>Andek Fireguard intumescent coating</td>
<td>Blown-in glass fiber insulation</td>
<td>Blown-in glass fiber insulation</td>
</tr>
</tbody>
</table>
TABLE 1-continued

<table>
<thead>
<tr>
<th></th>
<th>Example 1 (comparative)</th>
<th>Example 2 (comparative)</th>
<th>Example 3</th>
<th>Example 4</th>
<th>Example 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignition barrier amount (walls)</td>
<td>1.5 gal per 100 sq. ft.</td>
<td>1.5 gal per 100 sq. ft.</td>
<td>2.5 inches</td>
<td>3.5 inches</td>
<td>3.5 inches</td>
</tr>
<tr>
<td>Ignition barrier amount (deck)</td>
<td>None</td>
<td>None</td>
<td>4 inches</td>
<td>8 inches</td>
<td>2 inches</td>
</tr>
<tr>
<td>Estimated Insulation R-value (walls)</td>
<td>R-13</td>
<td>R-20</td>
<td>R-16</td>
<td>R-22</td>
<td>R-22</td>
</tr>
<tr>
<td>Estimated Insulation R-value (deck)</td>
<td>R-21</td>
<td>R-36</td>
<td>R-29</td>
<td>R-41</td>
<td>R-37</td>
</tr>
<tr>
<td>Flashover time</td>
<td>2:58</td>
<td>2:06</td>
<td>4:57</td>
<td>6:24</td>
<td>5:34</td>
</tr>
<tr>
<td>Burn-through time</td>
<td>10:48</td>
<td>10:29</td>
<td>15:56</td>
<td>16:09</td>
<td>&gt;20:00</td>
</tr>
</tbody>
</table>

[0039] As can be seen from the test results, use of the glass fiber insulation material in Examples 3 to 5 provided improved flashover time and burn-through time characteristics in comparison with the comparative examples. As well, employing the blown-in glass fiber insulation enabled the thickness of the spray foam layer to be reduced while achieving comparable insulation performance. The reduction of spray foam usage can contribute to reduced insulation materials costs.

[0040] Exemplary insulation systems were also subjected to testing under the ASTM E-84 tunnel test. Examples A to C employed differing types and amounts of insulation materials as shown in the following Table 2, and the results of the ASTM E-84 tunnel test are set forth in such table.

Table 2

<table>
<thead>
<tr>
<th>Insulation material(s)</th>
<th>Flame Spread/ Smoke Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example A (comp.) open cell polyurethane spray foam (5 inch thick, 0.5 pcf)</td>
<td>25/550</td>
</tr>
<tr>
<td>Example B (comp.) open cell polyurethane spray foam (5 inch thick, 0.5 pcf), painted with Firefree 88 (1.5 gallon per 100 sq. ft.)</td>
<td>15/625</td>
</tr>
<tr>
<td>Example C (comp.) open cell polyurethane spray foam (3 inch thick, 0.5 pcf), covered with blown-in fiberglass insulation (2 inch thick, 1.8 pcf)</td>
<td>10/20</td>
</tr>
</tbody>
</table>

[0041] The above test results show that Example C, which employed a polyurethane spray foam layer in combination with a blow-in fiberglass insulation layer, achieved flame spread/smoke developed characteristics which are significantly lower than those achieved by comparative Examples A and B.

1. An insulation system for a cavity of a building structure, comprising:
   - a layer of plastic foam insulation present on a substrate of the cavity, and
   - a layer of blown-in fiberglass insulation in substantial contact with the layer of plastic foam insulation, wherein the layer of plastic foam insulation is present between the substrate and the layer of blown-in fiberglass insulation.

2. The insulation system of claim 1, wherein the plastic foam is a polyurethane spray foam.

3. The insulation system of claim 1, wherein the thickness of the layer of plastic foam insulation is from about 0.5 inch to about 10 inches.

4. The insulation system of claim 1, wherein the thickness of the layer of blown-in fiberglass insulation is from about 1.5 inch to about 15 inches.

5. The insulation system of claim 1, wherein the density of the layer of blown-in fiberglass insulation is from about 1.5pcf to about 2.5pcf.

6. The insulation system of claim 1, wherein the layer of blow-in fiberglass insulation is left exposed and constitutes the outermost layer of the system.

7. The insulation system of claim 1, wherein the layer of plastic foam insulation further comprises a primer coating on its outer surface for enhancing adhesion to the layer of blown-in fiberglass insulation.

8. The insulation system of claim 1, wherein the system is present in an attic of a building structure.

9. The insulation system of claim 1, wherein the layer of blown-in fiberglass insulation is adhered to the layer of plastic foam insulation by a chemical adhesive.

10. A method of insulating a cavity of a building structure, comprising:
    - forming a layer of plastic foam insulation on a substrate of the cavity, and
    - forming a layer of blow-in fiberglass insulation such that the layer of blow-in fiberglass insulation is in substantial contact with the layer of plastic foam insulation,
wherein the layer of blown-in fiberglass insulation is arranged at an interior side with respect to the layer of plastic foam insulation.

11. The method of claim 10, wherein the plastic foam is a polyurethane spray foam.

12. The method of claim 10, wherein the thickness of the layer of plastic foam insulation is from about 0.5 inch to about 10 inches.

13. The method of claim 10, wherein the thickness of the layer of blown-in fiberglass insulation is from about 1.5 inch to about 15 inches.

14. The method of claim 10, wherein the density of the layer of blown-in fiberglass insulation is from about 1.5 pcf to about 2.5 pcf.

15. The method of claim 10, wherein the layer of blow-in fiberglass insulation is left exposed and constitutes the outermost layer of the system.

16. The method of claim 10, wherein the layer of plastic foam insulation further comprises a primer coating on its outer surface for enhancing adhesion to the layer of blown-in fiberglass insulation.

17. The method of claim 10, wherein the system is present in an attic of a building structure.

18. The method of claim 10, wherein the layer of blown-in fiberglass insulation is adhered to the layer of plastic foam insulation by a chemical adhesive.

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