TechNote

Installation of Common Insulation Types: Wood-Frame Walls and Attics

Thermal insulation is added to walls, roof/ceilings, and floors to slow down the flow of heat into or out of a home. For all types of insulation, the quality of installation is a significant factor in creating an energy-efficient and durable building enclosure and comfortable indoor environment. This TechNote provides practical information for the installation of three types of insulation in various applications. It is intended to help builders and designers meet the requirements of the energy code and maximize the value of each insulation type.

Insulation Types Addressed

Fiberglass is composed of spun glass fibers.

- **Fiberglass Batts** have glass fibers coated with a bonding agent. The batts come in pre-cut lengths and fit standard wall stud spacing or are shipped in rolls and cut to length at the job site. Batts are hand-cut/trimmed to be installed around pipes, electrical wiring, and in non-standard cavities. Batts are commercially available with or without vapor retarder facings (e.g., Kraft paper, foil).
- **Blown Fiberglass** utilizes an insulation blowing machine to blow the fiberglass material into wall cavities or onto an attic floor. In open-frame wall cavities, the fiberglass is held in place by a netting material or can be coated with an acrylic binder during application.

Cellulose insulation is made up of between 70% - 85% recycled newspaper, and is shredded and treated for fire, pest, and mold resistance.

- **Dry-Blown Cellulose** is installed using an insulation blowing machine. It is blown into open frame wall cavities behind netting or onto attic floors in loose form.
- **Damp-Spray Cellulose** is mixed with water (and possibly an adhesive), then spray-applied into open wall cavities. Damp blown cellulose requires time to dry before drywall can be installed.

Spray Polyurethane Foam (SPF) is fabricated on site using two components sprayed through a nozzle. Proper foam formation requires adhering to manufacturer instructions on ambient temperature and humidity, as well as receiving substrate temperature. The SPF cures in place and a short period of time is needed before re-entry. There are two types of SPF: low-density open-cell (ocSPF) and high-density closed-cell (ccSPF).

Figure 1. Installing Fiberglass Batts, Dry-Blown Cellulose, and Spray Polyurethane Foam in Wall Cavities

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Photograph courtesy of Cellu-Spray Insulation

Photograph courtesy of the American Chemistry Council

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Wall Cavities

See Home Innovation's TechNote on Vapor Retarders for guidance on developing a vapor management strategy before designing the wall assembly.

The first step to install **fiberglass batts** between wood framing members is to cut the batts to the proper length. If the cavity is irregularly shaped, the batt must also be cut to fit the shape of the cavity (or a smaller portion of batt should be cut to fill in any gap). The batt must be cut, notched, or split to fit around obstructions such as plumbing and wiring. Once cut, the batt is pressed into the cavity until it is in contact with the exterior sheathing. Then it is pulled back to expand the batt until it fills the depth of the cavity—this prevents compression, which would reduce the insulation's R-value. Batts without stapling tabs are simply friction-fit between the framing members, while batts with tabs can be face-stapled or inset-stapled to the studs.

Both **dry-blown fiberglass** and **dry-blown cellulose** are installed in wall cavities via a hose connected to a blower machine. Dry application requires a netting material to be installed before blowing in the insulation. The netting material is stapled onto the interior face of the framing members and a hole is made in the center for the blower machine tube. The installer fills the cavity from the bottom to the center where the hole is, then flips the tube and fills from the top of the cavity back to the center. After the cavity is filled to the insulation manufacturer's prescribed density, a roller is used to ensure the surface is flat.

HOT SPOT: The netting must be "drum tight" and free of wrinkles to avoid bulging once the insulation is installed. Any wrinkles and loose areas in the netting must be addressed prior to blowing in the fiberglass or cellulose insulation. This can be accomplished by side-stapling the netting to the studs on the interior of the wall cavity to increase the tension.

Damp-blown cellulose is spray-applied into the wall cavity through a hose connected to a blower machine. The cellulose is misted with water at application to help the fibers adhere to each other and to the studs, plates, and sheathing of the wall cavity Working from the bottom up, the installer fills the cavity past the studs. After the full height of the cavity has been filled, a wall scrubber is used to remove excess material from the top down. The excess material is collected from the floor to be recycled, typically using a vacuum.

HOT SPOT: The time it takes for the cellulose to dry depends on the relative humidity, air movement at the application site, the insulation's starting moisture content, depth of fill, ambient temperature, and presence of an interior vapor retarder. The Cellulose Insulation Manufacturers Association (CIMA) notes that it can take between 24 to 48 hours after application for the cellulose to dry. The cellulose manufacturer's recommended drying times for their product should be followed before dry-wall is installed.

Both **open-cell** and **closed-cell SPF** can be installed in wall cavities. Foam insulation is sprayed into the wall cavity directly against the exterior sheathing, where it expands to fill the entire space. Open-cell SPF expands more than closed-cell foam and is applied in a single pass to the specified thickness. Closed-cell SPF can be applied in multiple passes ranging from one-half to 2 inches per pass depending on product manufacturer instructions. The spray foam may expand past the studs and must be trimmed flush with the framing members. The foam must be applied at the manufacturer-recommended speed to prevent overheating during the curing process, which could cause the foam to char, smolder, or burn. Drywall should be installed within the time frame recommended by the SPF manufacturer in order to avoid degradation caused by UV light; alternatively, if permitted by its manufacturer, the SPF can be protected by applying an elastomeric coating.

HOT SPOT: It is recommended that only workers wearing personal protective equipment are present during the installation of the SPF; local exhaust ventilation should be provided during application and general ventilation should be provided directly after. Re-entry to the space by anyone is determined by consulting with the product manufacturer's literature. The Center for the Polyurethanes Industry notes that some manufacturers recommend 24 hours before re-entry for application of two-component, high-pressure SPF.

Vented Attics and Vented Roof Assemblies

Attic ceilings can be insulated using a single or a double layer of un-faced **fiberglass batts**. R30 and R38 batt products are commercially available and will satisfy minimum code attic insulation levels in a single-layer application for Climate Zones 1 through 3. In double-layer applications, lower R-value fiberglass batts are typically laid between the joists and a second layer of batts is laid transversely on top. The double-layer approach has the benefit of reducing thermal bridging at the joists. For either method, if the attic has eave vents, baffles must be installed at the eaves to prevent the batts from blocking the vents and prevent wind from passing directly through the fiberglass (air movement reduces the effectiveness of fiberglass insulation).

HOT SPOT: The IRC requires 3 in. of clearance between any non-Insulation Contact (IC) rated recessed lighting and attic insulation. Clearance can be provided by building an air-tight housing around the fixture using drywall, non-flammable rigid foam, metal, or a Sonotube®.

Vented Attics and Vented Roof Assemblies *(continued)*

Blown-in fiberglass and blown-in cellulose can be installed on the attic floor in a loose-fill application. The same blower machine used to install these materials in wall cavities is used to cover the entire attic floor to the depth required to meet the specified R-value. Installation should begin in the attic corner farthest from the access hatch and the installer should work his way back to the opening. Baffles are installed to ensure that the loose-fill insulation does not block the eave vents.

HOT SPOT: Consult the manufacturer's literature to determine the proper installation depth as loose-fill insulation will settle over time. Different products will settle to different degrees.

Builders can also opt to insulate the vented attic by applying **SPF insulation** directly onto the attic floor. The foam serves as both insulation and an air barrier. To reduce costs, some builders choose to install a hybrid system, typically ccSPF and blown-in (loose-fill) cellulose. In this configuration, the SPF is sprayed between the joists and, once cured, cellulose is blown-in on top. This approach may result in higher relative humidity in the conditioned space compared to a vented attic assembly.

HOT SPOT: For the lower 1/300 ventilation rate, the IRC requires a Class I or II vapor retarder in Climate Zones 6, 7, and 8.

Insulating a **cathedral ceiling** with fiberglass batts requires the roof assembly to be vented. Insulating a cathedral ceiling begins by installing baffles that extend from the eave vents to the ridge vents in order to provide one inch of clearance between the insulation and the roof sheathing. Once the baffles are installed, fiberglass batts are inserted between the roof rafters to fill the depth of the rafters; the batts are friction-fit in place.

If the rafters are not deep enough to accommodate sufficient insulation to meet the minimum R-value requirement, the builder needs to select a method of installing more insulation. Options to accomplish this include adding cross-hatched 2x4 furring below the rafters to allow the installation of more fiberglass, or installing rigid foam insulation above the roof sheathing. Drywall is installed below the final layer of insulation to create the ceiling in the living space.

Figure 2. Vented Roof Assembly

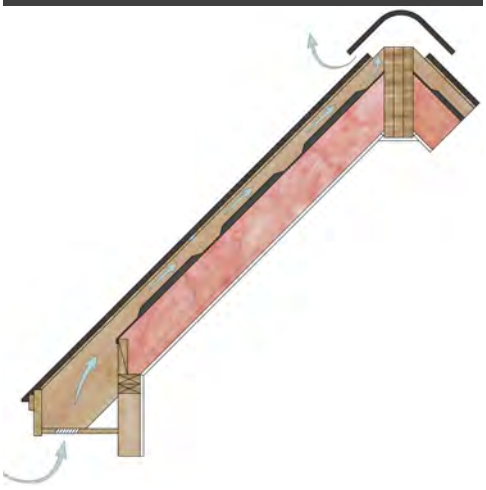


Figure 3. Attic Recessed Light Housing

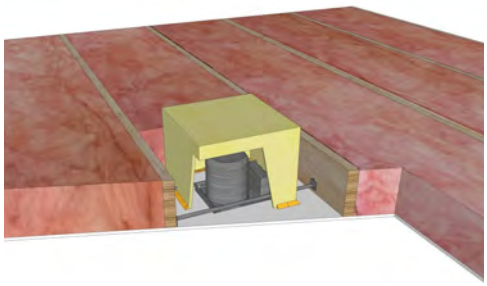
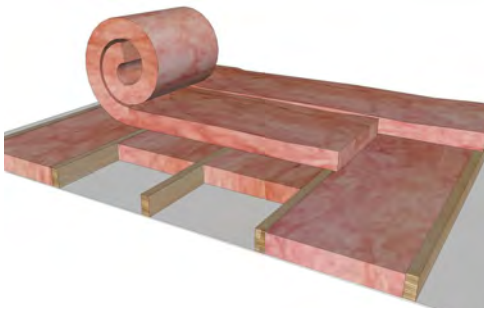


Figure 4. Double-Layer Batts



Insulated Rafter Assemblies

Insulated rafter assemblies can be constructed by omitting eave and ridge vents, and applying SPF directly to the underside of the roof sheathing. The thickness of foam will depend on the R-value per inch of the chosen product and the Climate Zone. An alternative insulation strategy is a hybrid SPF (applied to the sheathing) and fiberglass batts (installed below the SPF) method. The amount of ccSPF installed directly to the roof sheathing must be thick enough to comply with IRC Table R806.5 minimum R-values for each Climate Zone. Drywall is not required for the roof assembly in an unvented attic that does not contain fuel-fired appliances, as long as the space is only entered in for repairs or maintenance (not used as storage) and the foam is protected by an ignition barrier. [Note: an ignition barrier is not needed if the foam has been tested in accordance with IRC §R316.6].

HOT SPOT: The IRC requires a Class II vapor retarder coating for open-cell SPF in Climate Zones 5 - 8 [§R806.5.4]. Class I vapor retarders are not allowed on the ceiling side of the assemblies [§R806.5.2].

Figure 5. Insulated Rafter Assembly

Modeling a home's energy performance is becoming more common for both code compliance and participation in energy efficiency programs. The quality of insulation installation is one of the inputs for energy modeling. An inspector will evaluate the installation and assign it one of three grades based on the RESNET Energy Rating Index Standard. To avoid an energy performance penalty and future occupant comfort issues, specify the insulation contractor must meet the requirements of a Class I installation. [NOTE: energy rating software will model a Grade III installation as having 5% of the cavity area uninsulated. Neither Grade II or III comply with the minimum requirements of the 2015 edition of the National Green Building Standard.]

Table 1. RESNET Insulation Installation Grades

Grade	Insulation Installation Description
I	**Minor Deficiencies:** Occasional very small gaps are acceptable. Compression or incomplete fill amounting to 2% or less is acceptable, if the empty spaces are less than 30% of the intended fill thickness. Installed per manufacturer's instructions. Insulation must fit tightly around wiring and other services.
II	**Moderate Deficiencies:** No more than 2% of the surface area of the insulation is missing. No more than 10% of the surface area is compressed or has incomplete fill.
III	**Excessive Deficiencies:** Substantial gaps and voids; missing insulation between 2-5% of the cavity surface area. Does not meet the requirements for Class I or II installation.

Figure 6. Installing Damp-Spray Cellulose in Wall Cavities and Blown Fiberglass in an Attic

Photograph by Patrick McCombe, Fine Homebuilding Magazine
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Photograph courtesy of Construction Mentor Online.

HOT SPOT: Personal Protective Equipment (PPE) should be used when installing any type of insulation. This include safety glasses with side shields for the eyes; gloves, pants, and long sleeves for skin; and dust masks for the respiratory system.

Code Considerations

Key provisions of the model 2015 International Residential Code applicable to these types of insulation include the following:

- A minimum clearance of 3 inches is required between combustible insulation (fiberglass batt facings, SPF) and recessed lights, fan motors, and other heat producing devices unless they are insulation contact (IC) rated. [§R302.14].
- There must be at least 1 inch of free air space between air permeable insulation and roof sheathing in vented roof assemblies, and at the soffit vent [§R806.3].
- Construction documents must detail insulation materials and their R-value [§N1101.5].
- Unmarked fiberglass batts must be accompanied by an installer certification listing manufacturer and R-value [§N1101.10.1]
- For damp-spray cellulose, insulation installers must provide certification listing the initial installed thickness, settled thickness, settled R-value, installed density, coverage area, and number of bags, as applicable [§N1101.10.1].
- For blown or sprayed ceiling insulation, markers that list installed thickness must be installed for every 300 SF. For SPF, insulation installer's certification must include thickness and installed R-value [§N1101.10.1.1].
- Insulation must meet the minimum R-values for walls and ceilings shown in Table 2 on [Table N1102.1.2] or comply with the equivalent U-factors [§N1102.1.4] or total UA [§N1102.1.5] alternatives.
- For ceilings with an attic, the ceiling R-values may be reduced in from R-38 to R-30 or from R-49 to R-38 where the full height of the uncompressed insulation extends over the top plate at the eaves [§N1102.2.1].
- For ceilings without attic spaces that require ceiling R-values higher than R30, if the roof/ceilings assembly design does not allow enough space for the required insulation, the minimum installed insulation must be R-30 [§N1102.2.2].
- At access hatches from conditioned to unconditioned space, insulation must be installed to an equivalent level as that of the surrounding surfaces (e.g., R38 attic requires R38 insulation installed above hatch) [§N1102.2.4].
- Air-permeable insulation cannot be used as an air-sealing material [Table N1102.4.1.1]. Air sealing should be conducted prior to installing air permeable insulation (see companion TechNote on Air Sealing).

Consult the Authority Having Jurisdiction (AHJ) for location-specific requirements.

Table 2. Prescriptive Minimum R-Values for Walls and Ceilings (excerpt from 2015 IRC)

Climate Zone	Ceiling R-Value	Alternative Ceiling R-Value [See Note 3]	Wood Frame Wall R-Value
1	30	30	13
2	38	30	13
3	38	30	20/13+5
4 and 5	49	38	20/13+5
6, 7, 8	49	38	20+5/13+10

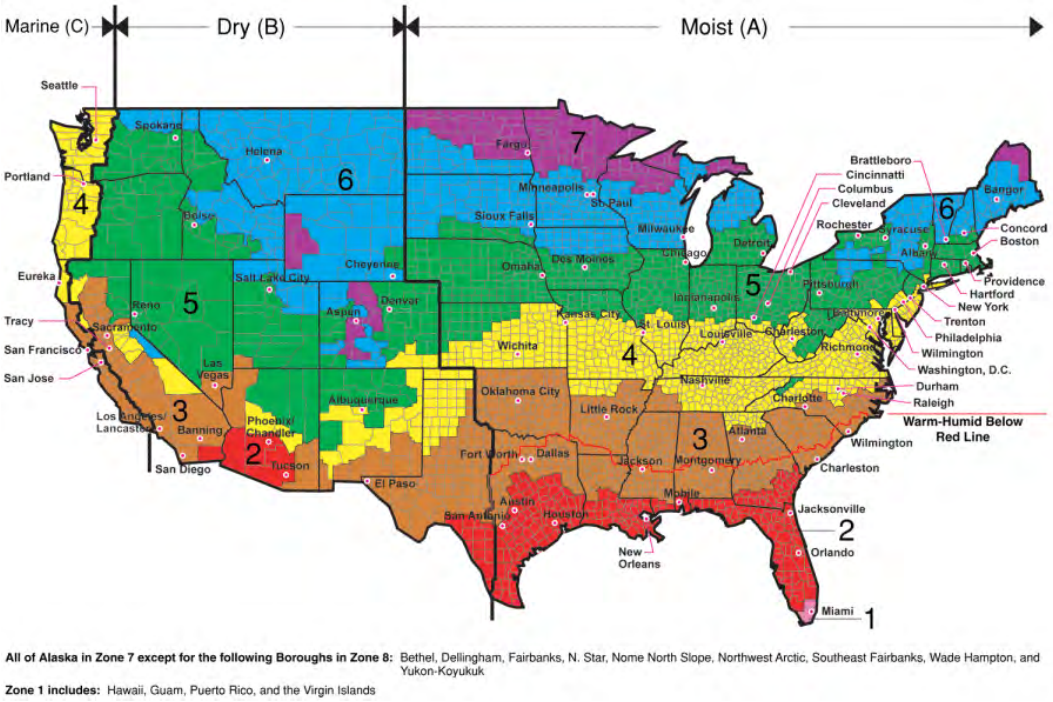
Where 13+5 means R13 cavity insulation and R5 continuous insulation (exterior to frame).

Note 1: As an alternative to these R-values, the IRC permits the use of equivalent U-factors [§N1102.1.4] or total building thermal envelope UA [§N1102.1.5].

Note 2: For locations at high elevations, the AHJ may require that the climate zone be determined using Heating Degree Days (HDD).

Note 3: Alternative ceiling R-values apply only to ceilings with an attic if the full height of the uncompressed insulation extends over the top plate at the eaves [§N1102.2.1].

Figure 7. DOE Climate Zone Map



All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

Table 3. Brief Summary

	R-Value Per Inch	Vapor Permeance	Air Permeance	Applications
Blown-In Fiberglass	R3.6—R4.4 (walls) R2.2—R2.7 (attic)	Vapor permeable	Air permeable	Wall cavities, cathedral ceilings, attic floors
Fiberglass Batts	R3.1—R3.8	Without facing: vapor permeable With kraft facing: Class II vapor retarder	Air permeable	Wall cavities, vented attic ceilings, cathedral ceilings, attic knee walls, floors above unconditioned crawl space, foundation walls
Dry-Blown Cellulose	R3.0—R3.4 (walls) R2.9—R3.4 (attic)	Vapor permeable (water storage capacity)	Air permeable	Wall cavities, cathedral ceilings, attic floors
Damp-Spray Cellulose	R3.6 – R3.8	Vapor permeable (water storage capacity)	Air permeable	Wall cavities (can only be used in vertical applications)
Spray Polyurethane Foam	R3.5—R3.8 (ocSPF) R5.8—R7 (ccSPF)	ocSPF: vapor permeable ccSPF: Class II vapor retarder when >1.5 in. thick	Air impermeable where meets minimum thickness – refer to product evaluation reports for minimum installed thickness (can require as little as 3 in. for ocSPF or 1 in. for ccSPF).	Roof decks, cathedral ceilings, wall cavities, floors above unconditioned crawl space

Table 4. Decision Matrix—What is Best Insulation for Me?

Type	Pros	Cons
Blown-In Fiberglass	• Fills irregularly-shaped wall cavities • Increased wall R-value with increased density • Reduced wall air infiltration with increased density • Fire resistant	• Installation requires special equipment (blower machine, nozzles, hoses, scrubbers, vacuum) • Requires netting when installed in wall cavities • Loose-fill requires protective measures to avoid inhalation and contact with skin and eyes • Dense packing walls requires a certified installer
Fiberglass Batts	• Installed without special equipment • Lowest upfront cost option for standard framing cavities • Can be purchased at chain hardware stores • Fire resistant	• Extra steps required to install properly around pipes and wiring and oddly-shaped cavities and rim area • Compression reduces R-value
Dry-Blown Cellulose	• Fills irregularly-shaped wall cavities • Increased wall R-value with increased installation density • Reduced wall air infiltration with increased density • Fire resistant • Has some moisture storage capacity, providing a buffer for moderate levels of vapor drive	• Installation requires special equipment and materials (blower machine, nozzles, hoses, scrubber, vacuum, netting) • Requires netting when installed in wall cavities • Dense packing walls requires professional installer • Reduced R-value due to settling if not installed per manufacturers specifications • Ability to soak up moisture may mask leaks
Damp-Spray Cellulose	• Fills irregularly-shaped cavities • Very little waste because excess material is collected and recycled • Improved sound control • Requires only basic PPE for installers • Fire resistant • Has some moisture storage capacity, providing a buffer for moderate levels of vapor drive	• Installation requires special equipment (blower machine, nozzles, hoses, water tank, scrubbers, vacuum) • Time must be spent cleaning the work area before installation can begin • Drywall cannot be hung until after the cellulose has dried sufficiently, which may delay the project schedule in humid environments • Ability to soak up moisture may mask leaks
Spray Polyurethane Foam	• Fills irregular-shaped cavities • Serves as air barrier at certain thickness (generally ≥ 3 in. for ocSPF and ≥ 1.5 in. for ccSPF) providing a complete air sealing solution • ocSPF can be used to provide an air seal • ccSPF: highest thermal resistance for same thickness • ccSPF also serves as a vapor retarder	• Highest upfront installed cost • Special equipment needed to mix, meter, and spray for installation • Not UV stable so it degrades in sunlight • Requires certified installer • Hydrofluorocarbons (HFCs), a greenhouse gas, may have been used as a blowing agent • Improper mixing may cause a lingering odor due to unreacted amine catalysts

Resources

- Cellulose Insulation Manufacturers Association (www.cellulose.org)
- National Green Building Standard (www.builderbooks.com/ngbs)
- North American Insulation Manufacturer's Association (www.insulationinstitute.org)
- Residential Energy Services Network (www.resnet.us)
- Spray Polyurethane Foam Alliance (www.sprayfoam.org)
- U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy (www.energy.gov/eere/efficiency/homes)