DIY Insulation and Air Sealing Program

Quality Standards Manual

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Efficiency Vermont

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Introduction

This manual is intended to present technical guidance and minimum standards that will help both homeowners and contractors meet the expectations of Efficiency Vermont's DIY Program. While this manual does not cover all possibilities and configurations, the fundamentals are widely applicable. It should be recognized that no document can take the place of exercising good judgment based upon basic building science principles to address site-specific concerns. Ultimately, any work done on a home is the responsibility of the homeowner and you should only undertake work on your home that you feel confident in performing.

Throughout this manual, you will notice references to the Vermont Residential Building Energy Code. It is important to adhere to this guidance in order to ensure quality installation and compliance with state technical standards. **If you have questions pertaining to the energy code, please contact the Energy Code Assistance Center toll-free at (855) 887-0673**.

By following the guidance set forth in this manual, you accept and acknowledge that you are taking on responsibility for the work performed in your home. Efficiency Vermont cannot, and does not, make any representations or warranties that this manual will apply to your specific situation or achieve any specific outcome. If you have any doubts or concerns with work you have performed, or are planning to perform, you should consult a building professional.

Key Terminology

It is important to understand key terms as they are used in this guide. The language throughout the document is intentional and shall be interpreted as follows:

"Should" = Recommended best practice

"Shall" = Must = Required to meet program requirements

1: DIY Program Details

Efficiency Vermont's DIY Program provides financial incentives to homeowners and contractors that complete air sealing and insulation upgrades in flat attics or basements/crawlspaces. Participants are expected to utilize the Completion Checklist and Quality Standards Manual to help them achieve the most impactful results.

1.1: Eligibility

DIY Program participants will be eligible for rebates for completed projects meeting program requirements in an attic or basement/crawlspace. Incentives cannot be achieved for upgrading both at the same time. A particular home may be eligible for one rebate through the DIY Program per year. Customers of Burlington Electric Department and Vermont Gas Systems are not eligible for incentives at this time.

The DIY Program is limited to single family homes. Row or town homes may be eligible if they are ground-to-sky units (no shared attics or basements).

To be eligible for a DIY Program rebate, work must meet the specifications outlined in this manual. All completed projects are subject to receive a quality assurance visit from one of Efficiency Vermont's energy consultants, who will confirm compliance with the standards specified in this manual and the Completion Checklist. For verification purposes, a receipt showing materials purchased (or an invoice from a contractor) must be included with the project completion documents.

DIY Program Eligibility Considerations		
Attic (min. R-49)	Eligible locations:	Attic flats Knee walls (see Section 4.4)
	Ineligible locations:	Roof slopes and cathedral ceilings
Basement or crawlspace (min. R-15)	Eligible locations:	Foundation walls, including rim joist
	Ineligible locations:	Basement ceiling
	Please note: a qualifying foundation wall has spray foam insulation sprayed directly on the foundation wall or rigid board material sealed directly to the foundation wall. Fibrous insulation installed in stud walls on below ground surfaces are not eligible.	
Vermiculite consideration	Efficiency Vermont will not provide incentives for work performed in attics where vermiculite is present.	
Moisture consideration	Efficiency Vermont will not provide incentives for work done in a home with an earthen floor, unless that floor is covered as shown in Section 2.3b: Bulk Water and Moisture Control – this includes instances where work is only performed in the attic.	

Please note that these are general requirements and each eligible location shall be treated per the requirements outlined in this manual; use the Completion Checklist as a guide

1.2: Steps to Receiving a Rebate

1. Review program eligibility and requirements on www.efficiencyvermont.com or call **Efficiency Vermont Customer Support at (888) 921-5990** to discuss your project.
2. Use the Completion Checklist and Quality Standards Manual to complete your DIY project and ensure it meets program requirements.
3. Submit the DIY rebate form and checklist along with proof of purchase for any installed materials.
4. Receive rebate by mail within 3-6 weeks of submittal.

   Please note that all DIY projects are subject to receive a quality assurance visit from Efficiency Vermont

1.3: Codes & Regulations

You (and your contractor) are responsible for ensuring that home improvements are installed, operated, and maintained in compliance with all applicable laws, codes, regulations, rules, standards, and manufacturers' instructions. Home improvements for which rebates are paid must comply with specifications detailed in the Quality Standards Manual. Rebates will not be paid for any work performed in homes that contain vermiculite insulation. Contractors completing projects in homes built before 1978 must adhere to the U.S. Environmental Protection Agency (EPA) requirements for the maintenance and renovation of lead-based painted surfaces and are required to be Lead-Safe Certified Renovators to perform renovation and repair work in areas that disturb lead-based paint. Homeowners are encouraged to use lead-safe work practices when renovations will disturb lead-based paint. Any exposed foam plastic interior wall covering must be installed in compliance with the 2015 International Building Code Sections 2603.4 and 2603.3.

1.4: Verification by Efficiency Vermont

Efficiency Vermont conducts site visits for a percentage of homes where rebates were paid to verify that the work performed is consistent with the information submitted on the DIY rebate form, checklist, and associated proof of purchase. Efficiency Vermont verification site visits do not encompass and shall not identify violations of any other law, code, or regulation, including but not limited to local building codes. You (and your contractors) are responsible for ensuring that all home improvements comply with all applicable local building codes in consultation with a local building official when necessary.

2: Health & Safety

Occupant safety, indoor air quality, and building durability are critical considerations when doing an energy efficiency upgrade and must be evaluated as a priority of any project. This section outlines the most common considerations, however, no manual can describe all scenarios that may need to be addressed prior to energy efficiency improvements being installed as no manual can take into account the specifics of your home or environment. It is your responsibility to follow all applicable federal, state, and program requirements, and to use good judgment and reach out to Efficiency Vermont if you have any questions or need a professional assessment.

IMPORTANT: Always inspect the home prior to beginning work – if any of the following are present in the home, do not proceed or contact a professional for remediation:

Item	Next Steps
Active knob and tube wiring	If active knob and tube wiring is in the area where work will be performed, contact an electrician for replacement.
Damaged wiring or missing junction boxes	Contact an electrician to repair, replace, or install junction box.
Vermiculite insulation	Any work in attics where vermiculite insulation is present will be ineligible for Efficiency Vermont rebates. For remediation assistance, contact the Vermont Department of Health.
Unvented propane or gas space heaters	Any unvented propane or gas space heaters must be made non-operational prior to project completion.

Further guidance on each of these items is provided in the sections below

2.1: Hazardous Materials

Nearly all homes contain hazardous materials in some form. When considering an energy efficiency upgrade, one should be familiar with materials such as lead, exposed foam plastic, asbestos, and vermiculite. Following the applicable guidelines for working with or around these hazards is a requirement for the health and safety of the worker, the building, and its occupants.

2.1.a: Lead-Safe Practices

Contractors completing projects in homes built before 1978 must adhere to the EPA requirements for the maintenance and renovation of lead-based painted surfaces and are required to be Lead-Safe Certified Renovators to perform renovation and repair work in areas that disturb lead-based paint. Homeowners are encouraged to use lead-safe work practices when renovations will disturb lead-based paint.

The U.S. EPA has additional resources that may be helpful:

- What is lead?
- Where is lead found?
- Who is at risk?
- Check and maintain your home
- Find a Lead-Safe Certified firm
- Before you renovate

2.1.b: Vermiculite & Asbestos

Under Vermont law, any construction work that will involve disturbing more than three square feet or three linear feet of friable asbestos or vermiculite must be carried out by a licensed asbestos contractor. The Vermont Department of Health does have exemptions for homeowners working on their own private residences that perform the remediation to this standard – see sections 1.1.6, 2.4.2-2.4.6, and 6 in the "Vermont Regulation for Asbestos Control" document for these specifications. Special equipment is required for proper remediation; DIY vermiculite removal is not easy or recommended.

While exemptions exist, it is best practice to not work in any area that will disturb vermiculite insulation unless you are a licensed asbestos contractor. Examples of disturbance include; moving it aside to air seal, blowing or placing insulation on top of it, or conducting a negative pressure blower door test. Any work performed in the presence of vermiculite will disturb it and make your project ineligible.

For further information regarding asbestos and vermiculite, please refer to the following organizations:

- The EPA's Asbestos Resources
- Zonolite Attic Insulation Trust: find out if you are eligible for partial reimbursement of abatement costs

2.1.c: Exposed Foam Plastic

All exposed-foam plastic interior coverings must be installed in compliance with the 2015 International Building Code, Sections 2603.4 and 2603.3. This includes the installation of spray foam and board foam in the applications listed below.

Guidance on meeting the exposed foam plastics requirements:

1. Required locations:

   There are very few locations where neither a thermal barrier nor an ignition barrier are required to be installed over foam. Rim/band joists and completely inaccessible crawlspaces and attics are the only exceptions.

   All basements, crawlspaces, and attics that are accessible require either a thermal or ignition barrier. Only crawlspaces, or attics that are accessible through a small hatch and cannot be used for storage, may use the ignition barrier alternative to a thermal barrier. Only spaces that are not accessible for service and maintenance, and are not connected to other accessible spaces, may have foam plastic that is left exposed.

2. Working with approved products:

   a. Ignition barriers: Drywall with a thickness of ⅜", 1 ½" mineral fiber insulation and ¼" thick structural wood panels as well as a few other products are approved ignition barriers.

   b. Thermal barriers: Drywall with a thickness of ½" is the prescriptive approved thermal barrier.

Materials equivalent to the products listed above are suitable alternatives and are commonly in the form of an intumescent paint. For an intumescent paint to be an approved thermal or ignition barrier with a foam product, it must have been tested as an assembly with that foam product. The easiest way to verify whether an intumescent paint product has been approved as a thermal or ignition barrier is to look at the foam product installation manual, or to find the ICC-ES evaluation report for the foam or paint. In some cases, there are several foam products that are approved and thus several ICC-ES reports.

There are some spray foam products that are approved as an ignition barrier (and some board foam products that are approved as thermal barriers) without an additional coating of intumescence. These products are ideal for use when the space and surfaces are compatible.

2.1.d: Electrical Hazards

Electrical deficiencies in the location being insulated may be an existing fire hazard or may become fire hazards when put in contact with insulation. It is required that no such hazards exist when treating a space with insulation and air sealing.

2.1.e: Knob & Tube Wiring

Knob and tube wiring may be found in homes built in the late 1800s and early 1900s. It was designed to allow heat to dissipate into the surrounding air and thus current codes forbid insulation from being in contact with it. It is best practice to disconnect knob and tube wiring to allow for effective air sealing and insulation whenever possible. Insulation must never be installed in contact with live knob and tube wiring. If rewiring is not an option, there are multiple techniques that can be used to treat areas with existing knob and tube wiring, but each has its own set of considerations.

2.1.f: Wiring Connections

All wiring connections within one foot of a surface that will be air sealed and/or insulated must be housed in a properly covered junction box. Contact a licensed electrician to inspect or repair an existing junction box, or to install a new junction box.

2.1.g: Damaged Wiring

Any visibly compromised wiring (frayed, pest-damaged, etc.) that is in the area to be weatherized must be repaired or replaced prior to beginning work. Contact a licensed electrician to repair any damaged wiring.

2.2: Indoor Air Quality

Indoor air quality can be greatly improved as a result of a complete home insulation and air sealing project. However, when a home is tightened, it is important to consider how the occupants and systems interact in order to optimize performance. This section identifies some of those considerations and provides guidance that can help to improve the indoor air quality in your home.

2.2.a: Carbon Monoxide

All homes must have at least one functioning carbon monoxide alarm installed in the living space. It is best practice to follow the Vermont Department of Health guidelines.

Materials & installation best practices

For existing carbon monoxide alarms:

- Alarm should be tested for proper operation by using the alarm's "test" button
- Alarm should be checked for an expiration date
- Alarm should be replaced if expired, if expiration date is unknown, or if it fails to function properly during testing

Installing new carbon monoxide alarms:

- It is recommended that an alarm be installed outside of each sleeping area in the immediate vicinity of the bedrooms. An additional detector is recommended in any sleeping room that contains a fuel-burning appliance.
- Installation should be in compliance with the Vermont Department of Public Safety and manufacturer's instructions
- New alarms should be tested upon completion of installation
- The installation date should be clearly marked on the device
- New alarms must meet the following specifications:
    - UL 2034 listed
    - Minimum 5 year warranty[1]

2.2.b: Smoke Alarms

All homes should have at least one working smoke alarm installed in the living space in accordance with Vermont Law and the Vermont Fire Safety Code.

Materials & installation best practices

For existing smoke alarms:

- Alarm should be tested for proper operation by using the alarm's "test" button
- Alarm should be checked for an expiration date
- Alarm should be replaced if expired, if expiration date is unknown, or if it fails to function properly during testing

For new smoke alarms:

- One alarm should be installed on each floor of the building, including basement and conditioned attics
- In multi-level dwellings, an alarm should always be installed at the top of the stairwell leading from one floor to another – if not already present
- In basements, an alarm should be located on the ceiling at the bottom of the basement stairway – if not already present in that location
- If there is already an alarm present on a given floor, but it is not in the specified location, leave the old alarm in place and install a new one in the correct location
- In single family homes, the alarm should always be mounted on the ceiling at least 4" from a wall

- In mobile homes, it is acceptable to mount the alarm onto an interior wall 4" to 12" from the ceiling
- Installation should be in compliance with these standards and manufacturer's instructions
- New alarms should be tested upon completion of installation
- The installation date should be clearly marked on the device
- New alarms must meet the following specifications:
    - UL 217 listed
    - Must use only photoelectric technology
    - Minimum 5 year warranty

2.2.c: Mechanical Ventilation

At a minimum, all bath fans must be vented completely to the outside of the building. It is not acceptable for a bath fan to be vented into an attic, basement, crawlspace, attached garage, or any other space where the warm and moist exhaust air might condense and cause moisture problems that could damage the building.

Assessing, installing, and maintaining mechanical ventilation can be complicated. Please contact Customer Support at 888-921-5990 if you would like to work with an Efficiency Excellence Network contractor.

In some situations, installing additional mechanical ventilation (bath fans or heat/energy recovery ventilation units) is recommended and may be required. A good starting point in any home is to install ventilation that meets Vermont Residential Building Energy Standards (VT RBES) or ASHRAE 62.2-2013 – these standards must be met if a new system is installed. The optimal time to complete this work is during an air sealing and insulation project, as there will be access to the space where fans and their venting components are located.

For mechanical ventilation, it is best practice to size and locate systems to meet occupant and building needs in an effort to ensure healthy indoor breathing air in each sleeping room.

2.2.d: Clothes Dryers

All clothes dryers present in a home must be vented to the outside of the building in the manner outlined below. When clothes dryers are vented to the indoors, they pump large quantities of moist air and lint into the occupied space.

Venting materials & installation specifications:

- Smooth-walled vent pipe should be used whenever possible
- PVC piping should not exist on any portion of a vent run
- Flexible vinyl/plastic ducts should not exist on any portion of the vent
- Flexible aluminum materials are allowed only if the installation of rigid materials is not possible – such as connecting the dryer to the smooth-walled pipe and connecting the smooth-walled pipe to the exterior damper assembly
- Pipe sections should not be screwed together
- Seams should be foil-taped (this is one of the few instances where use of tape is acceptable and encouraged)
- Whenever possible, a ⅛" to ¼" pitch down toward the exhaust outlet at the exterior building shell should be maintained to minimize the potential for condensation to drip back toward the dryer

In addition to venting the dryer to the outside, all vent piping sections located outside the thermal envelope should be insulated. FSK-faced fiberglass is a preferred material for this purpose. Use of foil-faced bubble wrap materials is not allowable for this purpose.

2.2.e: Unvented Fuel-Fired Space Heaters

Unvented fuel-fired space heaters are strictly forbidden from operation in a house or dwelling that participates in Efficiency Vermont's programs. This rule was established to align with VT RBES and includes appliances using LP gas, propane, or kerosene (electric space heaters do not require venting).

Unvented space heaters, often called "vent-free appliances", emit their combustion byproducts directly into the living space. Even though the combustion is very complete at nearly 99.9%, there are small amounts of carbon monoxide, nitrogen dioxide, and unburned hydrocarbons that are not healthy to breathe in. Not only are small amounts of those byproducts emitted, but they also release large quantities of moisture and carbon dioxide into the living space. High moisture levels can lead to condensation, mold and mildew issues, as well as concerns about building durability. High levels of carbon dioxide can cause drowsiness in occupants of the residence.

If a home has an unvented space heater it is recommended that it be removed. If it must remain, then one must ensure that the heater is made non-operational prior to a DIY project being completed. This shall be done regardless of whether the space heater is presently in use. At a minimum, the gas valves serving the space heater must be turned off.

2.2.f: Combustion Equipment

Regular inspection and maintenance of your fuel supply and fuel-burning equipment that provides space heating and water heating is recommended to ensure they are operating efficiently and producing low levels of carbon monoxide.

Additionally, chimney-vented equipment that relies on buoyancy of warm air to draft (not fan assisted or sealed combustion) should be evaluated for proper draft. Homes with vented dryers, vented bath fans, range hoods, and other exhaust equipment can experience high negative pressures resulting in back drafting of chimney vented equipment. This is more likely the tighter your home gets and it is best practice to test for proper draft under "worst case" negative pressures caused by exhaust equipment.

Combustion equipment should be assessed by a professional.
Please contact Customer Support at 888-921-5990 if you would like to work with an Efficiency Excellence Network contractor.

2.2.g: Attached and Tuck-Under Garages

In homes with attached or "tuck-under" garages, all leaks between the garage and the house must be sealed, gasketed, or weather-stripped. Potential leakage areas include joints, seams, penetrations, openings between door assemblies and their respective jambs/framing, and other sources of air leakage through walls and ceiling separating the garage from the residence. See additional details in the Appendix.

2.3: Moisture

Prior to installing efficiency upgrades, it is important to determine whether the basement/crawlspace is dry, damp, or wet[2]. While each situation is unique, there are many methods for mitigating moisture issues in order to optimize building performance.

Pre-existing moisture or other pollutant issues must be addressed before installing efficiency measures. Additional moisture-related protocols are outlined in the Health and Safety section of this manual.

Control existing moisture:

- Improve existing gutters and extend downspouts farther away from the building
- Install covers on existing sump pits
- Upgrade existing sump pumps
- Install new sump pits and/or sump pumps if none exist

Prevent new moisture from forming:

Install 6 mil. polyvinyl sheeting or equivalent over exposed earth or ledge, and onto rubble or stone walls to reduce the amount of moisture evaporated into the indoor air. This helps to control humidity levels through the home and reduces the likelihood for moisture and mold problems[4].

3

2.3.a: Prioritizing in Basements/Crawlspaces

Below is a list of considerations and how they may be best prioritized when completing an energy upgrade[5].

1. Mitigate all moisture concerns
2. Air seal and insulate box sill/rim
3. Air seal foundation walls
4. Insulate foundation walls

2.3.b: Bulk Water & Moisture Control

For homes with damp or wet basements or crawlspaces, moisture must be managed per the following guidance in order to be eligible for Efficiency Vermont rebates. There are two types of moisture that can be found in any basement or crawl space; each has its own mitigation technique.

- Damp basements/crawlspaces: often have an earthen floor and no recurring flooding or standing water issues
- Wet basements/crawlspaces: are prone to flooding or standing water

Damp Basements/Crawlspaces	Wet Basements/Crawlspaces
All earthen floors must be covered with a vapor barrier which must have: • 6 mm poly sheeting or equivalent installed over the earthen floor • Moisture barrier with seams and edges overlapping (min. 6") and sealed • If air pressure or ground slope is likely to cause movement of the moisture barrier, it must be fastened in place	Excessive moisture must be controlled before embarking on an energy efficiency retrofit. A vapor barrier should not be installed in wet basements/crawlspaces prone to flooding or standing water. However, if the measures below adequately transform the basement from "wet" to "damp", then the procedure for "damp" spaces should be followed and a vapor barrier should be installed. There are two main techniques for addressing wet basements/crawlspaces: • Install a sump pump (and any required system trenching) • Install a new gutter system, or improve the existing gutter system by extending down-spouts further down and away from the building In some instances, more extensive remediation may be required.

The installation of rolled roofing (or comparable) over a vapor barrier in heavily trafficked areas is encouraged to provide improved traction[6].

3: Defining the Thermal Envelope

A building's thermal shell or envelope consists of four layers: insulation, air control (e.g., drywall), vapor control (e.g., paint on interior walls, paper facing on insulation), and bulk water control (e.g., tar paper or other material behind siding). In cool climates like Vermont, any gaps or penetrations in this envelope allow conditioned air to escape, or "leak", causing the home to feel drafty, cold, or uncomfortable. Mechanical systems will need to work harder to keep the home warm, which causes fuel and/or electricity bills to increase. When the thermal envelope is properly defined, occupants should feel comfortable and confident that they are not paying to heat the outdoors.

In order to define the thermal envelope, one must first identify areas where it has been breached, and determine the relative magnitude of these breaches. There are many diagnostic tools and methods available to help with this assessment. Building professionals will use a blower door test before and after work is performed to determine leakage locations and to quantify leakage rates. Blower door tests depressurize the home, pulling air through any cracks or penetrations in the envelope, and result in an air leakage rate that is measured in cubic feet per minute (CFM). Once leaks have been sealed, the test will be performed again in order to quantify the improvement.

If you are interested in air leakage testing, enhanced diagnostic services, or quantifying your improvement, it may be best to work with an Efficiency Excellence Network contractor. Please contact Customer Support at 888-921-5990 for further guidance.

Not all breaches are created equal; their location plays a critical role in heating energy consumption and occupant discomfort, as well as influencing the operation of combustion appliances. For these reasons, the general strategy in addressing air leakage should be to focus on the top of the building first, then the bottom, and finally, the sides (with the exception of attached garages, which require priority for health and safety reasons). See the Appendix for additional details on assessing air leaks.

3.1: General Considerations for Effective Air Sealing

Air sealing is one of the most cost-effective ways to boost efficiency and save money in a home or business. Whether brand new or very old, almost every home has air leaks – finding and sealing those leaks improves comfort and saves on heating and cooling costs. The guidance below illustrates best practices for installation.

1

When caulking, hold the gun at a slight angle, and work backward along the seam rather than pushing forward.

2

Use low-expanding foam when sealing board insulation against wood rim joints.

3

Avoid sealing windows shut with caulk. Use weather stripping on any moving parts.

Air sealing covers a range of products, from basic spray foam to high tech air barriers used in new construction and gut rehabs. Caulking and weather-stripping are the workhorses of air sealing: they are inexpensive and good at blocking drafts from windows, doors, and cracks. For wide gaps, such as those around basement windows, use a one-part foam gun (this is different than spray foam insulation, which covers large areas and should be installed by a professional).

Air comes in through leaks in the basement, gets sucked up through the house, and leaks out through the attic. This is called the "stack effect". Plug those attic leaks and you'll slow the air flow considerably—reducing drafts, saving energy, and allowing your insulation layer to work more effectively.

Step 1

Finding leak points:

- Map the top floor of your home so you know where all the interior walls, lights, and irregularities are while you are in the attic working
- Lift up areas of existing insulation
- Discoloration, visible cracks, and open seams indicate leaking air

Step 2

Seal the big holes:

- The attic access
- Areas where you can reach from the attic into interior wall cavities
- Plumbing chases or dropped ceilings
- Around the chimney

Step 3

Seal the little holes:

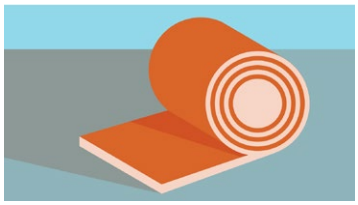
- Electric and plumbing penetrations
- Drywall joints at top plates

While some air sealing can be done on your own, the best results can be achieved by working with an Efficiency Excellence Network contractor who can account for air quality and address other health and safety concerns.

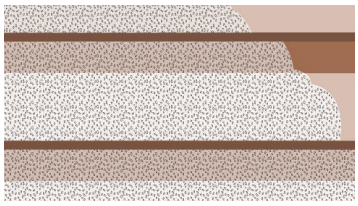
3.2: Selecting Insulation Materials

When combined with proper air sealing, adding insulation is one of the easiest and most affordable ways to reduce energy usage. As part of a home's thermal envelope, insulation can help to reduce ice dams on roofs and eaves, making the home more durable. Choosing the right kind of insulation depends on where it will be added, the desired R-value, and budgetary concerns.

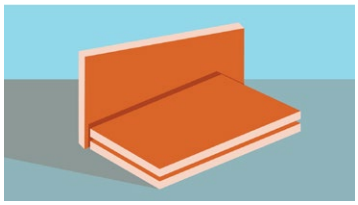
There are four basic types of insulation:



While many people think of the classic pink fiberglass batting, **rolls and pre-cut batts** also come in a mineral wool variety. Rolls and batts are easily installed and can be relatively inexpensive. However, it is important to consider that they must be cut and fit carefully to avoid any compressed areas or voids to be effective.



Cellulose is made of recycled newspaper and can be installed using loose-fill, wet-spray, and dense-pack methods. Loose-fill cellulose is better than batts at getting around wiring and joists, and is ideal for open attic spaces. Cellulose requires special equipment and careful installation that may be better left to a professional installer. Only use cellulose if you have the necessary skills or expertise.



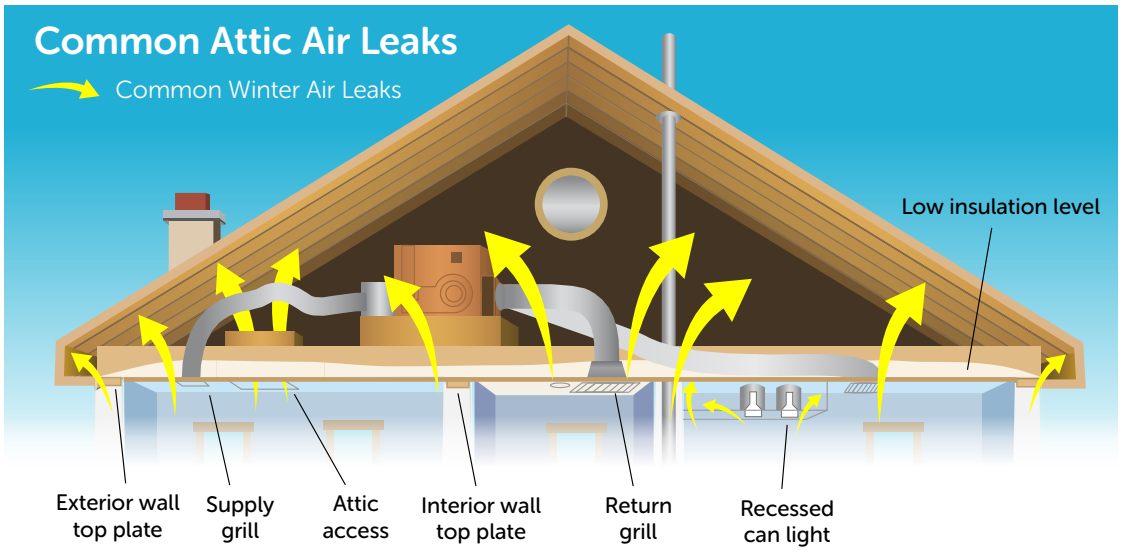
Rigid insulation panels can be used to insulate nearly any part of a home. It is a practical solution for sloped attic ceilings, foundations, exteriors, and flat roofs. Rigid insulation can offer an extra layer of continuous insulation, plus air sealing and vapor control. It is easy to install without professional equipment, however, it can be challenging to install in spaces with pipes or other obstacles.

Polyurethane foam (or "foam-in-place") can be blown into walls, onto attic surfaces, or under floors. It both insulates and reduces air leakage. It's often a good solution for field stone foundation walls, irregularly shaped areas, and for insulating around obstructions. Polyurethane spray foam requires special equipment and careful installation that may be better left to a professional installer. Only use polyurethane spray foam if you have the necessary equipment, skills and expertise.

Efficiency Excellence Network contractors are experienced at dealing with moisture as part of weatherization projects. Please contact Customer Support at 888-921-5990 for help finding a qualified contractor in your area.

4: Flat Attics

It is very likely that every attic space contains both air sealing and insulation opportunities. The importance of a thorough and effective job of eliminating air movement through attic insulation should not be underestimated[7]. Every surface at the top of the building that is part of the pressure boundary, including attics, rooflines, and exterior surfaces inside knee wall closets, shall be evaluated and all breaches of the thermal envelope shall be identified and effectively treated.



4.1: Attic Air Leakage Control

Air leakage control measures must be considered as part of every improvement effort. Aside from saving energy, attic air sealing measures can also help to improve air quality, building durability, and occupant comfort. Adequate air sealing is crucial to ensuring optimal performance of attic insulation.

DIY program requirements for insulation and air sealing in flat attics:

- Remove or move aside any existing insulation to gain access for air sealing
- Seal all penetrations – including those from wiring, plumbing, surface-mounted ceiling fixtures, recessed lighting fixtures, and exhaust fan assemblies; ensure that each is properly separated from insulation materials
- Seal all top plates – including top plates of partition walls, exterior walls, and merger walls between adjoining building sections
- Block and seal all cavities open to the attic – including kitchen cabinet soffits or other dropped ceilings, balloon framed walls, and utility and chimney chases
- Ensure that the sealed durable rigid air barrier is in direct contact with the warm side of the insulation
- Install insulation to manufacturer specifications with no gaps or voids to a minimum of R-49
- Insulate all attic openings to at least R-20 – including pull-down stairs and attic access doors/ hatches
- Install all plastic foam products per manufacturer instructions and in compliance with thermal and/or ignition barrier code requirements

If you have a decked attic floor, see additional guidance in the Appendix

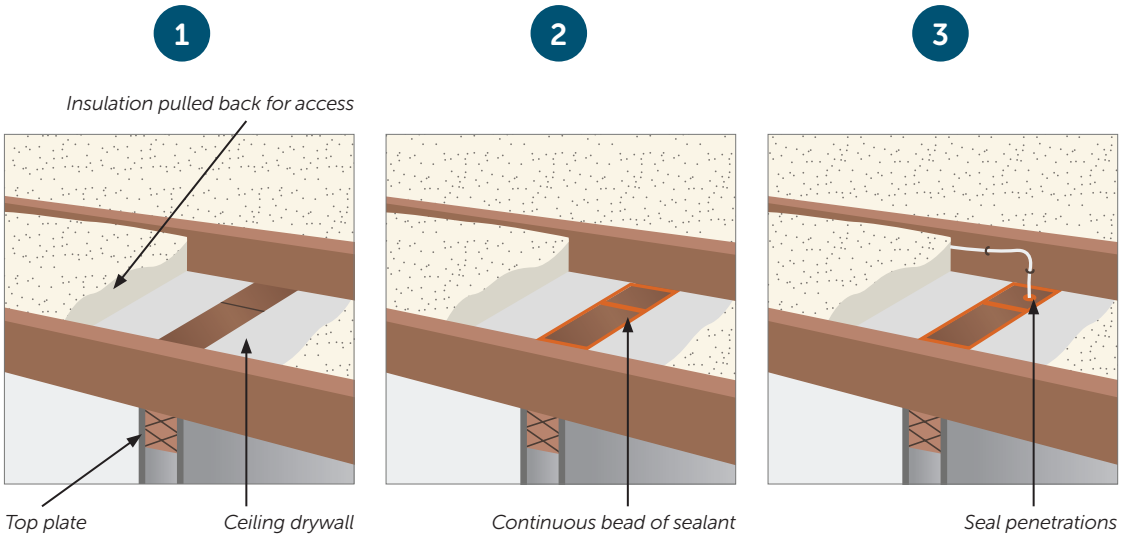
Attics insulated as part of a DIY or Home Performance with ENERGY STAR® project must have an effective R-49 attic insulation value. If there is not adequate roof clearance to achieve R-49 over the top plates, then insulation must be installed to achieve an average of R-49. Typically, this means installing R-60 in all areas that have adequate roof clearance.

Effective air sealing work typically requires the removal of existing insulation to gain access, as illustrated below. Note that in addition to the wiring penetration, the crack between the dry wall and partition wall top plate has been sealed with foam. The perimeter insulation has been removed to gain access to exterior wall top plates.

4.2: Common Points of Penetration

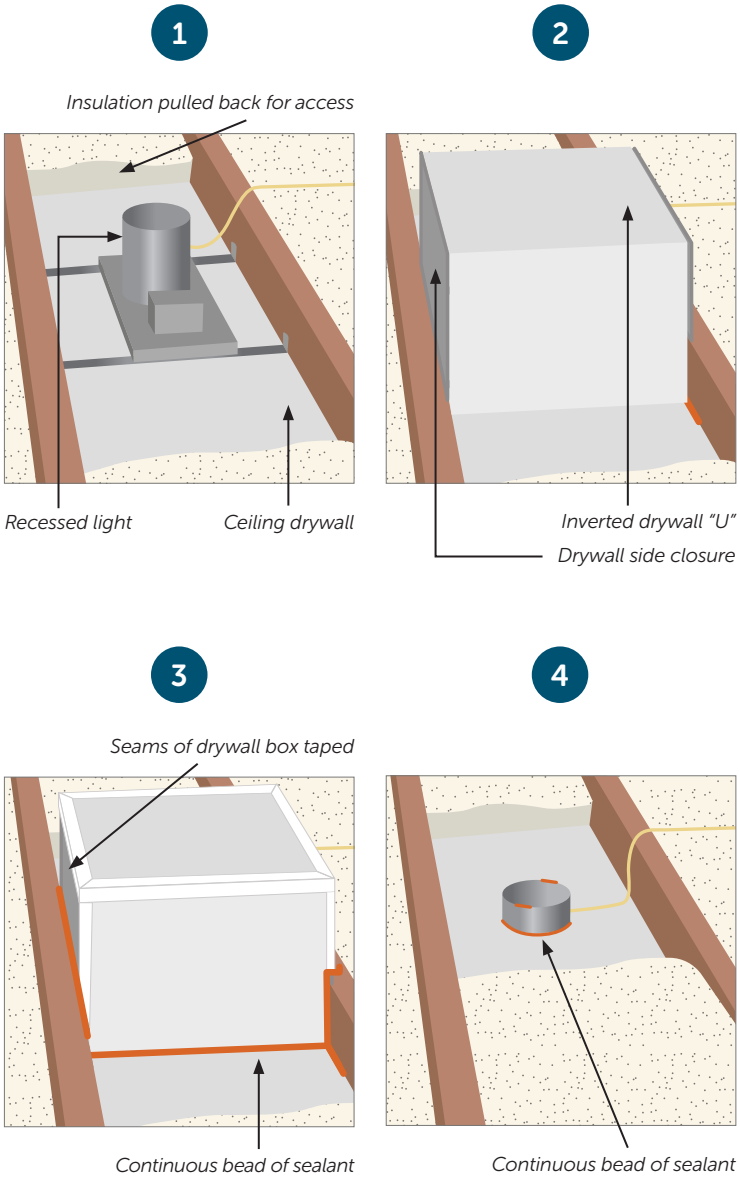
4.2.a: Sealing Top Plates

Every interior wall of the top level of your home is connected to the attic. The tops of these walls must be sealed to the drywall of the ceiling below on either side of the top plate with expanding foam, caulk, or other sealant. Making a map of your interior partition walls before going up into the attic can make it easier to find the tops of these walls.



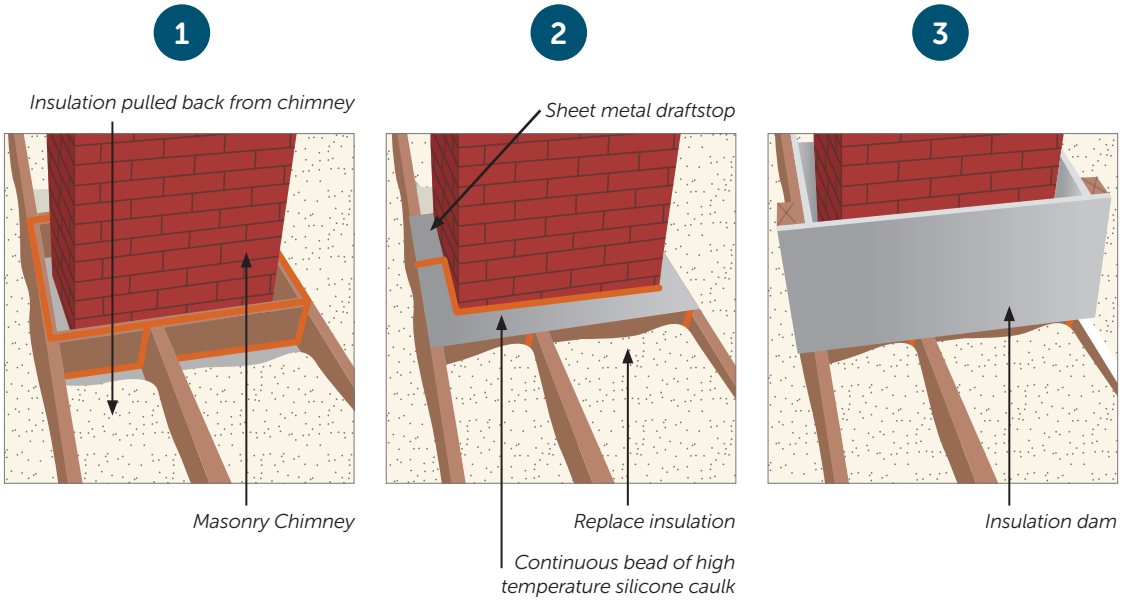
4.2.b: Sealing Wiring, Plumbing, Light & Fan Fixtures

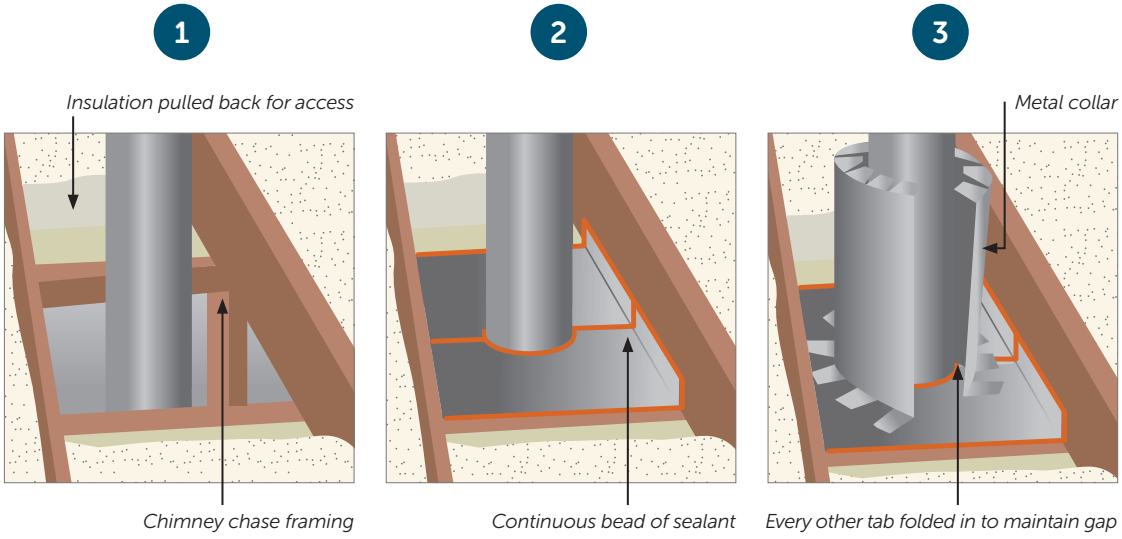
Most wiring and plumbing penetrations can be located and sealed while air sealing the top plates of the partition walls. However, light fixtures, smoke alarms, bath fans, and other devices are penetrations that will be in the middle of the room and not along a wall. For standard surface-mounted fixtures, the electrical box that is used to mount can be sealed. If recessed light fixtures are not "IC rated," it will be necessary to build a five-sided box out of drywall or other rigid board material, as illustrated below. This allows ample clearance to the fixture housing on the inside and can be sealed to the drywall of the ceiling on the outside. Make sure the box is large enough to maintain clearances specified by the manufacturer (or 3" if not specified).



4.2.c: Sealing Chimneys

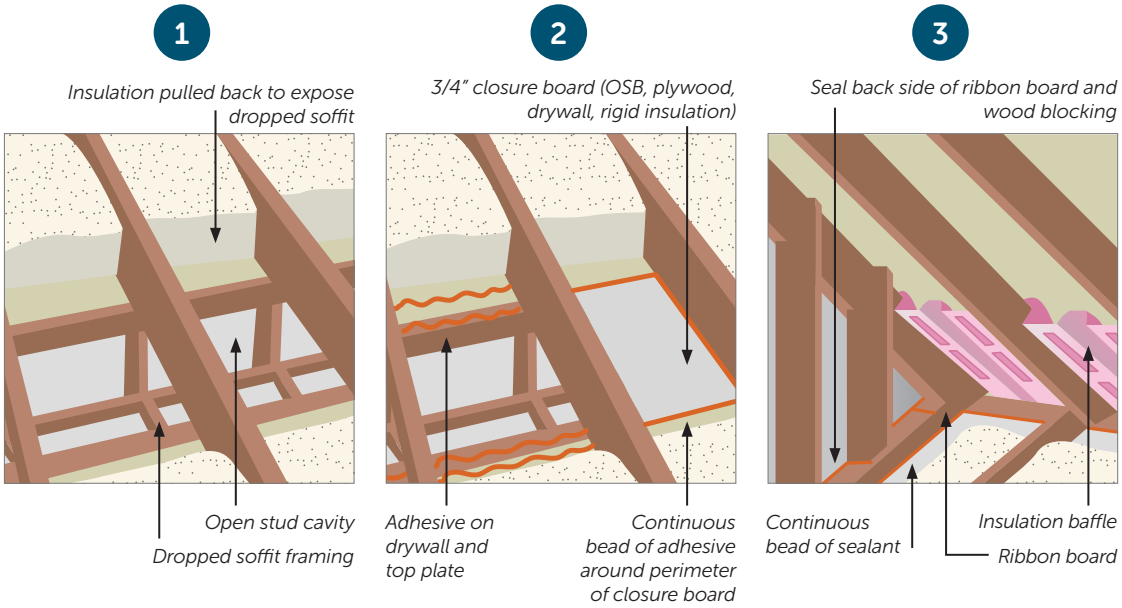
Air sealing chimneys requires special attention to detail and awareness of the proper clearances from combustible materials. These penetrations are often left open and are large leaks into the attic. To treat these areas, use sheet metal (or other non-combustible material) to create a draft stop that is sealed to the wood framing on one side, and the chimney itself on the other, using a fire-rated sealant. After air sealing is complete, create an insulation dam that will maintain the proper clearance between the insulation and the chimney.





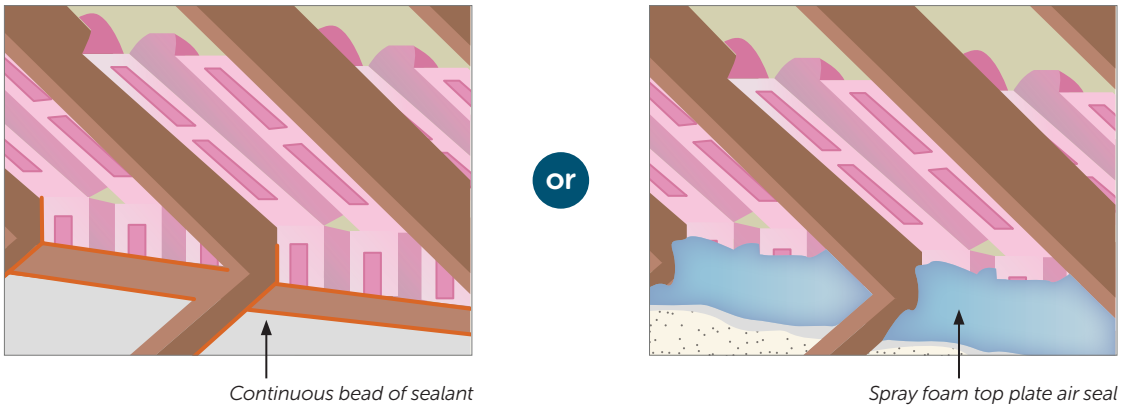
4.2.d: Sealing Large Cavities Open to the Attic

All cavities open to the attic must be blocked and sealed with a durable rigid air barrier to make a contiguous air barrier. This includes common large air bypasses such as kitchen cabinet soffits, dropped ceilings, and balloon framed walls. The diagram below illustrates the proper installation strategy.



4.3: Attic Eaves

During an attic insulation job, it is critical to protect the eaves of the attic from wind-washing while allowing for adequate ventilation. This means that the existing insulation may need to be removed and reinstalled after air sealing and eave baffles have been installed. In this application, blown cellulose insulation has an advantage over fiberglass batts, as the malleable shape can provide optimal coverage with less labor.

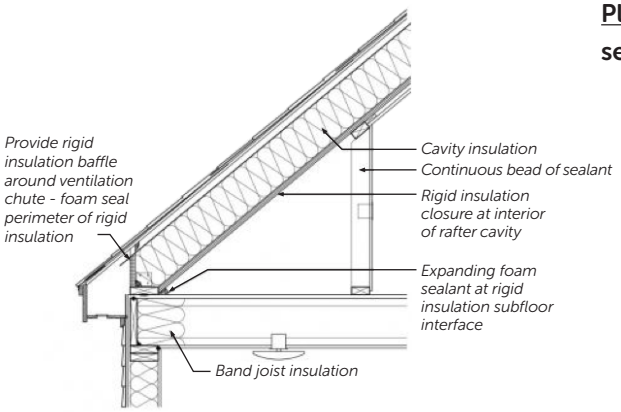


4.4: Knee Walls

Knee walls are an important component of the thermal boundary and should be addressed as such. The Vermont Residential Building Energy Standard dictates that knee walls must be sealed. When part of the thermal envelope, knee wall insulation must be enclosed on all six sides, and be in contact with a durable interior air barrier.

4.4.a: Defining the Thermal Envelope

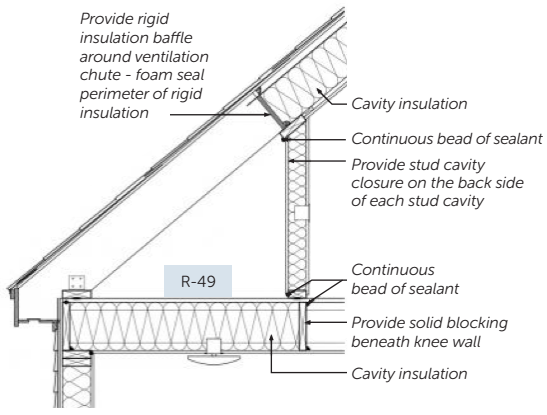
There are two different strategies for defining the thermal boundary at the knee wall. Plan A treats the slope as the thermal boundary. This method reduces the number and difficulty of air sealing tasks that are required to properly establish a continuous thermal envelope. It also decreases the amount of surface area that will require insulation.



Plan A[8] – the following surfaces must be air sealed and insulated:

- Sloped roof section between the eaves and the top of the knee wall
- Rim joist area (optional if floor decking present)
- Gable end walls
- Any exterior walls extending above the knee wall closet floor, typically small triangle shaped end walls

An alternative strategy is to treat the knee wall as the thermal boundary. This is an acceptable alternative to Plan A in circumstances where the knee wall provides an opportunity for higher insulation levels than the roof framing system does, or if the knee wall closet is over an unheated space. It can also be appropriate when Plan A will make proper roof ventilation difficult.



Plan B[7] - the floor system beneath the knee wall must be thoroughly air sealed. It will not be sufficient to simply dense pack in each floor bay.

- Access the area underneath the knee wall
- Seal rigid insulation into place
- Alternatively, it would be acceptable to stuff fiberglass batt or alternative blocking material into each bay beneath the knee wall and spray foam over the blocker

In homes with knee walls, untreated rims allow air to leak past the insulation work illustrated above in Plans A and B, reducing the efficacy of that work. Whenever there is an accessible knee wall closet, the rim should be thoroughly sealed and insulated inside each knee wall closet to ensure a complete thermal envelope[9].

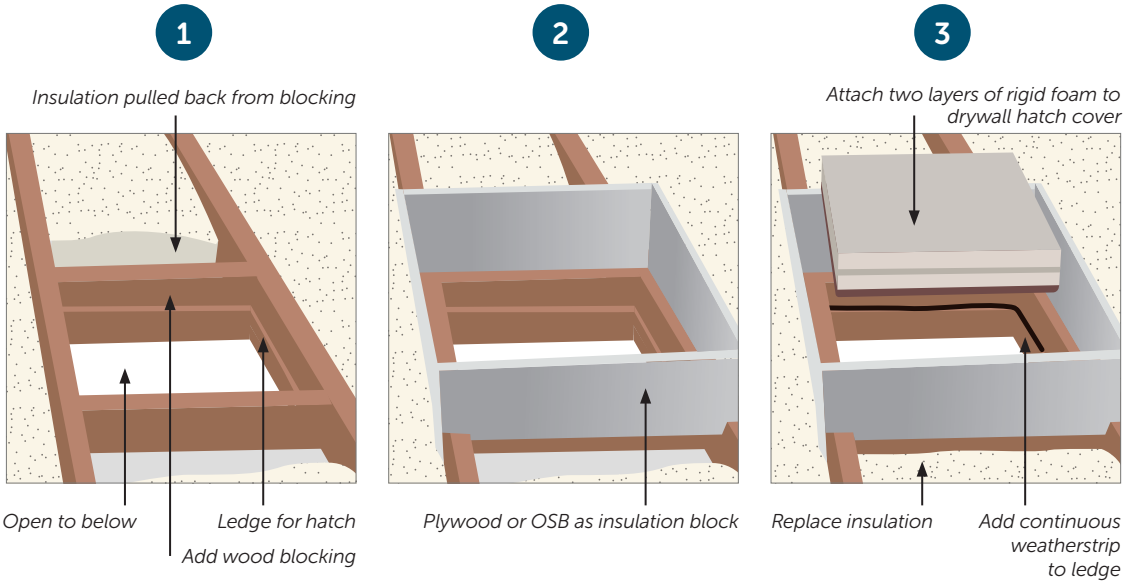
4.5: Attic Access Points

When attic hatches and other access points are left untreated, heat from the conditioned space below is able to escape into the attic. Properly insulated attic access points will better define the thermal boundary, keeping conditioned air in the home's living space.

4.5.a: Attic Access Hatch & Pull-Down Stairs

Attic hatch requirements:

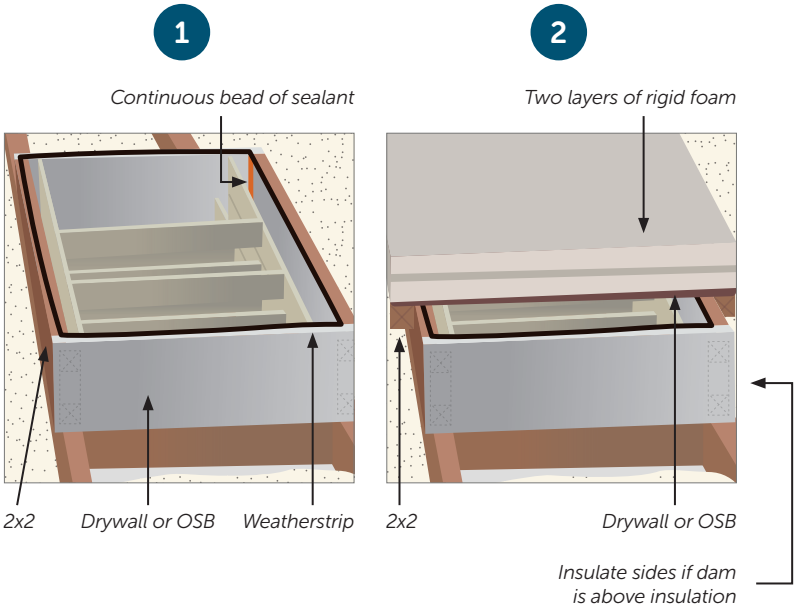
- R-20 (minimum) foam board affixed to the hatch; additional R-value may be required so the entire attic's average R-value – including the hatch surface – is at least R-38
- Higher R-values should be installed whenever roof clearances allow
- A durable insulation dam must be installed around all attic hatch openings
- The dam must extend at least 2" higher than the settled insulation depth
- The seams of a hatch assembly or insulation dam, other than at the hatch opening, must be sealed airtight
- Insulation must continue up the dam to the height of the hatch weather-stripping (i.e. at the corners and bottoms of the dam). Trim seams must also be sealed to prevent leakage from the conditioned space into the attic
- If the weather-stripping is above the settled depth of any blown-in insulation, then the sides of the assembly must be insulated separately with either polyisocyanurate or closed-cell spray foam



Weather-stripping the attic hatch:

Vinyl-clad foam weather-stripping or comparable performance weather-stripping should be used to ensure proper sealing of the attic hatch when closed, but should still allow attic access. Felt weather-stripping is less effective and shall not be used on DIY Program projects.

Unless the thermal boundary has been moved up to the roofline, a high quality attic hatch assembly must be built and installed to enclose pull-down staircases. The assembly shall include a durable insulation dam, vinyl-clad foam weather-stripping (or comparable quality) and a removable top panel.

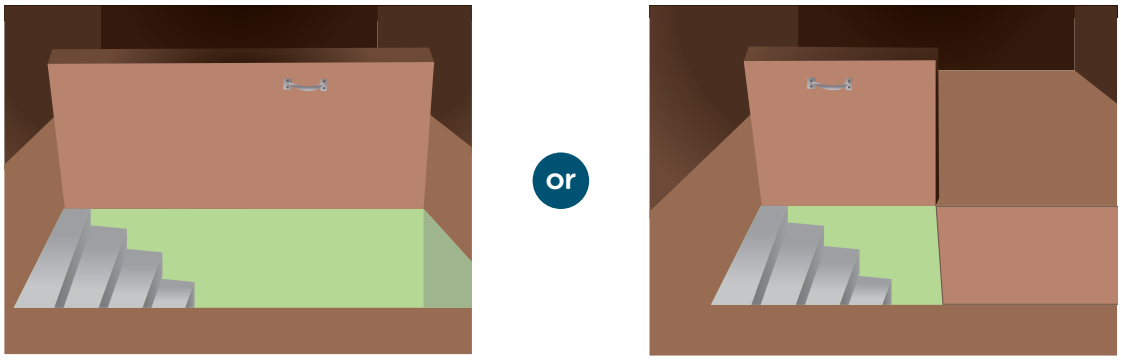


4.5.b: Walk-up Staircases

Whenever possible, a hatch panel should be located at the top of a staircase that is used to access the attic. The alternative is allowable only when building a hatch assembly at the top of the stairwell is not possible.

When the stairwell functions as the thermal boundary, it increases the number of surfaces that need to be addressed and reduces the ending R-values between the house and the attic. If the stairwell is addressed in this manner, the access door must be treated as an exterior door, which will have a low R-value. For these reasons, treating the walls of the stairwell, the stairs, and the door at the bottom of the stairs is strongly discouraged.

If the weight of a large hatch assembly presents a concern, the hatch panel may be divided into sections, or a pulley system may be installed[10].

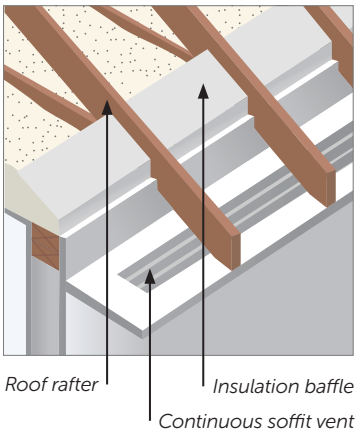


The Vermont Residential Building Energy Standards (RBES) prescriptive requirement states that "hatches and doors must be insulated to the same level as the surrounding surface." Insulating the majority of the attic above code levels allows a lower hatch R-value to meet RBES, thus there should be an R-20 minimum for this area.

4.6: Passive Attic & Roof Ventilation

It is essential for building durability, moisture control, and insulation efficacy that attic ventilation is assessed, improved, maintained, or installed. Each eave vent baffle should be maintained or installed in a manner that will protect the attic insulation from both intrusion of precipitation and wind-washing while maintaining adequate ventilation of the space above the insulation.

Attic ventilation must be installed if local code requires attic ventilation during weatherization or retrofits.



The Building Codes that may be applicable to Vermont are:

- The 2015 International Building Code: https://codes.iccsafe.org/public/document/toc/542/
- See details with regards to roof ventilation: https://codes.iccsafe.org/public/document/code/542/9679101
- The 2015 International Residential Code: https://codes.iccsafe.org/public/document/toc/553/
- See details with regards to roof ventilation: https://codes.iccsafe.org/public/document/code/553/9838540

5: Foundation

Insulating and air sealing the foundation of the building is typically the second priority, after addressing the attic or top of the building. The lower sections of the building see significant cold air infiltration during the winter that can cause the first floor of the home to feel cold and drafty. In addition to stopping air leaks, insulation is needed to keep the home from constantly losing heat to a cool basement heat sink.

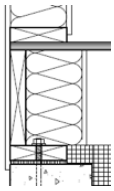
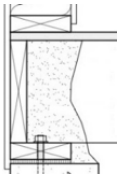
5.1: Box Sills, Band Joists & Beams

Foundation air sealing & insulation requirements:

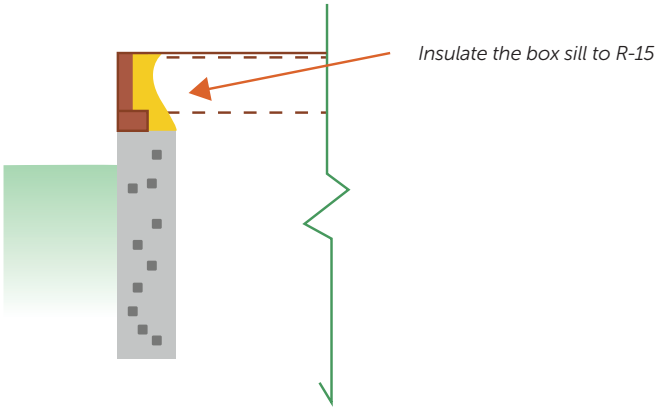
- Foundation walls and box sill/band joist/beam areas must be thoroughly air sealed and insulated to a minimum of R-15
- All slab penetrations must be sealed, including sump pumps, drains, pits, etc.
- If there is any pre-existing fiberglass batting at the box sill, it must be removed, air sealed, and re-insulated
- All moisture issues and thermal fire barrier requirements, as outlined in the Health and Safety section of this manual, shall be followed

Before treating a box sill, band joist, or beam, it is necessary to remove any existing batting. This will allow access for proper air sealing before new insulation is installed. See the diagrams below for effective insulation strategies.

Rim/band joists (box sills) - *R-15 required*

Detail[11]	Material	Thickness
	Cellulose, fiberglass, or mineral wool	Equal to the wall cavity thickness, plus an installed rigid air barrier*
	CCF or rigid foam board	2.5" CCF or PIC *-or-* 3" XPS

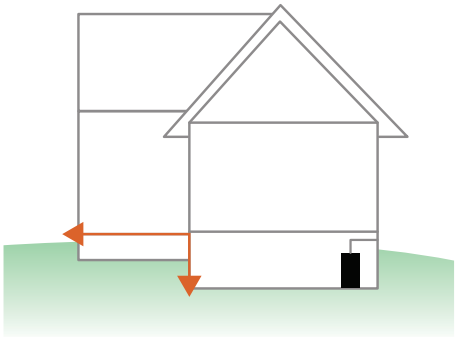
**If using cellulose, fiberglass, or mineral wool insulation in the rim/band joists, insulation must have a rigid air barrier on the interior side and be completely sealed to surrounding floor joists and ceiling/floor.*



5.2: Defining the Thermal Boundary

Whenever a basement or crawlspace contains a heating system, water heater, or associated distribution system, that space should be considered inside the thermal boundary and should be treated accordingly.

If the crawlspace/basement has no heating system or water heater, then it may be considered either inside or outside of the thermal boundary. When considering where the thermal boundary should extend, one should consider factors such as occupant desire and minimizing the amount of exposed surface area.



The diagram to the left shows a full basement with a boiler located adjacent to a crawlspace that has no mechanical systems or plumbing lines. The arrows represent the surfaces that would need to be completely air sealed and insulated in order to place the crawlspace outside of the thermal envelope.

5.2.a: Multiple Basement Zones

In instances where there are multiple basement/crawlspace areas, and it is determined that adjacent zones should be treated differently, the zones must be completely isolated from each other.

Each floor system over a crawlspace should be sealed and insulated whenever a crawlspace is considered to be outside of the thermal envelope. Basement ceilings become interior surfaces whenever the thermal boundary is established at the basement perimeter.

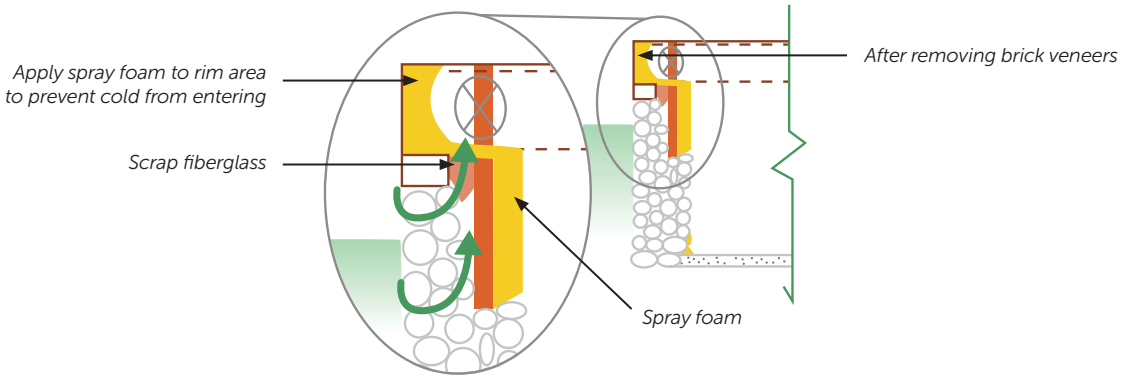
If your home has an alternate configuration such as a tuck-under garage or cantilevered floors, see additional guidance in the Appendix.

5.3: Creating Access to Enable Effective Installations

In certain situations, it may be necessary to alter a space in order to create adequate access for proper installation. Older buildings often have layers of insulation that must be peeled back to expose the bare surface for effective treatment.

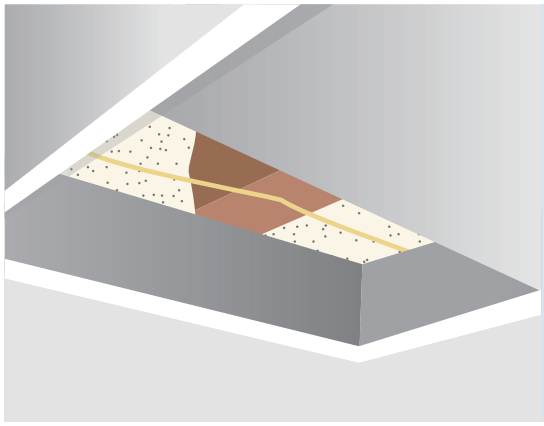
5.3.a: Brick Veneers

If there is a non-structural brick veneer and airspace located in form of the rim and/or foundation, the top rows of brick must be removed prior to performing any air sealing or insulating measures with foam products. Often, the airspace between a brick veneer and the rim joist or foundation is only a few inches deep. Sometimes simply removing the top two or three bricks can be enough to ensure a quality air seal at the rim with foam products. After the top bricks are removed, stuffing a scrap piece of fiberglass down into the gap between the remaining bricks can help to enable a continuous foam seal from the rim/sill area down onto the rest of the brick/foundation wall[12].



Note that in the image above, if the brick was not removed and foam was applied over the brick, the rim (and outer section of the floor above it) would be isolated to the cold side of the insulation. This would significantly reduce the efficacy of the installed weatherization measures, and likely result in cold floors in these areas[13].

5.3.b: Suspended & Drywall Ceilings

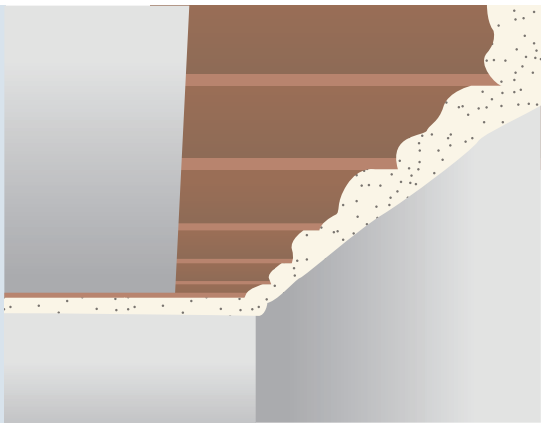


Suspended Ceilings

If you have a tiled suspended ceiling, the tiles should be temporarily removed in order to air seal and insulate the box sill area properly.

Drywall Ceilings

If you have a finished basement with a drywall (or comparable) ceiling, it may be necessary to cut out a swath around the perimeter in order to air seal and insulate the box sill. For contractors not working on their own home, this will require permission from the homeowner.



5.4: Large Foundation Openings

Often, homes will have openings in the basement or crawlspace that require additional attention. If not properly treated, these areas can experience significant heat loss or allow for the entry of pests.

5.4.a: Sandwich Doors

Exterior crawl space/basement doors, including those at the base of a bulkhead stairway, must be addressed to properly define the thermal envelope. If an existing door cannot be improved in a way that delivers a tight air seal and at least R-10 conductive resistance, then a sandwich door must be built or a new door must be installed[14].

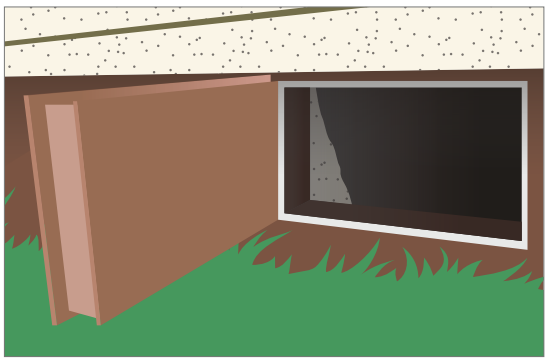
15

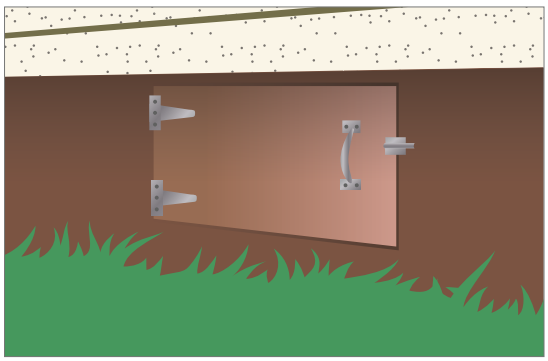
Sandwich doors:

- Durable inside and outside layers (pressure treated CDX plywood is recommended for the outer layer, which is exposed to the elements)
- Middle layer of insulation board to achieve R-10
- Weather-stripping and gate latches and/or barrel bolts to secure the door tightly to the opening

5.4.b: Foundation Plugs

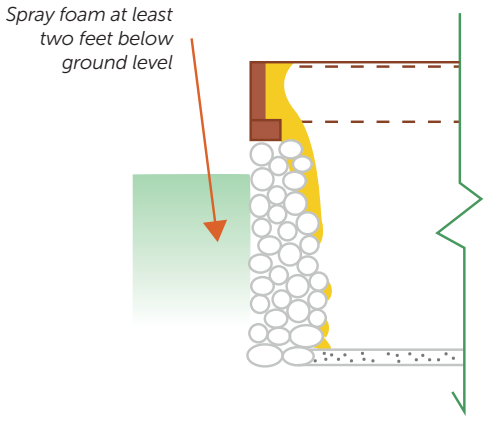
Homes that have foundation vent grills or windows inside the thermal envelope should treat these areas to prevent air leakage. All foundation vent grills must be sealed closed. Foundation windows must be air sealed at a minimum. Foundation window plugs should be installed and air sealed into all window openings. The installation of smaller, sandwich-door style hatches is acceptable if a durable, energy efficient, fully operational access point into a basement or crawlspace is needed.





5.5: Rubble & Stone Foundations

When homes have a rubble and stone foundation, air is able to leak in from the above-ground portion of the outside wall through cracks and gaps between the laid-stone foundation. In these situations, it is necessary to ensure effective air sealing in order to avoid outdoor air infiltrating the basement. At a minimum, air sealing must be conducted on all rubble and stone foundation walls. This applies to surfaces both above and below ground level[16].



Rubble & Stone Foundations:

Air seal and then insulate rubble and stone foundations with closed cell spray foam to at least two feet below grade. This will involve using spray foam to completely cover the areas down to at least two feet below ground level and spot sealing any gaps in the foundation wall around and between stones below that level.

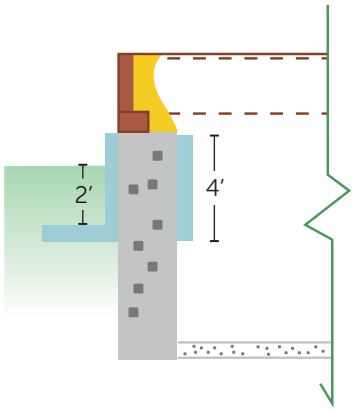
The entire rubble or stone foundation wall may also be sealed and insulated. If exterior drainage is not good, water migration may push foam off, or cause freezing to push rubble into the space. In this situation, it is best practice to work with an Efficiency Excellence Network contractor to develop a plan that will install an insulation system integrated with a water mitigation solution. A cost-effective short term solution would be to insulate down 3-4 feet above the foundation floor, and install a French drain on the interior perimeter to drain to the outside.

5.6: Smooth Surface Foundations

For smooth foundations such as concrete or cinder block, there are two options for achieving optimal insulation.

Option A:

Insulate the outside of the foundation wall to at least 4' below grade (total down and to the outside horizontally away from the foundation)



Option B:

Insulate the inside of the foundation wall to at least 2' below grade

Considering multiple approaches

The figure above demonstrates viable approaches for increasing the insulation value of a foundation wall. In a situation where multiple installation methods are possible, the most cost-effective installation should be used. Insulating the above-grade portion of the foundation wall is usually the most cost-effective[17].

A: Appendix:

A1: Assessing Air Leakage & Insulation

If you choose to take on an insulation and air sealing job yourself, it's a good idea to assess the current state of your home. Grab a pad of paper and a pencil (or your smartphone), walk through your building, and make a note of any air leaks and missing insulation:

- Air leaks: Look for evidence such as visible cracks, or drafts you can feel. Also check for gaps along floor edges, where walls and ceilings meet, and anywhere pipes or other hardware enters the wall. Next, search your building's exterior for places where two different building materials meet—this often leaves a gap—or anywhere hardware or pipes pass through the siding.
- Attic and basement insulation: Finished basements require insulation along perimeter walls; unfinished basements should have insulated ceilings and band joists. In finished attic spaces, look for ceiling and perimeter wall insulation. And in unfinished attics, check for floor insulation.
- Wall and equipment insulation: Find an exterior wall with an electrical outlet. First, turn off the power to that outlet. Then remove the cover plate and probe behind the drywall with a screwdriver or similar tool to check for insulation. Also make a note of whether your water heater tank, hot water pipes, and air ducts are insulated.

A2: Decked Attic Floors

It is important not to add insulation on top of a decked attic floor without determining an appropriate approach to air sealing the area first. There are three basic strategies for dealing with decked attic floors:

1. Dense packing under the decking with cellulose and leaving the decking bare on top for storage and service accessibility
2. Dense packing under the decking with cellulose and adding additional insulation on top
3. Remove the decking to thoroughly air seal and build up the attic floor using either rigid foam board or framing that allows R-49 to be installed and creates the structure for a new storage floor

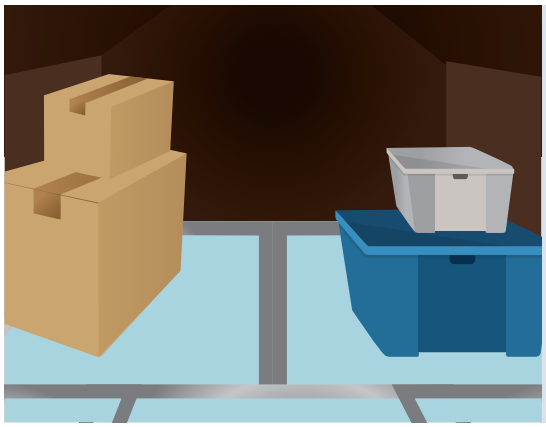
It is important to remember that while dense-packed cellulose alone can decrease air infiltration, it is strongly encouraged to remove strategic floor boards for access to the tops of all partition walls and other potential penetrations prior to installing insulation. These areas should be sealed and the flooring replaced before dense-packing. When there is a floored attic, this is the only way to ensure that the thermal envelope is adequately defined. The following steps should be followed in any application:

- Establish the thermal boundary
- Air seal tops of partition walls and penetrations
- Optimize insulation value

Thoroughly dense-packing under decked attic floor cavities should be the minimum work scope requirement in a floored attic space. Installing additional insulation over the flooring is encouraged if it is acceptable to the homeowner's personal preference. There are two strategies to optimizing attic insulation levels while still allowing storage space or service access[18].

Build Insulation Dams

Dividing an attic into sections or providing runways using insulation dams is one way to maintain attic functionality and maximize the insulation value over portions of a decked attic floor.



Build Up the Attic Floor

Option 1: Install rigid foam insulation sheets on top of the decked floor for storage. A minimum of R-25 is recommended for optimal condensation control.

Option 2: Remove the decking, air seal, and use the new framing to increase the depth available for insulation. Build raised storage platforms if desired.

A3: Tuck-Under & Attached Garages

When dealing with garages that are under the living space, it is important to define them as outdoor spaces. Garages connected to the thermal boundary of the home can present occupant safety issues by allowing carbon monoxide to leak into the home.

Effectively define the thermal envelope:

- Air seal and insulate the garage ceiling when there is conditioned space above
- Air seal and insulate any garage wall(s) bordering the basement
- Air seal and insulate, or reroute, any return ducts in the garage
- Insulate any plumbing and/or heat distribution lines in the garage
- Treat any door(s) separating the garage from the basement or house as exterior doors

Alternatively, keep cars and other pollutants outdoors.

The garage may be placed inside the thermal boundary only after permanently disabling the garage doors. This will involve:

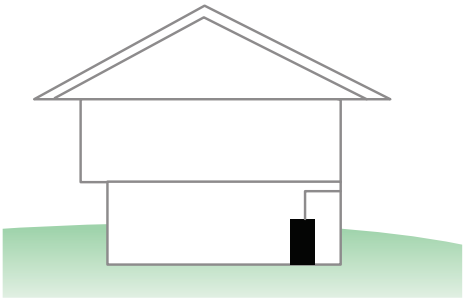
- Framing a new wall system into the rough opening for the garage door. The new wall may include a standard exterior entry door
- Treating the exterior surfaces of the former garage like any other exterior surface of the home, including the use of suitable exterior grade materials and paints/sealants

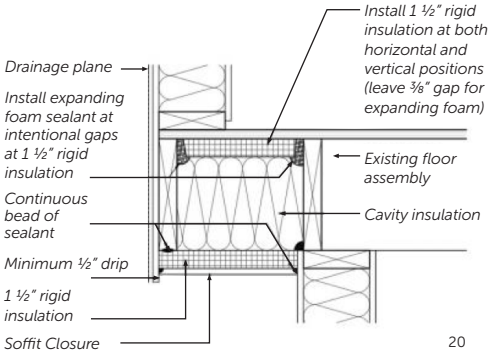
A4: Cantilevered Floors

All possible efforts must be made to ensure that cantilevered floor systems that overhang the foundation wall are completely air sealed and insulated to the highest performance value possible to maintain a continuous thermal boundary.

Raised Ranches:

- If there is access to the sills, any pre-existing fiberglass batting in the cantilevered floor section should be removed.
- Foam board sheets should be installed at the box sill area atop the foundation wall.
- The cantilevered floor system should then be dense packed with cellulose insulation through the foam board, as shown in the images below[19].





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Alternate approaches

If the basement is finished and there is no access to the sill without demolition, then the options below should be considered:

- Install dense-packed cellulose from the exterior
- Create access to the cavity and spray foam up against the subfloor and a vertical blocker
- Add 2" or more of rigid foam board to the bottom and reinstall finishes

Resources

- Lead-safe practices:
  https://www.epa.gov/lead
- 2015 International Building Code Sections 2603.4 and 2603.3:
  https://codes.iccsafe.org/public/document/IBC2015/chapter-26-plastic
- Vermont Dept. of Health asbestos control guidelines:
  http://www.healthvermont.gov/sites/default/files/documents/2016/11/ENV_AL_asbestos_control_reg.pdf
- EPA asbestos information:
  https://www.epa.gov/asbestos
- Zonolite Attic Insulation Trust:
  http://www.zonoliteatticinsulation.com/
- Vermont Dept. of Health carbon monoxide guidelines:
  http://firesafety.vermont.gov/sites/firesafety/files/files/Documents/dfs_codesheet_co_matrix.pdf
- Vermont Dept. of Public Safety:
  http://firesafety.vermont.gov/
- Vermont Residential Building Energy Standard:
  http://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/RBES/2015_VT_Energy_Code_Handbook_V4.1.pdf
- Foundation insulation:
  https://buildingscience.com/documents/bareports/ba-1108-hybrid-foundations-retrofits-measure-guideline/view
- Efficiency Vermont home efficiency estimator tool:
  https://www.efficiencyvermont.com/tips-tools/tools/efficiency-estimator
- Efficiency Vermont electric usage tool:
  https://www.efficiencyvermont.com/tips-tools/tools/electric-usage-tool
- AHRAE ventilation guidance:
  http://www.residentialenergydynamics.com/REDCalcFree/Tools/ASHRAE6222013.aspx

Endnotes

1. Vermont Department for Children and Families, Office of Economic Opportunity (DCF). 2013. "Vermont's Weatherization Program: Technical Policies & Procedures Manual." http://www.waptac.org/data/files/website_docs/technical_tools/best_practices_field_guides-standards/vermont-wap-technical-manual.pdf

2. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

3. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

4. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

5. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

6. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

7. A step-by-step guide can be found at Building Science Corporation. "Attic Air Sealing Guide and Details." 2010. https://buildingscience.com/documents/guides-and-manuals/gm-attic-air-sealing-guide/view

8. U.S. Department of Energy, https://basc.pnnl.gov/resource-guides/attic-knee-walls#quicktabs-guides=5

9. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

10. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

11. U.S. Department of Energy, https://basc.pnnl.gov/resource-guides

12. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

13. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

14. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

15. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

16. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

17. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

18. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

19. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."

20. U.S. Department of Energy, https://basc.pnnl.gov/resource-guides

21. DCF, "Vermont's Weatherization Program: Technical Policies & Procedures Manual."