Chapter

7

Loose-Fill Insulation

Loose-fill insulation materials are distinguished from other insulation types by the size of the individual unit of material. Produced as shreds, granules, or nodules, loose-fill insulation products can either be poured or blown into place depending on the material or the construction application. Generally speaking, loose-fill insulation materials for pouring applications are most commonly sold in bags. Larger applications, such as attic installations, may require mechanical blowing equipment available from professional insulation installers. Pneumatic applications probably account for about 90 percent of residential installations of loose-fill insulation (Fig. 7.1).

Loose-fill insulations are well suited for places where it is difficult to install other types of insulation, such as irregularly shaped areas, around obstructions (such as plumbing stacks), and in hard-to-reach places. Framing that is irregularly spaced or out of square can be especially problematic with standard-sized blanket insulation products. Loose-fill insulation products can be installed in either enclosed cavities such as concrete block walls, wood frame walls when an additional barrier is installed, or unenclosed spaces such as attics. Blown-in loose-fill insulation is particularly useful for renovation and retrofit installation because it can be installed with minimal disturbance of existing interior or exterior finishes. Hand-packed fills are also useful for hand fitting into odd spaces such as around door and window frames in wood frame construction.[1]

Loose-fill insulation materials that are modified with water-activated binders or adhesives and installed by pneumatic methods are

Figure 7.1 Blowing loose fill insulation. (*NREL/DOE*)

discussed in Chap. 9. This chapter explores the use of nonmodified loose-fill insulation materials or systems that are simply poured or blown in.

General Description

Loose-fill materials such as cellulose, fiberglass, mineral wool (rock wool and slag wool), vermiculite, perlite, wood shavings, and expanded polystyrene will be discussed in this chapter. Although specific properties of each will be discussed, there are general characteristics relating to the generic performance of loose-fill insulations that should first be reviewed.

Weight

Ceiling gypsum wallboard can sag under heavy loads, especially those sometimes created by insulation. One gypsum wallboard manufacturer recommends loads of no more than 1.3 lb/ft^2 for $^1/_2$" ceiling gypsum wallboard with framing spaced 24" on center. The limit increases to 2.2 lb/ft^2 for framing spaced 16" on center and for $^5/_8$" gypsum wallboard.[2] Cellulose and rock wool insulation manufacturers usually include weight-limit information on the bag because the thickness required may cause excessive weight limits.

Because fiberglass is much less dense, its weight on ceiling gypsum wallboard may not be a concern.

Convective heat loss

As discussed in Chap. 3, *convection* is heat flow caused by air currents. Although convective heat loss in insulation is rare, it can occur when large temperature differences above and below the insulation create tiny air currents, called *convection loops,* within the insulation. Studies have shown that convective heat loss typically occurs with lighter-density loose-fill materials, such as fiberglass, at the very low attic temperatures possible in extremely cold climates. Depending on the attic temperature, the insulation's measured R-value could decrease by as much as 50 percent. These convection loops can be minimized by installing material in accordance with the manufacturer's winter design conditions, installing blown-in cellulose, or placing a fiberglass or mineral wool blanket on top of the loose-fill fiberglass[2] (Fig. 7.2).

Settling

Some loose-fill insulations installed in attic cavities will lose some of their installed R-value over time because of settling. Installers need to refer to the "installed thickness" specifications. Researchers say that it is possible, however, to install loose-fill insulations in wall cavities without settling if the cavity is completely filled with insulation at the proper density. A general density guideline for walls is roughly 3.5 lb/ft^3 of wall cavity for cellulose and 1.5 lb/ft^3 for fiberglass or rock wool. These specifications are roughly two or three times the density of horizontal applications.[2]

Density measurements may not be practical for do-it-yourself installers. Another guideline to ensure that wall cavities are being filled at a density sufficient to prevent settling is based on the quantity of material. For example, if installing in 8-ft walls with 16" on-center wall cavities and 2 × 4" framing, use roughly one 30-lb bag of cellulose or about 15 lb of fiberglass or rock wool for every three wall cavities to be filled.[2] (These quantities are for general information only. Consult the manufacturer's literature for a specific application.)

Moisture resistance

All loose-fill insulations are permeable to water vapor. (As discussed in Chap. 4, *permeability* is the extent to which water

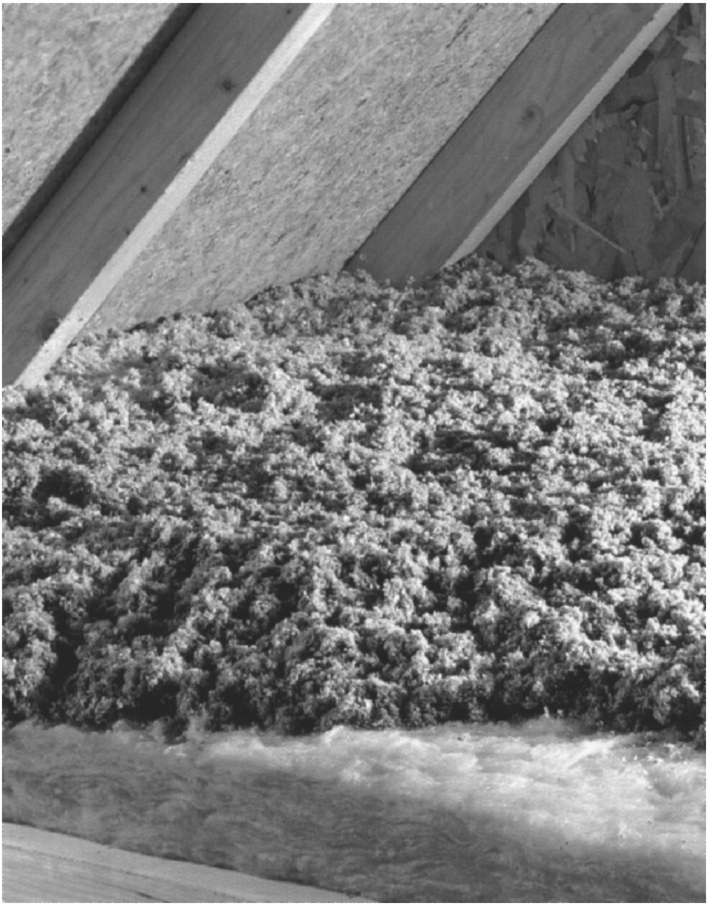

Figure 7.2 Cellulose insulation on top of fiberglass batts. (*Greenstone*)

vapor can pass through a given material.) Fiberglass and rock wool absorb less than 1 percent of their weight, whereas cellulose absorbs 5 to 20 percent of its weight. It is important to note that any insulation can absorb moisture if exposed to extremely high humidity.

If water penetrates a cavity, such as with a roof leak, moisture can accumulate in the attic cavity and wet the insulation to the point that it mats and compacts. Enough moisture penetration could even cause the ceiling to sag under the extra weight. Typically, if insulation is saturated only one time, it will dry eventually and regain most of its original R-value unless permanent compression is present (i.e., matted down.) However, loose-fill insulations that are repeatedly saturated will lose much of their R-value. Mold and mildew growth also can develop under extensive conditions.

Insulation blown into ceiling cavities should cover the top plate of the wall, but be sure the eave vents are not covered. These vents provide necessary ventilation to the attic, and covering them could result in severe moisture problems.

Voids and gaps

Voids or gaps will occur if the insulation is installed at too low a density or the cavity is not completely filled. Voids are most likely to occur at the top of wall cavities, above windows, around doorways, and in the corners of ceiling cavities. Voids also occur if the installation holes are improperly located between the vertical framing studs or if there are too few fill holes. It also may be difficult to achieve the recommended R-values with loose-fill insulation in the eave area of an attic.

Fluffing

Fluffing occurs when insulation is installed to a minimum thickness but not to the minimum weight requirements. The result is a less dense application of insulation that requires fewer bags. When insulation is fluffed, air passes more easily through it, leading to increased heat loss. Additionally, the fluffed loose-fill insulation eventually may settle and result in a thinner layer with a lower overall R-value.[2] Fiberglass is typically more problematic with fluffing than cellulose or rock wool. The best way to verify if fluffing has occurred, either accidentally or by dishonest contractors, is to count the number of bags used during installation and compare it to the instructions and coverage charts on the bag. The manufacturer should specify the amount of insulation per square foot (or square meter) of space needed to obtain the required R-value.

Safety guidelines

Pipes for kitchen stoves, wood stoves, and furnaces should only be insulated with fiberglass or rock wool because cellulose may smolder if flue temperatures become hot enough. Similarly, electrical devices and recessed lights, except those which are rated for direct contact with insulation, require a minimum of 3" of clearance from insulation.[2]

Health considerations

While the debate continues as to the health effects of loose-fill insulations, it is important to be protected during any type of insulation installation. A National Institute of Occupational Safety and Health (NIOSH)–approved respirator and protective eyewear and clothing such as goggles, gloves, long-sleeved shirts, and pants will minimize contact with the insulation. The home's ductwork should be sealed properly, as well as any other openings where insulation could leak out of the wall or ceiling cavities and into the living space. Insulation fibers also can be drawn into air-distribution systems if the ducts are not sealed properly, allowing the fibers to circulate within the living space.

Cellulose Loose-Fill Insulation

The term *cellulose* refers to the base fiber for all plant life. Wood, paper, and other plant-based products all are cellulosic materials. Cellulose loose-fill insulation is produced from recovered wood pulp materials. These include used newsprint and boxes that have been shredded and pulverized into small fibrous particles and subsequently treated with boron-based chemicals to make the material fire retardant. Dry loose-fill cellulose insulation is installed in attics and walls with pneumatic blowing machines, whereas existing walls may be insulated by blowing insulation in through access holes (Fig. 7.3).

Figure 7.3 Cellulose installation by pneumatic equipment. (*Greenstone*)

Originally manufactured as a sound deadener, cellulose soon caught on as an effective, dense insulation material. Early cellulose insulation remained a small portion of the market as fiberglass became increasingly popular after World War II. When the energy crisis arose in the 1970s, the demand for better insulation grew, and a resurgence of interest in cellulose insulation soon followed. The cellulose industry expanded rapidly, but the increased demand allowed a number of inferior manufacturers to enter the competition. Once the energy crisis subsided, the cellulose industry experienced a shakeout and again settled into a relatively small share of the insulation market. The 1980s saw relatively few changes in the products or the ranks of major cellulose insulation producers. Consequently, the number of active cellulose producers reduced in number from 200 companies in 1983 to 61 companies in 1991.[3]

According to the Cellulose Insulation Manufacturers Association (CIMA), an advocacy organization for the cellulose insulation industry, cellulose commands about 10 percent of the insulation market. Cellulose dominates the manufactured homes market (at least 60 percent) and enjoys a healthy share of the retrofit industry.

Another form of cellulose insulation, spray-applied in wet or damp form, is covered in Chap. 9. As a self-supporting material, it relies on water, adhesive, or a combination of both to build bond strength to a substrate and within itself. Spray-on products also may be used in wall cavities (fully open and dried before covering) or on other suitable exposed wall or overhead surfaces.

Standards

Cellulose insulation has been exposed to a broad range of construction, environmental, and various code requirements that have called for a more elaborate definition of physical properties. These requirements have been identified and met in the following federal regulations, federal procurement specifications, and industry standards[4]:

16 CFR Part 1209 (The CPSC Safety Standard). This is the Consumer Products Safety Commission (CPSC) safety standard that covers four product attributes: settled density, corrosiveness, critical radiant flux (a measure of surface burning), and smoldering combustion. It is illegal to market cellulose insulation that does not conform with this section of the *Code of Federal Regulations.*

16 CFR Part 460 (The FTC R-Value Rule)

ASTM C-739 [Standard Specification for Cellulosic Fiber (Wood-Base) Loose-Fill Thermal insulation]. This is the industry standard for loose-fill cellulose insulation. It covers all the factors of the CPSC regulation and five additional characteristics: R-value, starch content, moisture absorption, odor, and resistance to fungus growth.

ASTM C-1149 (Standard Specification for Self-Supported Spray Applied Cellulosic Thermal/Acoustical Insulation)

HH-I-515E (The General Services Administration Purchasing Specification for Loose-Fill Cellulose Insulation; requires ASTM C-739 conformance)

The states of California and Minnesota have their own insulation regulations that are based on the American Society for Testing and Materials (ASTM) standards and, in the case of cellulose insulation, on the CPSC standard. Of course, the insulation requirements of all pertinent building codes also apply to the installation of cellulose. Building codes are required by the Consumer Products Safety Act to follow the CPSC standard. Thus cellulose insulation conforming with the federal standard is approved for installation in any code jurisdiction.[4]

Loose-fill cellulose insulation, like all loose-fill insulation, should be installed in accordance with ASTM Standard C-1015, "Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation."

Product description

Cellulose is a relatively low-cost insulation product, is easy to install, and is not subject to convective heat loss. Studies show that cellulose (as well as rock wool) is more resistant to airflow than fiberglass because it has greater density. Cellulose (as well as rock wool) also may be more effective at reducing air leakage and associated heat loss because its higher density causes it to settle and seal more around rafters and in corners.[2]

Cellulose loose-fill insulation settles more than rock wool or fiberglass loose-fill insulation. The proportions are about 20 percent for cellulose, 2 percent for rock wool, and 4 percent fiberglass. Therefore, install about 20 percent more blown-in cellulose insulation to offset this settling. Cellulose manufacturers are required by federal law to state "settled thickness" on their bags. Because this can be confusing to consumers, many cellulose producers also specify the "installed thickness."[2]

Blow-in methods are also referred to as *dense-packing*. Dense-pack cellulose is installed at densities of at least 3.5 lb/ft^2 and up to approximately 4.0 lb/ft^2. The insulation flows from a high-velocity insulation blower at 100 ft/s. The air that is trapped between the cellulose fibers contributes to the insulating value, approximately R-3.8 per inch. Technique is important in work with a higher-density installation. The hose has a tendency to become clogged if the installer is inexperienced.

New cellulose insulation technologies are increasing the use of lower-density cellulose produced by "fiberizing" newspaper. Fiberizing breaks the raw material down into individual fibers that are fluffier. This modification means that the product is cleaner, creates less dust, and has a slightly higher R-value.

R-value

The typical R-value of cellulose insulation is between 3.6 and 3.8 per inch. For example, an attic with 10 in of dry cellulose could provide an R-value of 38. A typical manufacturer's coverage chart is shown in Fig. 7.4.

Limitations

Moisture absorption, ranging from 5 to 20 percent of its weight, is one disadvantage of cellulose insulation. This also may alter its physical and chemical properties, as well as settle, if the insulation is not applied at the correct density. Other concerns with loose-fill fiber insulation are displacement as a result of wind and infestations of rodents. It is also possible that, over many decades, dust and dirt accumulation could reduce the R-value, either by compressing the insulation or by filling air pockets.

Weight considerations

Loose-fill cellulose could cause the ceiling to sag if installed at R-38 on $^1/_2$" ceiling gypsum wallboard with framing spaced 24" on center. Therefore, when deciding whether to use these materials for new construction, consider switching to $^5/_8$" ceiling gypsum wallboard or, if possible, changing your ceiling framing widths to 16" on center.

Health considerations

Cellulose fiber is characterized as a nuisance dust but is not a health hazard. The fire retardants used in cellulose insulation are

30 lb. bag

PNEUMATIC APPLICATION COVERAGE CHART							
R-Value at 75°F Mean Temperature	Minimum Thickness		Net Coverage No Adjustment for Trusses			Gross Coverage Based on 2 x 6 Trusses on 16 Centers	
			Maximum Net Coverage		Minimum Weight Per Square Foot		
To Obtain an Insulation Resistance (R) of	Installed Insulation Should Not Be Less Than (inches)	Thickness After Settling (inches)	Square Feet Per Bag	Minimum Bags Required Per 1,000 Square Feet	The Weight Per Square Foot of Installed Insulation Should Not Be Less Than (lbs.)	Square Feet Per Bag	Bags Required Per 1,000 Square Feet
R-50	15.0	13.5	16.7	60.1	1.802	17.3	57.8
R-42	12.6	11.4	19.8	50.5	1.514	20.8	48.2
R-40	12.0	10.8	20.8	48.0	1.441	21.9	45.8
R-38	11.4	10.3	21.9	45.6	1.369	23.1	43.4
R-32	9.6	8.6	26.0	38.4	1.153	27.7	36.1
R-30	9.0	8.1	27.8	36.0	1.081	29.6	33.7
R-24	7.2	6.5	34.7	28.8	.865	37.7	26.5
R-22	6.6	5.9	37.8	26.4	.793	41.4	24.1
R-19	5.7	5.1	43.8	22.8	.685	48.3	20.7
R-13	3.9	3.5	64.0	15.6	.468	70.7	14.2
R-11	3.3	3.0	75.7	13.2	.396	83.5	12.0
Sidewalls (pressure filled-density 2.6 PPCF)							
R-13 (2 x 4)	3.5	3.5	39.6	25.3	0.758	43.7	22.9
R-20 (2 x 6)	5.5	5.5	25.2	39.7	1.192	27.8	36.0

Figure 7.4 Typical manufacturer's coverage chart. (*Greenstone*)

also regarded as nonhazardous. For example, the toxicity of boric acid is one-sixth that of table salt. Nevertheless, respiratory protection should be worn while handling and installing the insulation material.

Environmental considerations

Cellulose is an excellent example of recycled material use in insulation. Insulating a typical 1500-ft^2 ranch-style home with cellulose insulation productively recycles as much newsprint as an individual will consume in 40 years.[5] Most cellulose insulation is approximately 80 percent postconsumer recycled newspaper by weight. The remaining 20 percent is comprised of fire-retardant chemicals and/or acrylic binders depending on the product. In 1994 alone, the cellulose industry used approximately 840 lb of recycled newspaper. Experts suggest that if all new homes constructed in the United States were insulated with cellulose, over 3.2 million tons of waste newsprint would be used each year.[5]

According to CIMA, cellulose has a very low comparative embodied energy, calculated to be 20 to 40 times less than mineral fiber insulations. (*Embodied energy* is the total energy, such as the fuels, electric power, transportation, and job-site related power, used to extract, fabricate, package, transport, install, and commission a building product, material or system.)

Fire resistance

Ever since cellulose insulation was first marketed in the late 1940s, sellers of competing products have raised questions about the safety of the material. Cellulose insulation, as an organic material, will burn without special processing. Unlike two competing insulation materials, fiberglass and rock wool, which are naturally fire resistant, cellulose's fire resistance is achieved by adding chemicals.

According to Dan Lea, executive director of CIMA, the common fire retardants in cellulose insulation are borax, boric acid, and ammonium sulfate. Public concerns may be due more to misinformation than fact. For example, boric acid is commonly used as an eyewash. The salts of borax are used in laundry products but have a toxicity level even lower than that of boric acid. Ammonium sulfate is used as a food preservative and a soil fertilizer.

The CPSC does not believe cellulose insulation is a hazardous product. Fire statistics do not support the hazard claim, and knowledgeable fire officials who have studied the matter agree. Extensive evidence indicates that cellulose is a positive factor in residential building fire safety, mainly due to the material characteristics of cellulose. Once the surface of a cellulose insulation layer is charred, it no longer flames, and the charred material actually becomes a barrier against rapid combustion deeper in the insulation. Smoldering combustion may continue, but its progress through the insulation will be very slow due to the dense fiber structure of cellulose and its fire-retardant characteristics.[6]

The most recent findings were released in test results made available in February 2000. Independent laboratory tests, commissioned by CIMA and conducted according to the ASTM E119 protocol by Omega Point Laboratories of Elmendorf, Texas, have shown that cellulose insulation can increase the fire resistance of walls by up to 77 percent compared with uninsulated walls. Cellulose can now be used in a 1-hour fire-wall assembly that meets the new *International Building Code* and *International Residential Code.* Walls for the test were constructed with both $^1/_2$" and $^5/_8$" type X gypsum wallboard. The insulation was standard off-the-shelf cellulose installed by a local contractor.[7] This is an increase in fire resistance as compared with earlier tests sponsored by the cellulose industry and the mineral fiber insulation industry. These stated that cellulose produced a 22 to 55 percent increase in fire resistance.[6]

The biggest long-term performance concern with cellulose insulation is the possible loss of fire-retardant chemicals. There are other reports that claim cellulose insulation may be safe initially but that over time the fire retardants bake out, leech out, settle out, break down, sublime, evaporate, or somehow disappear. Because borates are water soluble, they can leach out if the insulation gets wet. Some people claim that the chemicals gradually disappear even if the material does not get wet, although these claims have not been substantiated independently. According to Dan Lea of CIMA, there is a shift within the industry toward ammonium sulfate fire retardants, which actually improve in fire-retardant performance over time. A concern with ammonium sulfate, however, is the corrosion of metals in contact with the insulation, particularly with wet-spray applications.

According to CIMA, the Forest Products Laboratory of the University of California at Berkeley performed an extensive literature search and reviewed all relevant published studies on cellulose insulation chemical permanency. The study concluded that "the only substantive report that indicated an aging effect is that recently reported by the California Bureau of Home Furnishings and Thermal Insulation." CBHF said of its study: "The results are inconclusive and variable, and certainly cannot be used to condemn this material." Numerous other studies, including tests by scientists and technicians at Oak Ridge National Laboratory, Tennessee Technological University, Allied Signal Corp., U.S. Borax Corp., Underwriters Laboratories, and the United States Testing Company, found no sign of "disappearing fire retardants."[6]

The competitive nature of the insulation business has generated a great amount of literature in support of, or in defense of, the material characteristics and performance of each product. Since an independent test is not within the scope of this book, one must weigh all the information in order to arrive at a general consensus as to the actual fire-resistance characteristics of cellulose insulation.

For example, the North American Insulation Manufacturers Association (NAIMA) claimed in one report that "independent tests confirm [the] potential fire hazards of cellulose insulation." In defense of cellulose insulation, CIMA states that "all six cellulose products tested exceeded the requirements of the only material standard that references the test method used in the study." According to CIMA, the NAIMA tests "actually proved the safety of cellulose insulation."[6]

Even when a fire is classified as "insulation related," the insulation is seldom the first material to ignite. Heat-producing devices and electrical short circuits were major factors in insulated-related fires. In the vast majority of cases, a heat-producing device, such as a recessed lighting fixture, is covered by the insulation. Heat builds up and is conducted through wiring or metal brackets to a wood structural member. This indicates that it is usually the wood or electrical insulation that ignites first.

Installation standards and practices

Dry loose-fill cellulose insulation is typically installed in attics and walls with pneumatic blowing machines (although in some attics the insulation can be poured in place). Even though installation methods may vary slightly depending on the material, the machine used, or the actual job-site conditions, the CIMA standard guidelines will provide a general framework in order to better understand installation procedures. The following specifications are for general information only.[8] These guidelines cover the application of cellulosic loose-fill thermal insulation in attics, sidewall cavities, and between floors of single- and multifamily dwellings by means of pneumatic equipment and by pouring in place in attics (see Fig. 7.1).

Preliminary inspection

An inspection of the building should be made prior to installation, with special consideration given to the following areas:

1. Holes in ceilings or sidewalls that would allow the insulation to escape should be sealed.
2. Weak areas of interior walls that may not be able to withstand pressures during the filling operation should be reinforced or filled using less pressure.
3. Walls with alterations, such as built-in bookshelves and cabinets, that may create isolated cavities require special entry holes.

4. Wall cavities that are used as air ducts for heating or air-conditioning systems must not be filled with insulation.
5. Openings in heating or air-conditioning systems in insulated areas must have blocking placed around them but not so as to restrict airflow.
6. Wall cavities that open into basements or crawl spaces must be sealed.
7. The external siding of existing buildings should be inspected for paint peeling or other evidence of moisture problems because insulation or a vapor barrier alone may not solve such problems. Other remedial actions may be necessary.

Preparation

For new construction, several key areas need to be addressed. First of all, if individual vents are used in the soffit, the rafter space immediately in front of and on either side of the vent should be provided with an air chute (Figs. 7.5 and 7.6). Other spaces should be totally blocked. Where a continuous strip vent is used in a soffit, an air chute should be provided every third rafter space, with the other spaces completely blocked. The small cavities around door and window frames should be insulated prior to installation of the interior covering. The material should not be forced into the cavity so tightly that frames or finishes are distorted. Finally, insulating the corners of attics in buildings with hip roofs may require special nozzles or placement tools. Alternately, corners can be insulated with suitable insulation before the gypsum wallboard or plasterboard is installed. Any other areas that will be inaccessible after the interior finish is installed must be handled in like manner.[8]

For existing structures, preparation should be performed in critical areas where the insulation may not be contained. For example, in joist areas, where soffit vents are installed, the opening from the attic into the soffit area may be blocked by use of pieces of batt-type insulation between and at the ends of the joists. Insulation should not totally fill the space between ceiling and roof. There should be a 1-in opening next to the roof for ventilation from the soffit area (or a chute or baffle may be installed).

For new and existing structures, a number of areas typically will be addressed in a similar manner for each project type. These include

1. Blocking should be placed around access to the attic to prevent insulation from falling out.

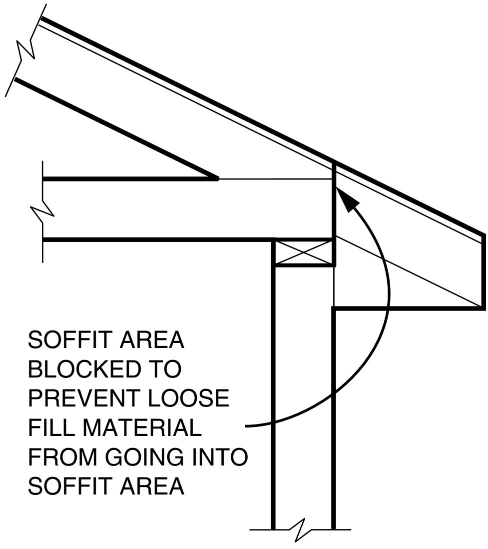

Figure 7.5 Blocked soffit. (*CIMA*)

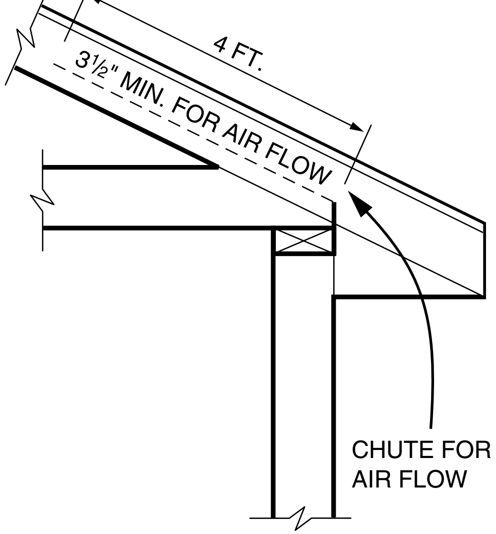

Figure 7.6 Roof venting. (*CIMA*)

2. Blocking should be placed around recessed light or heating fixtures, chimneys, and flues. Clearance between heat-producing elements and combustible construction should follow applicable codes. Blocking should be placed permanently so as to keep insulation a minimum of 3 in away from all sides of recessed lighting fixtures and other heat-producing devices. The open area above recessed lighting fixtures and other heat-producing devices should not be insulated, per the *National Electrical Code*.
3. Cabinet bulkheads, stairway wells, and wall cavities that open into an attic should be covered by backer board to support the insulation.
4. The open side of any wall between a heated and unheated area should be covered by backer board to form a cavity for retaining the loose-fill material.

Coverage requirements

When installing insulation, care should be taken not to exceed the square-foot coverage shown on the label. (ASTM C739 requires that each bag of cellulose loose-fill insulation be labeled with technical information, including the maximum net coverage per bag of the particular insulation for all commonly specified R-values.) The labeled thickness is the minimum thickness required for a given R-value. The initial installed thickness in ceiling applications will exceed the settled thickness shown on the coverage chart. The bag count and weight-per-square-foot requirements of the coverage chart must be followed to provide the specified R-value at settled density.

Application procedures

Ceiling areas. When installing insulation by pneumatic means in accessible ceilings, it is important that the blowing machine be set as recommended by the machine manufacturer. Specifiers do not need to compensate for settling in attics because federal law (the CPSC standard and the FTC R-Value Rule) requires R-value and coverage data to be stated at settled density. Specifiers, installers, and buyers need to understand that the "minimum thickness" column on cellulose coverage charts represents settled thickness if the chart has only one thickness column. The "bag count" and "weight" columns are the "official" coverage statements.[4]

Installations in enclosed ceiling cavities must be made by pneumatic means, and the cavity should be filled completely. This is done by inserting a fill tube into each cavity and withdrawing it as the cavity is filled. The air setting on the machine should be set as recommended by the machine manufacturer for sidewall application. Coverage will be proportional to that shown on the manufacturer's coverage chart under sidewalls, depending on the cavity size.[8]

Sidewalls in existing buildings. Installation into sidewall cavities must be made by pneumatic means. The air setting on the machine should be set as recommended by the machine manufacturer according to the size nozzle being used. After fill holes are drilled, all cavities should be checked for fire blocking or other obstructions with an electrician's fish tape or other similar tool. A mathematical check should be made in the first few stud spaces to ensure that the proper amount of insulation is being installed. Installers also should verify with the manufacturer's coverage chart.[8]

In wall applications, standard practice is to compact loose-fill cellulose to a density that will prevent settling. While this is a matter of some controversy, most authorities recommend a density of at least 3.0 lb/ft^3 for cellulose insulation in walls. Materials with high nominal settled densities (2.0 lb/ft^3 and higher) should be installed at 3.5 lb/ft^3. Research has confirmed that settling is virtually nil with any cellulose insulation at densities of 3.5 lb/ft^3 or higher. Compacting cellulose insulation may produce a very slight reduction in R-value.[4]

If filling the wall cavity through the external siding in an existing building, the following procedure is recommended by CIMA. First, drill holes from $^5/_8$ to 2" in diameter, depending on the siding, in each wall cavity. The vertical distance between the access holes and the top or bottom plate should not exceed 2 ft; the vertical distance between the holes should not exceed 5 ft. Homes with shingle or lapped siding should have the holes drilled as near the shadow line as possible. Homes with brick veneer should have holes $^5/_8$ to $^3/_4$" in diameter drilled in the mortar joints. All holes should be filled with suitable plugs[8] (Fig. 7.7).

Filling the wall cavity with a fill tube in some applications is desirable. When using this method, only one entry hole per cavity is necessary. The fill tube should be inserted far enough to reach within 18" (45.72 cm) of the plate farthest from the point of entry. Fill-tube size will depend on the size of hole that can be drilled (see Figs. 7.8 and 7.9 for alternate points of entry for the fill tube).

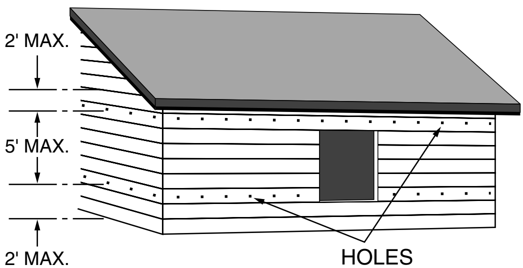

Figure 7.7 Installation holes. (*CIMA)*

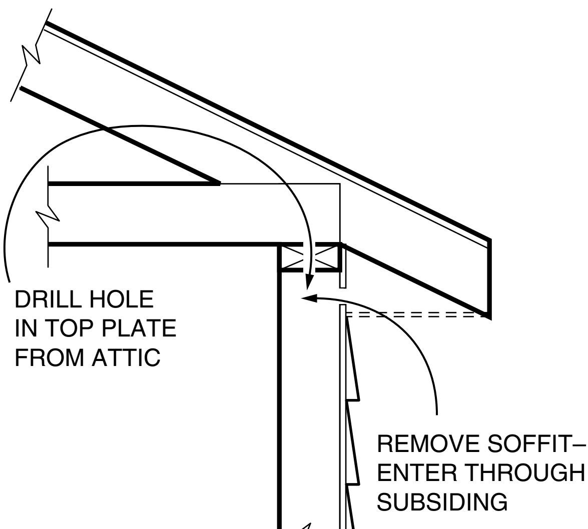

Figure 7.8 Soffit access. (*CIMA*)

Sidewalls in new buildings. Various types of permanent retainer systems are used to install dry cellulose insulation in new walls. All systems are proprietary, and the manufacturers provide detailed instructions and often special training programs for their use. All systems require pneumatic installation and compression of the material to sufficient density to prevent settlement. The Insulation Contractors Association of America (ICAA) recommends a density of 1.5 times nominal settled density for sidewall installations. Some manufacturers recommend an installed density of at least 3.5 lb/ft^3 in sidewalls.

Dry cellulose insulation can be installed in new walls using temporary retainers that are clamped in place to create a closed cavity.

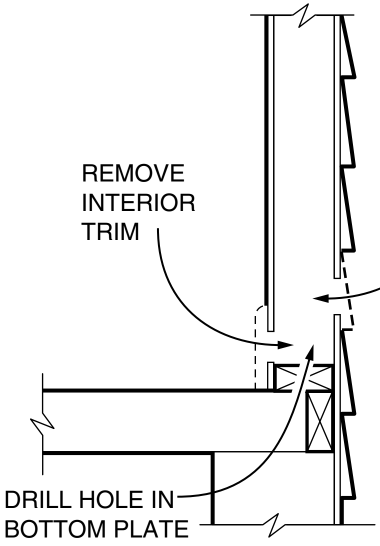

Figure 7.9 Wall access. (*CIMA*)

Insulation is blown into the temporary cavity at sufficient density to keep it in place when the retainer is removed.

One manufacturer of a proprietary product uses a polyester tire chord vapor retarder as the retainer during installation. Convenient access to the cavity is advantageous and allows visual inspection of the process during installation. The ParPac system uses any loose-fill cellulose insulation and is installed at a density of 3 lb/ft^3, resulting in an R-value of 3.61 per inch (Figs. 7.10 and 7.11).

Vapor retarders. As discussed in Chap. 4, the need for vapor retarders and their proper location within a wall assembly are influenced by the interior and exterior environmental conditions as well as the wall's thermal and vapor flow characteristics. It is important to note that each building is fairly unique in terms of wall construction, interior use, and environmental conditions, and should be evaluated individually by the building designer. The homeowner also could consult an insulation manufacturer and building code official for recommendations on where to place a vapor retarder.

When installing loose-fill insulations, a material such as 6-mil (0.006") polyethylene plastic sheeting can be used as a vapor retarder. Some cellulose manufacturers recommend against use of vapor retarders in walls insulated with spray-applied cellulose.

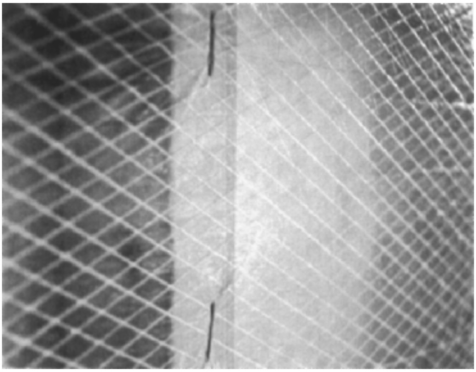

Figure 7.10 Polyester tire chord vapor retarder. (*ParPac, Inc.*)

Figure 7.11 Installation through vapor retarder. (*ParPac, Inc.*)

CIMA is not aware of any endemic problems resulting from this practice.

A vapor retarder is typically not required under attic insulation when the attic is adequately ventilated, but a vapor retarder must be used when the cold side of ceilings cannot be ventilated. A ground-surface vapor retarder such as plastic film is recommended when there is a crawl space beneath a floor.

In existing construction, most cellulose producers regard vapor retarders as unnecessary with dense-pack cellulose under most conditions. If design temperatures are below −15°F (−26°C), the interior surfaces of exterior walls and ceilings where the cold side cannot be ventilated can be painted with a vapor barrier paint. As with new construction, a ground-surface vapor retarder, such as plastic film, is recommended when there is a crawl space beneath a floor.

Ventilation. Ventilation guidelines are specified in the locally adopted building codes. The more stringent requirement should be used if the following CIMA guidelines contradict with the building code. In vented attics without vapor retarders, standard practice is to provide 1 ft^2 of net vent area for each 150 ft^2 of ceiling area. In vented attics with vapor retarders, standard practice is to provide 1 ft^2 of net vent area for each 300 ft^2 of attic floor area. When using a combination of roof and eave vents and no ceiling vapor barrier, there should be 1 ft^2 of net vent area for each 300 ft^2 of ceiling area. Vents should be installed with 50 percent of the total area in the eaves and 50 percent of the total area in the roof near the peak. If the residence is built over an unheated crawl space, there should be 1 ft^2 of net vent area for each 150 ft^2 of floor area.

Installation precautions and limitations

As stated earlier, the following items may be in concert with or in contradiction with the adopted state and federal building codes. The building codes are a minimum level of safety and quality and must be adhered to.

1. Heaters and recessed light fixtures must not be covered by the insulation unless the fixture has a direct contact rating. It is recommended that a minimum of 3" of airspace be maintained between any fixtures and the blocking.
2. Cold air returns and combustion air intakes for hot air furnaces must not be blocked or insulation be installed in a manner that would allow it to be drawn into the system.
3. Insulation must not be in contact with chimneys or flues. A minimum of 3" of airspace must be maintained, with blocking used to retain the insulation.
4. The homeowner should be advised that in tightly constructed homes or when insulating existing homes that have fuel-fired heating systems within the living area or basement, an air duct must be installed between the furnace room and a well-ventilated outside area to provide combustion air. A local heating contractor should be contacted for proper duct size and installation.
5. The homeowner should be advised that the relative humidity within the living area should be kept below 40 percent when outside temperatures fall below 32°F (0°C).

6. Dry cellulose insulation is not recommended for use in sidewalls below grade.
7. Dry cellulose insulation is not recommended for filling the cavities of masonry walls.
8. Dry cellulose insulation is to be used in the temperature range of −50 to 180°F (−45.6 to 82.2°C).
9. The installer must wear appropriate respiratory protective equipment.
10. Installers and specifiers are advised to refer to other relevant documents, including the *National Electrical Code,* ASTM Standard C1015, CIMA Technical Bulletin 1, and CIMA Technical Bulletin 3 for additional information.

Fiberglass

Fiberglass is one of a group of glassy, noncrystalline materials historically referred to as man-made mineral fibers (MMMFs) or man-made vitreous fibers (MMVFs). Glass fibers are made from molten sand, glass, or other inorganic materials under highly controlled conditions. The glass typically is melted in high-temperature gas or electric furnaces. The material is then spun or blown into fibers that are then processed into the final product.

Most major manufacturers use 20 to 30 percent recycled glass content. Rock wool (or slag wool) loose-fill insulation is similar to fiberglass except that it is spun from blast furnace slag (the scum that forms on the surface of molten metal) and other rocklike materials instead of molten glass.

Fiberglass loose-fill insulation is available in two forms: processed either from a by-product of manufacturing batts or rolls or from "prime" fibers produced especially for blowing applications. Both must be applied through pneumatic means using a mechanical blowing machine, whether it be "open blow" applications such as attic spaces or closed-cavity applications such as those found inside walls or covered attic floors.

Product description

Fiberglass loose-fill insulation is inorganic and noncombustible. The fibers will not rot or absorb moisture and do not support the growth of mildew, mold, or fungus. Fiberglass absorbs about 1 percent of its weight, but any insulation can absorb moisture if exposed to extremely high humidity. The moisture vapor absorption of fiberglass loose-fill insulation shall not be more than 5 percent by weight when tested in accordance with ASTM C1104. It is also not subject to drastic settling, usually about 1 or 2 percent in attic spaces up to a maximum of 4 percent.[2]

R-value

The R-value of loose-fill fiberglass, when settled naturally as in an attic at 0.7 lb/ft^3, is 2.2 per inch. When installed at a density of 2.0 lb/ft^3 in a wall, the R-value is 4.0 per inch. One of the most significant criteria for achieving the desired R-value is meeting the designated minimum weight per square foot of material. It is also important that the minimum thickness be achieved, since this, along with the required weight per square foot of material, is essential to obtain the desired R-value. As mentioned earlier, the correct values for coverage with each loose-fill material are stated by the manufacturer in a bag label specifications chart.

Fiberglass blown insulation can be purchased installed for about 7 cents per inch-thick square foot. Except for blown cellulose insulation, which costs about the same, fiberglass in blown (or batt) form is the cheapest insulation on the market for the insulating value achieved.[9]

Limitations

Laboratory attic tests have shown that light-density loose-fill products may suffer a reduction as attic temperatures drop further. For example, the actual R-value of loose-fill fiberglass insulation has been shown to decrease by 20 to 40 percent under extreme winter conditions. Oak Ridge National Laboratory measured R-values as low as R-12 at an attic temperature of 9°F for an R-19 fiberglass installation. Follow-up testing at the same laboratory seems to suggest that convection currents actually resulted in an increase of only $20 in energy cost (gas heating bills) per annum. Electric resistance heat costs were slightly higher.[10]

Health considerations

A contentious point of debate continues to revolve around the health concerns of fiberglass insulation. Health and safety research on fiberglass has been ongoing for nearly 60 years. Member companies with NAIMA, the trade association of North American manufacturers of fiberglass, rock wool, and slag wool insulation products, have committed tens of millions of dollars in research projects with leading independent laboratories and universities in the United States and abroad. Recent studies have presented results that suggest that the carcinogenic concerns about fiberglass may only have an impact under extreme exposure conditions. An Occupational Safety and Health administration (OSHA) report in 1994 stated that fiberglass insulation is carcinogenic, but results indicated that there was virtually no risk to home occupants. The greatest risk was the exposure to installers during installation.[11]

In 1997, the American Conference of Governmental Industrial Hygienists (ACGIH), representing over 1600 academic and government professionals engaged in occupational safety and health programs, concluded that the "available evidence suggests that [fiberglass]…is not likely to cause cancer in humans except under uncommon or unlikely routes or levels of exposures." The ACGIH designated fiberglass as an "A3, animal carcinogen." The A3 designation indicates that the substance may cause cancer in experimental animals at relatively high doses and by routes of exposure that "are not considered relevant" to workers.[12]

The Canadian government classified fiberglass as "unlikely to be carcinogenic to humans" and concluded that glass wool "is not entering the environment in quantities or under conditions that may constitute a danger in Canada to human life or health." The CPSC (1992) also has found that "fibrous glass is carcinogenic in animals only when surgically implanted into the lung or abdomen. In tests where animals were exposed by inhalation, the expected route of human exposure, the animals did not develop tumors. Therefore, the animal implantation studies do not establish a hazard to humans."[13]

Nevertheless, fiberglass as a simple irritant is well documented. Workers in fiberglass manufacturing plants, as well as people working with or using materials that contain fiberglass, may develop a skin irritation. This mechanical irritation is a physical reaction of the skin to the ends of fibers that have rubbed against or become embedded in the skin's outer layer. Any skin irritation caused by fiberglass is temporary. Washing the exposed skin gently with warm water and mild soap can relieve it. The vast majority of workers and consumers, however, can control skin irritation by following recommended work practices when handling the material. Fiberglass is also a catalyst for eye irritation if deposited in the eye by the user's fingers or through fibers in the air. If this should happen, the eyes should not be rubbed but rinsed thoroughly with warm water, and a doctor should be consulted if irritation persists.[12]

Fiberglass released into the air during its manufacture or handling also may create temporary upper respiratory irritation. Like skin irritation, upper respiratory irritation is a mechanical reaction to the fibers. It is not an allergic reaction, and the irritation generally does not persist. Such exposures to high concentrations of airborne fiberglass may result in temporary coughing or wheezing. These effects will subside after the worker is removed from exposure.[12]

As will be discussed later in this chapter, proper clothing and handling and the use of approved respiratory protection can effectively control exposure to airborne fibers and therefore reduce the likelihood of skin or upper respiratory tract irritation.

Environmental considerations

NAIMA tracks the fiberglass industry's recycling efforts through an annual survey of its members. A total of 6,107,397,000 lb of pre- and postconsumer glass waste have been recycled during the production of fiberglass insulation over the past 6 years. Much of present-day fiberglass insulation contains upwards of 40 percent recycled glass depending on the manufacturing facility.[14]

Fire resistance

Loose-fill fiber glass is naturally fire resistant.

Installation standards and practices

Fiberglass loose-fill insulation typically is installed in attics and walls with blowing machines, but most attics can be poured in place if necessary. Although installation methods may vary slightly depending on the material, the machine used, or the actual job-site conditions, the NAIMA standard guidelines will provide a general framework to better understand installation procedures.[15]

In order to estimate the amount of loose-fill fiberglass insulation to be installed, the area to be insulated is measured first. This should be the net area only, since the area occupied by framing members should be deducted from the total wall or attic space. From these calculations, the required number of bags or pounds of insulation is determined from the bag label chart for the desired R-value. (ASTM C764 requires that each bag of fiberglass loose-fill insulation be labeled with technical information, including the maximum net coverage per bag of the particular insulation for all commonly specified R-values.) Any deviation from the quantity specified will affect the desired R-value. This holds true in both open- and closed-blow installations.

According to NAIMA, thickness must not be used as the sole factor in determining the R-value of loose-fill insulation. When blown-in insulation is installed properly (at the recommended weight per square foot or bags per 1000 ft^2), it may have an "installed thickness which is greater than the stated minimum thickness." This is sometimes described as *overblow* in order to compensate for any potential insulation settlement. If the correct number of bags are installed and the thickness exceeds the minimum thickness, the labeled R-value will be achieved or exceeded.[16]

If these products were installed at the minimum thickness, the overblow would produce a coverage per bag that would exceed the maximum net coverage shown on the bag label, but the weight per square foot would be less and the R-value would be lower than the intended R-value. In any event, if the thickness installed using the correct number of bags is less than the stated minimum, then additional material must be added to bring the installed thickness up to the required minimum thickness.[16]

If an existing installed insulation amount needs to be verified, NAIMA provides a few recommendations. These involve taking measurements of the insulation thickness, removing and weighing a known area of insulation, and calculating the weight per square foot of the insulation. The measured weight per square foot and the installed thickness are then compared with the value shown on the manufacturer's label. Meeting or exceeding the labeled values ensures that the proper R-value has been achieved.[16]

Installers are required to provide a data sheet verifying the amount and achieved R-value installed. This is known as the *United States Federal Trade Commission's Labeling and Advertising of Home Insulation Rule,* and it mandates that the consumer is to receive a signed and dated contract or receipt for the insulation thickness installed. The receipt for loose-fill insulation must show the type of insulation, the coverage area, the thickness, the R-value, and the number of bags installed. The installer also must provide a manufacturer's fact sheet. The fact sheet for loose-fill insulation must contain, in addition to the manufacturer's name, address, and type of insulation, a chart containing the R-value and coverage information. Installers must have this information and must show it to customers before they agree to buy the insulation. Similarly, a seller of new homes must put the following information in every sales contract: the type, thickness, and R-value of the insulation that will be installed in each part of the house.[16]

General work practices applicable to all work involving synthetic vitreous fibers (SVF) such as fiberglass (rock wool and slag wool) have been established by OSHA. Excerpts of the guidelines are as follows[17]:

1. Minimize dust generation.
   - Keep the material in its packaging as long as practicable and if possible.
   - Tools that generate the least amount of dust should be used. If power tools are to be used, they should be equipped with appropriate dust-collection systems as necessary.
   - Keep work areas clean and free of scrap SVF material.
   - Do not use compressed air for cleanup unless there is no other effective method. If compressed air must be used, proper procedures and control measures must be implemented. Other workers in the immediate area must be removed or similarly protected.
   - Where repair or maintenance of equipment that is either insulated with SVF or covered with settled SVF dust is necessary, clean the equipment first with a HEPA vacuum or equivalent (where possible) or wipe the surface clean with a wet rag to remove excess dust and loose fibers. If compressed air must be used, proper procedures and control measures must be implemented. Other workers in the immediate area must be removed or similarly protected.
   - Avoid unnecessary handling of scrap materials by placing them in waste disposal containers and by keeping equipment as close to working areas as possible, which prevents release of fibers.

2. Ventilation
   - Unless other proper procedures and control measures have been implemented, dust collection systems should be used in manufacturing and fabrication settings where appropriate and feasible.
   - Exhausted air containing SVFs should be filtered prior to recirculation into interior workspaces.
   - If ventilation systems are used to capture SVFs, they should be checked and maintained regularly.

3. Wear appropriate clothing.
   - Loose-fitting, long-sleeved, and long-legged clothing is recommended to prevent irritation. A head cover is also recommended, especially when working with material overhead. Gloves are also recommended. Skin irritation cannot occur if there is no contact with the skin. Do not tape sleeves or pants at wrists or ankles.
   - Remove SVF dust from the work clothes before leaving work to reduce potential for skin irritation.

4. Wear appropriate personal protective equipment.
   - To minimize upper respiratory tract irritation, measures should be taken to control the exposure. Such measures will be dictated by the work environment and may include appropriate respiratory protective equipment. See OSHA's respiratory protection standard.
   - When appropriate, eye protection should be worn whenever SVF products are being handled.
   - Personal protective equipment should be fitted properly and worn when required.

5. Removal of fibers from the skin and eyes.
   - If fibers accumulate on the skin, do not rub or scratch. Never remove fibers from the skin by blowing with compressed air.
   - If fibers are seen penetrating the skin, they may be removed by applying and then removing adhesive tape so that the fibers adhere to the tape and are pulled out of the skin.
   - SVFs may be deposited in the eye. If this should happen, do not rub the eyes. Flush them with water or eyewash solution (if available). Consult a physician if the irritation persists.

Before starting, verify that the machine is set in accordance with the instructions on the bag. The machine settings were developed by manufacturers using machines in good working order and proper application techniques. Always keep the hose level, and install with a minimum of hand deflection. It is also important to always blow parallel with, and not across, the joists. To verify that proper amounts are being applied, it is wise to section the attic into quadrants and make sure one-quarter of the specified number of bags is used in each section to achieve the desired R-value.

Applying insulation in unfloored attics. NAIMA recommends that the installer keep the hose parallel to the floor, with the insulation falling

10 to 12 ft in front of the hose. It is best to back away from the work while blowing, to prevent packing. The installer can blow three or four joist spaces from one position by moving the hose to the right or to the left. Where working space is tight, the installer should prevent the insulation from packing by allowing it to blow off his or her hand.

Special construction conditions will require extra attention during installation. For example, the insulation is to be installed on both sides of obstructions such as solid cross-bracing, wiring, and masonry chimneys. If a batt or baffle is not used to block off the ends of joists, the insulation is to be applied to the outer edge of the plate. When roof construction does not allow full depth to the ends of the joists, the insulation can be "bounced" off the underside of the roof to increase density in that area, but be sure not to block the eave vents[15] (Fig. 7.12).

Clearance needs to be maintained around heat-producing devices, fossil-fuel appliances, and light fixtures, or as specified in the local building code. For example, the insulation is not to be placed in airspaces surrounding metal chimneys or fireplaces. Unfaced fiberglass insulation can be used between wood framing and masonry chimneys.

The installer should even out any high or low spots to verify that the minimum thickness has been achieved. Some areas will not be covered by design. Access panels, stair wells, and fan covers will need a piece of batt insulation on top of areas where loose-fill insulation has not been applied.

If the attic space is already floored, the installer should attempt to blow no more than 4 to 6 ft under flooring. This will require the

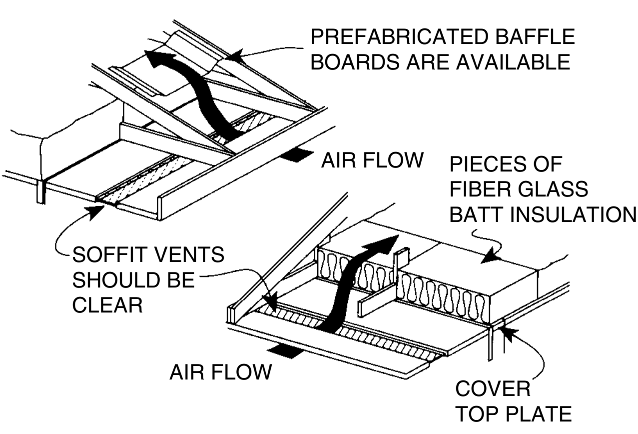

Figure 7.12 Air flow clearance. (*NAIMA*)

removal of floorboards (or plywood sheathing) approximately every 8 to 12 ft to guarantee adequate blowing coverage. When blowing below a floor, the installer should insert the hose approximately 4 to 6 ft under the floor and gradually pull it out as the space fills with insulation. Twist and turn the hose as it is removed to ensure complete coverage of the area under the floor. In finished attic knee walls and slopes, it is possible to use retainers and blow knee walls, but it is easier to use batts (Fig. 7.13).

Applying insulation in sidewalls. Regardless of the outside finish, all existing house sidewalls are insulated in a similar manner. [As opposed to the Blow-In Blanket System (BIBS), which is installed while the home is under construction. See Chap. 9.] The only variable is the method required to remove the exterior finish in order to access the stud cavity. There can be many variations of the procedures for the removal and replacement of different types of sidewall materials. Any method that gives sufficient access to the sidewall area can be used, but an experienced carpenter, framer, or mason should be used to guarantee that the existing exterior finish material will be returned to its original condition.

Generically speaking, the first step is to have isolated portions of the outside finish removed. Openings are then made in the sheath-

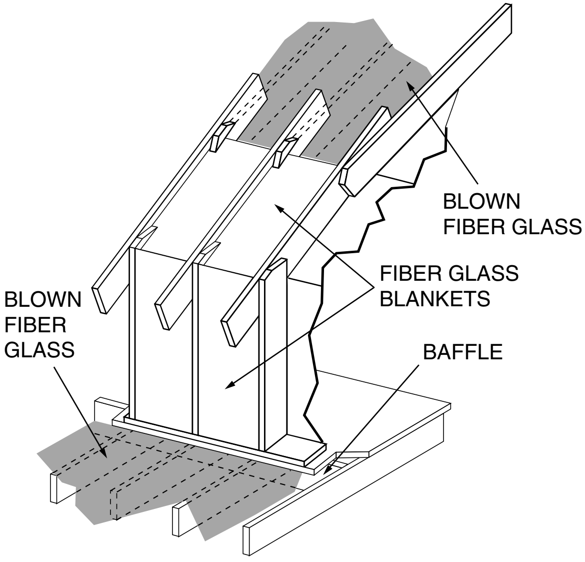

Figure 7.13 Attic knee walls and slopes. (*NAIMA*)

ing so that the loose-fill fiberglass can be blown into the empty stud spaces. The "double blow" method, with two openings (top and bottom), is commonly used for sidewalls. Different applicators have different methods of filling sidewalls, but it is generally recommended that the lower holes be filled first to ensure that the lower parts of stud cavities are filled. Some stud sections may require three or more openings because of construction features, such as firestops, blocking, junction boxes, electrical cables, and bracing (Fig. 7.14).

NAIMA's guidelines state that openings should be made into the stud area for each 4 to 5 ft in wall height. Since blowing is limited to no more than 4 ft down or 12" up a space, this is the only way to ensure the stud space will be filled properly. Blowing through a single opening in an 8-ft wall could leave some of the stud space with voids or no insulation. One way to check the actual stud cavity depth is to drop a plumb bob into the wall. Areas above and below windows and below firestops and bracing also must be opened to determine the exact location of obstructions and ensure that the cavity is filled completely.[15]

Mineral Wool

The term *mineral wool* historically refers to two materials: rock wool and slag wool. (Fiberglass is also included in some references to mineral wool.) Rock and slag wool fall within a group of

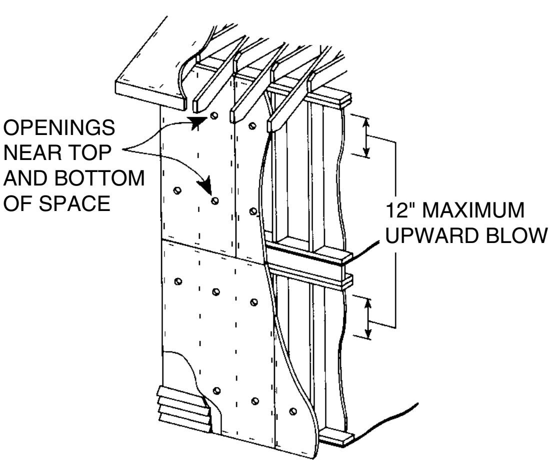

Figure 7.14 Application holes. (*NAIMA*)

materials historically referred to as man-made mineral fibers (MMMFs) or synthetic vitreous fibers (SVFs); however, a more appropriate name is man-made vitreous fibers (MMVFs), reflecting the glassy, noncrystalline nature of these materials.

The mineral wool form of MMVFs was developed initially in the late 1800s by melting slag and spinning it into insulation for use in homes and industry. Over the past century, mineral wool manufacturing has evolved into a large and diversified industry as more and more products have been developed.

Rock wool and slag wool each use different raw materials in their manufacture. Rock wool is made from natural minerals, made primarily from natural rock such as basalt or diabase. Slag wool is made primarily from iron ore blast furnace slag. Slag wool accounts for roughly 80 percent of the mineral wool industry, compared with 20 percent for rock wool, in the United States. These proportions are reversed in European countries.[18]

While mineral wool was at one time the most common type of insulation, its market share was lost largely to fiberglass in the 1960s and 1970s. In the past few years, however, the product appears to have been making a comeback. There are currently several manufacturers of mineral wool in the United States and about eight plants that produce it.[18]

Rock and slag wool insulations are produced by a centrifugal wheel process. Natural rocks or iron ore blast furnace slag are melted, and the hot, viscous material is spun into fiber by pouring a stream of molten material onto one or several rapidly spinning wheels. As droplets of the molten material are thrown from the wheel(s), fibers are generated. As the material fiberizes, its surface generally is coated with a binder and/or dedusting agent (e.g., mineral oil) to suppress dust and maintain shape. The fiber is then collected and formed into batts or blankets or baled for use in other products, such as acoustical ceiling tile and spray-applied fireproofing, insulating, and acoustical materials.[19]

Because of the manufacturing process and the differing performance characteristics of specific products, rock or slag wool insulation materials are comprised of a wide range of fibers with varying thicknesses or diameters. Typically, individual fibers range between 1 and 15 μm in diameter, with an average diameter of 3 to 7 μm. (A micron is 1/1,000,000 of a meter or 1/25,400 of an inch.) By comparison, a human hair is about 70 μm in diameter.[19]

When viewed under a microscope, rock and slag wool fibers resemble single rods. Because they are noncrystalline in nature, these fibers break across their long axis, resulting in shorter fibers of the same diameter. They do not split lengthwise into thinner, smaller-diameter fibers, as do many crystalline fibers such as asbestos, an important factor when considering potential exposures.

Product description

Similar to fiberglass in texture and appearance, mineral wool, an inorganic fiber, will not absorb moisture. Rock and slag wool fibers are dimensionally stable, have high tensile strength, and do not support combustion. There is no significant settling with rock and slag wool as long as it is installed properly. Mineral wool will not support the growth of mildew, mold, or bacteria when tested in accordance with the specifications of the ASTM (ASTM C665).

R-value

The blown material has an R-value of 2.7 per inch depending on the installed density. The poured material has the same characteristics as the blown material, but with a slightly higher R-value of 3 per inch. Small amounts of moisture have little effect on the material's R-value.

Limitations

Mineral wool (and to a lesser extent, fiberglass) tends to "hang up" on protrusions and nails in the wall cavity. It also can settle over time if not blown properly, so the manufacturer's recommendations should be followed.

Weight

Loose-fill rock wool, being a heavier material, can cause ceiling sag if installed at R-38 on $^{1}/_{2}$" ceiling gypsum wallboard with framing spaced 24" on center. Consider switching to $^{5}/_{8}$" ceiling gypsum wallboard or, if possible, changing the ceiling joist spacing to 16" on center.[2]

Health considerations

Health and safety research on rock and slag wool has been ongoing for more than 50 years. NAIMA member companies have helped fund three areas of research involving rock and slag wool. These include exposure assessments of current production workers and end users, analyses of the rates and causes of death of former production employees, and animal test studies. Airborne levels of respirable rock and slag wool fibers have been demonstrated to be very low, less than 1 fiber per cubic centimeter of air in most instances. Human epidemiologic studies have not demonstrated evidence of a dose-related causal association between lung cancer or nonmalignant respiratory disease and occupational exposure to rock and slag wool. Animal inhalation studies using massive doses of rock and slag wool fibers, hundreds to thousands of times greater than human exposures, have not shown a relationship between inhalation of rock and slag wool fibers and lung cancer either. Since 1987, several major reviews have been undertaken on the health and safety of rock and slag wool. All these reviews concluded that inhalation of rock and slag wool fibers does not induce significant disease in animals.[19]

Various other studies have not established a link between casual exposure to rock and slag wool and lung cancer either; however, limited evidence does demonstrate an association between exposure to rock wool and cancer in manufacturing workers.

The use of injection/implantation studies as the sole determinant of the carcinogenic hazard of a fibrous material is not generally accepted for human health hazard assessment. These studies, however, have not produced significant tumors, except for one injection test at an exceedingly high concentration.[20] However, the fact that rock wool fibers, when intentionally inserted into animals, have produced tumors may not be a practical analysis for casual exposure. Based primarily on these studies using nonphysiologic routes of exposure, the International Agency for Research on Cancer (IARC) considered the animal evidence as limited for rock wool and inadequate for slag wool and, following its own guidelines, has classified both rock and slag wool as a "2B, possibly carcinogenic to humans." For reference purposes, the IARC also has classified coffee, saccharin, gasoline engine exhaust, and more than 150 other common substances as "possibly carcinogenic to humans." In general, IARC rules dictate that this designation be given if there is sufficient evidence of carcinogenicity in animals, even if the route of exposure is artificial (nonphysiologic) and human data are inadequate or limited.[19]

Rock and slag wool fibers are a catalyst for skin irritation. This irritation is a mechanical reaction of the skin to the ends of rock and slag wool fibers that have rubbed against or become embedded in the skin's outer layer. Workers in contact with mineral wool during manufacturing processes or installation are susceptible to this temporary nuisance. It can be relieved by gently rinsing the exposed skin with warm water. Hot water and scrubbing will exacerbate the condition.

Eye irritation occurs when rock or slag wool are deposited in the eye by the user's fingers or through airborne fibers. If this occurs, the eyes should not be rubbed but rinsed thoroughly with warm water. A doctor should be consulted if the irritation persists.

If sufficient amounts of rock and slag wool are released into the air during manufacture or handling, some workers may experience temporary upper respiratory tract irritation. Such exposures to high concentrations of airborne rock and slag wool fibers may result in temporary coughing or wheezing, a mechanical reaction. These effects will subside after the worker is removed from exposure. The use of approved respiratory protection can effectively control upper respiratory tract irritation by limiting exposure to airborne fibers.

With publication of the OSHA hazard communication standard in 1983 and the IARC decision in 1987 to classify rock and slag wool as "possibly carcinogenic to humans," rock and slag wool manufacturers have added cancer warnings to their product labels. While this may appear alarming to an uninformed user of rock and slag wool products, the primary purpose of the labels is simply to identify a potential hazard. The labels do not signify that there is any real risk to humans at actual levels of exposure. The manufacturers of these products remain confident that the risk associated with the use of rock and slag wool products, if there is any risk at all, can be effectively controlled via reduction of workplace exposures and adherence to simple recommended work practices.[19]

Some of the mineral wool insulation manufactured before about 1970 has been found to contain lead particles. According to industry sources, lead slag is no longer used in the manufacture of mineral wool, although lead can be present as a trace impurity. OSHA has expressed concern in situations where new insulation is installed over pre-1970 mineral wool and lead particulates are released into the air. Exposures will vary markedly from job site to job site because of such factors as the size of the space, the method of application, and the amount of lead dust in the mineral wool. Exposures are likely to be highest when insulation is blown into place in a confined space.[21]

Environmental considerations

NAIMA tracks the slag wool industry's recycling efforts through an annual survey of its members. During the past 6 years, NAIMA's data show that 6,289,156,000 lb of blast furnace slag have been recycled during the production of slag wool insulation.[14]

Fire resistance

Rock and slag wool have good fire resistance due to the physical and chemical properties. The fibers are noncombustible and have melting temperatures in excess of 2000°F and supply fire protection, as well as sound control and attenuation.[14] Mineral wool is also a good material for insulating around chimneys because it does not support combustion.

Installation standards and practices

General work practices, applicable to all work involving synthetic vitreous fibers (SVFs) such as rock wool and slag wool, have been established by OSHA. These are listed in the loose-fill fiberglass section of this chapter.

Perlite

Perlite is a granular-type loose-fill insulation quarried mainly in the western United States. It is a naturally occurring silicous rock. Perlite is different from other volcanic glasses because when the crushed ore is heated to a suitable point in its softening range, it expands from 4 to 20 times its original volume. This expansion is attributed to the presence of water, between 2 and 6 percent, in the crude perlite rock. When the rock is quickly heated to above 1800°F, the material pops in a manner similar to popcorn as the trapped water vaporizes to form microscopic cells, or voids, in the heat-softened glass. After expansion, an air blast separates and grades the particles according to size. This expansion process accounts for the lightweight quality of expanded perlite. While the crude rock may range from transparent light gray to glossy black, the color of expanded perlite ranges from snowy white to grayish white.

Product description

Perlite is used widely as a loose-fill insulation in masonry construction. In this application, perlite is poured into the cavities of concrete block, where it completely fills all cores, crevices, mortar areas, and ear holes. A nominal R-value of 2.7 per inch typically is used for calculation purposes; however, a range of 2.5 to 4.0 has been achieved. Expanded perlite can be manufactured to weigh as little as 2 lb/ft^3, making it adaptable for numerous applications. In addition to providing thermal insulation, perlite is fire-resistant, has low water absorption, reduces noise transmission, and is resistant to rot, vermin, and termites. Perlite loose-fill insulation is packaged in bags and must be poured into place. It is not suitable for blow-in installation methods. It is best used for attics and is reasonably well suited for walls.

Vermiculite

Vermiculite is a mineral closely related to mica, primarily mined in Montana and South Carolina. Consisting of silica, magnesium dioxide, aluminum oxides, and other minerals, vermiculite expands when heated to form a lightweight material with insulating properties. There are two types of vermiculite: untreated and treated. The treated material is coated with asphalt to make it water-repellent for use in high-moisture areas. Untreated vermiculite absorbs water and, once wet, dries very slowly.

Product description

Aluminum magnesium silicate is constructed of approximately 1 million separate layers per inch, with a minute amount of water between each layer. Flakes of the mineral are placed in a furnace at 1800°F, which changes the water to steam, causing the vermiculite to expand to 15 times its original size. (The name originates from the vermicular, or wormlike, movement of the layers during expansion.) The expanded material is soft and pliable, silvery or gold in color, and contains less than 1 percent water by weight (Fig. 7.15).

Untreated vermiculite has an R-value of 2.3 per inch, compared with an R-value of 2.5 per inch for the treated material. Vermiculite is usually hand-installed, is nonabrasive, pours easily into irregular spaces, and is suitable for both horizontal and vertical applications. It is noncombustible, odorless, resistant to vermin, and nonirritating.

As discussed in Chap. 16, W. R. Grace Co., the manufacturer of Zonolite vermiculite loose-fill insulation, was hit with three class-action lawsuits after failing to warn the public that the Zonolite attic insulation it sold from 1963 through 1984 contained tremolite

Figure 7.15 Vermiculite. (*Strong Lite Products Corp.*)

asbestos. Grace discontinued its attic insulation in 1984 but still produces a loose-fill vermiculite masonry insulation. The U.S. Environmental Protection Agency (EPA) estimated in 1985 that 940,000 American homes contained or had contained Zonolite attic fill.[22] Although it is not possible that all Zonolite installations were contaminated, more than 70 percent of the vermiculite ore mined in the world came from the Libby Montana mine, which has been closed since 1990. This particular mine was unusual because the area also included a natural deposit of tremolite asbestos.

If you know you have vermiculite insulation in your attic or walls and you are concerned about it, it probably makes sense to test the material to see if it contains asbestos. A trained consultant or licensed contractor should collect the sample and get it analyzed at a laboratory.

Small-Market Products

Wood shavings, granulated cork, and expanded polystyrene beads are loose-fill insulation products that are seldom seen today. For example, wood shavings, although rarely used today, were once a very popular insulation product because of their wide availability and low cost. Shavings often were treated with lime or other chemicals to increase resistance to water absorption, fire, and fungal growth. This insulation product is still a common sight in older homes across North America.

Appendix

The Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
800-DOE-EREC (363-3732)
Fax: 703-893-0400

Cellulose Insulation Manufacturers Association (CIMA)
136 South Keowee Street
Dayton, OH 45402
513-222-2462

Insulation Contractors Association of America (ICAA)
1321 Duke Street, Suite 303
Alexandria, VA 22314
703-739-0356

North American Insulation Manufacturers Association (NAIMA)
44 Canal Center Plaza, Suite 310
Alexandria, VA 22314
703-684-0084
Fax: 703-684-0427
E-mail: *insulation@naima.org*
Web site: *http://www.naima.org*

CertainTeed Corporation
Insulation Group
Mike Lacher
P.O. Box 860
Valley Forge, PA 19482
610-341-7000
Fax: 610-341-7571

Cocoon/Greenstone
6500 Rock Spring Dr.
Suite 400 Bethesda, MD 20817
888-592-7684
Fax: 402-379-2780
http://www.greenstone.com/

Knauf Fiber Glass
Glenn Brower
One Knauf Drive
Shelbyville, IN 46176
800-825-4434
317-398-4434
Fax: 317-398-3675
Email: *gab2@knauffiberglass.com.*

ParPac® Dry Pac Systems
27 Main Street
Swanzey, NH 03446
1-877-937-3257

The Perlite Institute Inc.
88 New Dorp Plaza
Staten Island, NY 10306-2994
718-351-5723
Fax: 718-351-5725
http://www.perlite.org/

The Vermiculite Association
Contact: Dr. Michael J. Allen
Whitegate Acre
Metheringham Fen
Lincoln, LN4 3AL UK
+44 1526 323990
Fax: +44 1526 323181
E-mail: *tva@vermiculite.org*
Web site: *http://www.vermiculite.org/*

Thermafiber Mineral Wool
James Shriver
3711 W. Mill Street
Wabash, IN 46992
219-563-2111
Fax: 219-563-8979
E-mail: *jshriver@thermafiber.com.*

References

1. Tyler Stewart Rogers, *Thermal Design of Buildings,* (New York: John Wiley and Sons, 1964), p. 38.
2. ”Loose Fill Insulations,” U.S. Department of Energy (DOE), DOE/GO-10095-060, May 1995, p.3.
3. Daniel Lea, Cellulose Insulation Manufacturers Association, NIBS/BETEC Symposium, November 19, 1997.
4. CIMA Technical Bulletin 1, “Cellulose Insulation Codes, Regulations and Specifications,” Special Report, December 1998.
5. *Resource Conservation Research Home Insulation Fact Sheet,* Cellulose Insulation Manufacturers Association, p. 1.
6. Cellulose Insulation Fire Safety Special Report: “The Burning Question: Cellulose Insulation and Fire,” CIMA. Available at *http://www.cellulose.org.*
7. Cellulose Insulation Manufacturers Association Web site press release. April 9, 2000. Available at *http://www.cellulose.org/press.htm.*
8. CIMA Technical Bulletin 2, “Standard Practice: Installing Cellulose Building Insulation,” December 1998.
9. T. Neil Davis, “Fiber Glass Insulation,” *Alaska Science Forum,* Geophysical Institute, University of Alaska Fairbanks, April 30, 1981.

10. Technical Bulletin 53, CertainTeed Corporation, January 7, 1993.
11. J. D. Ned Nisson (ed), *Energy Design Update* 14(10), 1994.
12. NAIMA, *The Facts on Fiber Glass,* Publication No. N001, July 1998.
13. NAIMA, Health and Safety Research on Fiber Glass. Available at *http://www.naima.org/*.
14. NAIMA, "Fiber Glass and Slag Wool Insulations: Materials for a Sustainable Planet," Insulation Factsheet No. 45.
15. NAIMA, *Recommendations for Installation in Residential and Other Light Frame Construction,* Publication No. B1403, March 1997.
16. NAIMA, "Facts about Fiber Glass Loose-Fill Insulation," Insulation Factsheet No. 9, December 1996.
17. NAIMA's Health and Safety Partnership Program (HSPP), *http://www.naima.org/hspp/hspp.shtml*.
18. "Insulation Materials: Environmental Comparisons," *Environmental Building News,* 4(1), January-February 1995.
19. NAIMA, "The Facts on Rock and Slag Wool." Available at *http://www.naima.org/*.
20. NAIMA, "Health and Safety Research on Rock and Slag Wool." Available at *http://www.naima.org/*.
21. Haz-Map Occupational Toxicology Database. Available at *http://www.haz-map.com/*.
22. Environmental Protection Agency Web site, *http://www.epa.gov/region01/qa.html*.