Best Practices for Air Sealing and Insulation Retrofits

For Single Family Homes




BRITISH COLUMBIA

Homeowner Protection Office
Branch of BC Housing

FORTIS BC™

BC hydro powersmart

Preface

About this Guide

Best Practices for Air Sealing and Insulation Retrofits is published by the Homeowner Protection Office (HPO), a branch of BC Housing. This guide consolidates best practices for air sealing and insulation retrofits (i.e. building enclosure weatherization) for British Columbia homes. It does not cover mechanical systems, appliances, lighting, or diagnostic testing.

The guide is intended to be a valuable reference tool for construction industry professionals and can help train contractors to perform weatherization work. It is similar in content to contractor-focused weatherization program training guides, but with specific regard to British Columbia's unique climate, construction practices, and building code requirements.

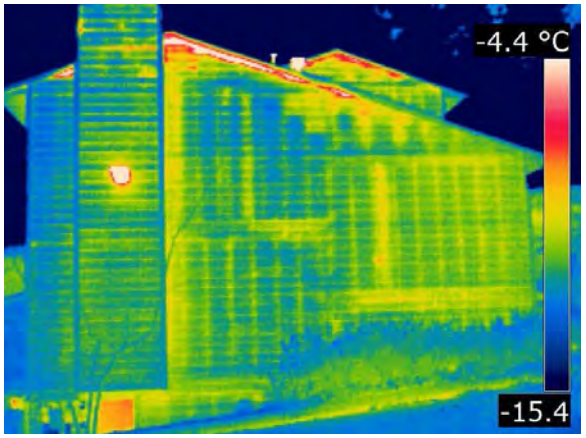
The information may also interest homeowners performing home retrofits without a contractor, though is not written for the do-it yourself audience. Guides such as *Keeping the Heat In*, published by Natural Resources Canada, or *Insulate and Weatherize—Build Like a Pro Series*, from the Tauton Press, are examples of publications that are more appropriate for homeowners planning to undertake the work themselves. Homeowner tips are provided to assist with operation and maintenance.

Background

Air sealing and insulation weatherization retrofits of homes are proven methods to reduce space-conditioning energy consumption, improve durability, reduce utility bills, and reduce the gas and electric load on provincial utility providers.

Building enclosure weatherization retrofits or energy efficiency measures primarily consist of air sealing and adding or upgrading insulation in the building enclosure, either as a stand-alone activity, or during other planned renovation and repair activities.

Simple weatherization work can be performed by homeowners or occupants, while more advanced activities and extensive repairs or renovations typically involve a contractor. There are many health and safety issues to consider when working in existing homes and handling different building materials.



Infrared images such as this, showing a wood-frame home in B.C., can identify insulation discontinuities and air leakage locations, which can assist contractors with weatherization retrofits.

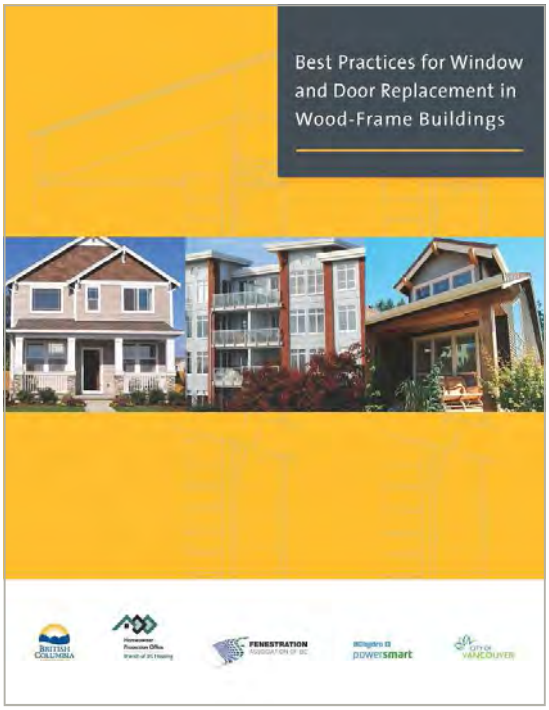
Insulation retrofit of an attic, showing blown-in cellulose added after air sealing and insulating with polyurethane foam.

Air sealing of an electrical penetration and unsealed top-plate connection in an attic.

Preface

Scope

The guidelines in this publication apply to wood-frame residential detached, semi-detached (e.g. duplex to quad-plex) and rowhouse/ townhomes in British Columbia. Non wood-frame homes, mobile homes, and multi-storey multi-unit residential buildings are beyond the scope of this guide.



Specifically, the guide provides procedures for common air sealing and insulation installation energy efficiency measures for attics/roofs, above-grade walls, basements, crawlspaces, floors, and the interfaces in and between these assemblies. This guide does not address home evaluations, basic building science, material selection, and detailed health and safety procedures, as numerous home weatherization guides and publications already provide a thorough background on these topics.

The guide does not cover the weatherization or replacement of windows or doors, as this is covered in the HPO guide *Best Practices for Window and Door Replacement in Wood-Frame Buildings* (cover image to right).

In addition, the guide does not cover measures that relate directly to heating, cooling, and ventilation systems, such as duct sealing.

It is important to note that each home and weatherization project presents unique conditions. This guide provides recommended best practice techniques, but it is likely these methods will need to be adapted to accommodate the variations in each project.

Content

This guide is written in the context that the homeowner/contractor has decided to proceed with some air sealing or insulation weatherization work in their home and understands both the benefits and the potential health and safety risks of doing so.

- Section 1 provides a summary of the key considerations for air sealing and insulation retrofits, recommended retrofit insulation and airtightness levels for British Columbia, and a short overview of health and safety considerations.
- Section 2 provides a brief discussion on how a home energy performance assessment can help select appropriate energy efficiency measures covered in this guide.
- Section 3 covers the actual procedures for air sealing and installation of insulation, the main focus of this guide.
- Section 4 provides additional resources and references.
- Appendices provide checklists and a glossary of terms to further assist the reader.

Preface

Acknowledgements

The HPO gratefully acknowledges the invaluable support and funding contributions of FortisBC and BC Hydro in the production of this guide. This guide was prepared by RDH Building Engineering Ltd., Innes Hood Consulting, Ken Farrish Marketing, and Constructive Home Solutions. Additional acknowledgement is extended to Quality Program Services for providing technical consultation and weatherization sites for documentation.

Disclaimer

This publication is provided for general information and suggestions only. The greatest care has been taken to confirm the accuracy of the content. However, the authors, funders, publisher, members of the project Steering Committee or other contributors assume no liability for any damage, injury, loss or expense that may be incurred or suffered as a result of the use of this publication, including products, building techniques or practices. The views expressed do not necessarily represent those of any individual contributor, BC Housing, FortisBC, or BC Hydro.

Building science, products and construction practices change and improve over time and it is advisable to regularly consult up-to-date technical publications on building envelope science, products and practices rather than relying solely on this publication. It is also advisable to seek specific information on the use of products, the requirements of good design and construction practices, and the requirements of the applicable building codes before undertaking a construction project. Consult the manufacturer's instructions for construction products, and also speak with and retain consultants with appropriate engineering and/or architectural qualifications, and appropriate municipal and other authorities, regarding issues of design and construction practices. Most provisions of the building codes (British Columbia Building Code and the Vancouver Building By-law) have not been specifically referenced. Always review and comply with the specific requirements of the applicable building codes for each construction project. Nothing in this publication is an endorsement of any particular product or proprietary building system.

Main entry under title:
Best practices for air sealing and insulation retrofits

ISBN 978-0-7726-6880-6

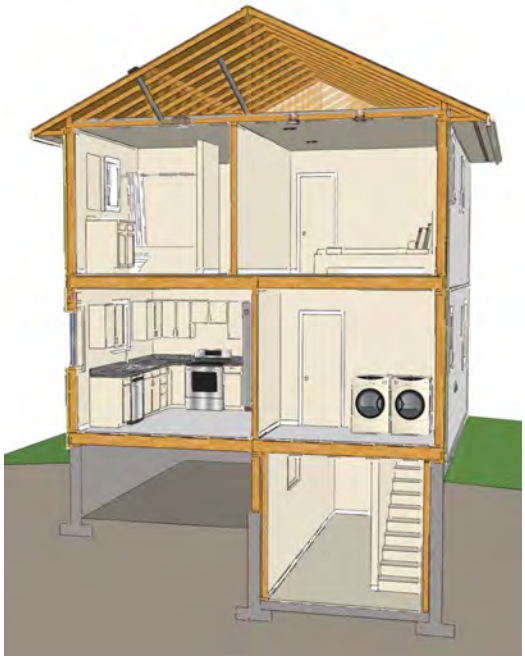
Homeowner Protection Office
Branch of BC Housing
1701—4555 Kingsway
Burnaby, British Columbia, V5H 4V8
Canada

Table of Contents

Table of Contents

Table of Contents

1.1: House as a System - Effect of Air Sealing and Insulation Retrofits



All the parts of the house including its contents and occupants interact together to form an integrated system - this is imperative to understand when performing air sealing and insulation work. This guide covers air sealing and insulation weatherization work for all parts of the house from the basement to the attic.

A house is made up of numerous parts (e.g. structure, finishes, mechanical systems, electrical and lighting, building enclosure materials) and contents (e.g. people, pets, plants, furniture etc.) that all interact together as an interconnected system. This notion of interconnectedness and performance relationship is known as the "house as a system" concept. That is, the performance of one part of a house depends on its relationship with other parts of the house.

A home's heating, cooling, and ventilation systems and building enclosure are particularly important in the context of energy efficiency. For example, the heating system will not run at optimum performance or efficiency if the house's building enclosure allows a lot of air leakage or is poorly insulated. However, weatherization of older homes with significant air leakage can also create new problems. For example, if a house is made more airtight then it is easier for naturally aspirated combustion equipment—including furnaces, fireplaces and hot-water heaters—to backdraft and spill carbon monoxide and other dangerous combustion gases into the home if the space becomes negatively pressurized. Sources of negative pressure include exhaust fans for kitchen range hoods, clothes dryers, bathrooms or the whole house, and chimneys.

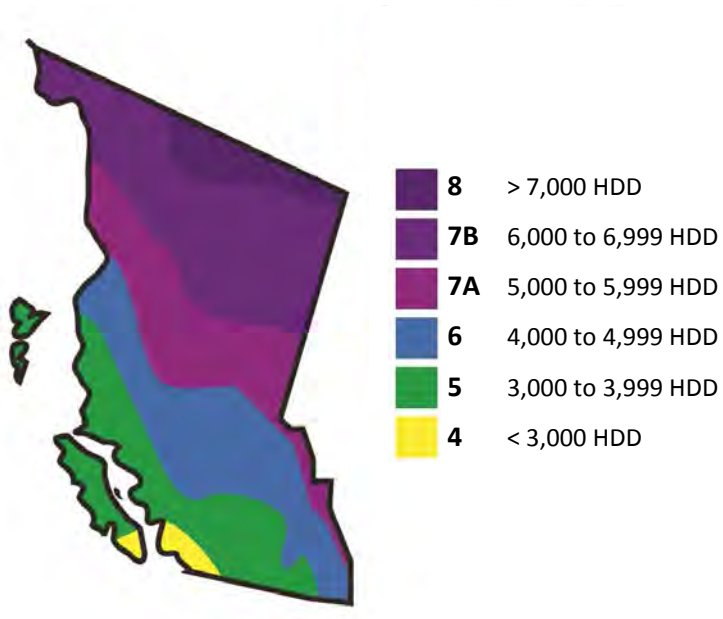
Trained weatherization professionals who conduct home energy evaluations (for example, Certified Energy Advisors (CEAs) with the NRCan EnerGuide rating system) and contractors who perform air sealing and insulation work should ensure they understand the interactions of airtightness, insulation, and mechanical and ventilation equipment, and be aware of possible remedial measures.

The following is a list of the key potential effects of air sealing and insulation retrofits on home performance highlighting the system interactions that can occur.

- Air sealing work makes a home less drafty and more comfortable, and reduces space conditioning costs.
- Air sealing work will seal holes that may have previously provided natural ventilation in the home.
- A more airtight home means that exhaust fans and un-sealed combustion appliances will create higher negative pressures on the building enclosure unless dedicated make-up air is provided.
- A negative pressure on the building enclosure can cause backdrafting and potentially harmful spillage of combustion gases from unsealed combustion appliances and fireplaces, unless provisions are made to provide make-up air to neutralize the pressure or the unit is directly vented to outside.
- Adding insulation will reduce space conditioning costs and will make indoor spaces more comfortable and interior surfaces less prone to condensation and subsequent deterioration.
- Adding insulation to walls, roofs, and floors can cause condensation in concealed spaces if vapour diffusion and air leakage control is not properly addressed, or incorrect materials are used.
- Some insulation and sealant materials contain volatile organic compounds (VOCs) and other harmful chemicals and must be used carefully and properly ventilated until cured.
- Care must be taken when selecting building materials as some materials are incompatible with each other and with existing building components such as electrical wiring and plastics.

1.2: Air Sealing and Insulating Retrofit Considerations for British Columbia

Over a million detached and low-rise wood-frame homes were constructed in B.C. in the past century. Over the past decades, insulation levels and building enclosure airtightness have evolved. Older homes tend to be poorly insulated and have more air leakage compared to new homes. In general, older homes will benefit more from insulation upgrades, as insulation levels before the 1980s were relatively low or non-existent, in particular in basements and crawlspaces. Attic insulation levels in houses constructed before the 1990s are also typically low. Even newer homes constructed in the past decade will benefit from air sealing work, as this is often overlooked during construction. Air sealing is unlikely to provide a significant benefit for new homes that were airtightness tested during construction and have an air exchange rate of less than 2 ACH_{50}.



Heating Degree Day (HDD) map of B.C. showing approximate climate zones 4 through 8 as defined in the National Energy Code for Buildings (NECB) and new British Columbia Building Code (BCBC). Note that actual HDD values are found in the BC Building Code and are available online for many municipalities.

The optimal amount of insulation for a wall, floor, or roof depends on where the home is located within B.C. Houses in the colder regions need to have more insulation and be more airtight in order to be comfortable in the wintertime and use as little space-heating energy as possible to maintain a comfortable indoor environment for occupants.

The following airtightness targets and insulation levels (effective R-value) are recommended for homes in B.C. based on best practices and insulation retrofit potential. Note that these are not Code required values; insulation requirements of the 2012 BC Building Code can be found in the HPO published *Illustrated Guide to Energy Efficiency Requirements for Houses in British Columbia,* which should also be consulted for guidance regarding required and optimal insulation levels. Upgrading a house to this level of performance can be costly, and some levels of insulation or sealing may not provide significant utility bill savings depending on the specifics of the project, but could bring other benefits such as improved thermal comfort.

Wood-frame Building Enclosure Assembly	Zones 4 & 5 - <4000 HDD	Zone 6 - 4000-4999 HDD	Zone 7A - 5000-6000 HDD	Zone 7B & 8 - >6000 HDD
Attic Spaces	R-40	R-50	R-60	R-60
Cathedral or Flat Roofs	R-30	R-30	R-35	R-40
Above-grade Walls	R-20	R-25	R-25	R-30
Below-grade Walls	R-20	R-20	R-25	R-25
Suspended Floors	R-25	R-30	R-40	R-50
Slab-on-grade Floors	R-10	R-15	R-20	R-25
Airtightness (ACH50)	<3 ACH	<2.5 ACH	<2 ACH	<1.5 ACH

1.3: Health and Safety Considerations

With proper precautions and training, air sealing and insulation weatherization work on homes should pose little to no threat to the health and safety of the contractor or the occupants of the home. However, improperly used building materials and tools can be dangerous to users or occupants or can damage the building, so it is important that contractors read and follow all manufacturers' recommended safety and installation procedures. Wherever possible, less harmful and lower VOC air sealing and insulation materials should be used, particularly if materials will be exposed to interior living space.

The following pages summarize some of the key points to consider, with references provided for further information and occupational health safety procedures. A health and safety checklist for contractors, provided in the appendices, covers some of the major considerations. However, the health and safety information in this guide is neither comprehensive nor complete, and those performing weatherization work guide should always be appropriately trained and aware of the safety risks associated with the work.

Structural Elements and Connections

Structural elements of the home should not be compromised during weatherization work even if it is necessary to cut, drill, or relocate wood structural elements during renovation work. Contractors should avoid cutting wood elements such as studs, trusses, joists and beams when air sealing or insulating unless a structural engineer has been retained to review the modifications and suggest remedial or reinforcing techniques.

Ventilation of the Home

Air sealing work seals openings in the building enclosure that may have previously been relied on for natural or passive ventilation in the home. Inadequate ventilation can lead to indoor air quality concerns and moisture problems, and therefore a properly functioning and sized mechanical ventilation system is necessary. Further information can be found in numerous resources on ventilation system design including Chapter 18 of the new *Canadian Home Builder's Association Builders' Manual* and the *TECA Quality First Ventilation Guidelines.*

Ventilation while Performing Work

Many sealants, adhesives, and spray polyurethane foams release VOCs and other potentially harmful chemicals when curing. The product manufacturers' installation and safety procedures should be followed when performing work, and ventilation should be provided as required: opening windows, using temporary ventilation fans or using full respiratory equipment, depending on the nature of the work being performed. In some cases—for example when using large quantities of spray polyurethane foam in attics, roofs, or walls—contractors need full respiratory equipment while in the work area and homeowners may need to leave the house for up to 24 hours after spraying, where all windows are kept open for a full-house flush. Note that there is an increasing number of available products that release little or no VOCs.

Asbestos-containing Products and Vermiculite Insulation

In many older homes, particularly those built before the 1990s, asbestos fibres may be found in building products such as vermiculite insulation, asbestos cement board siding, asbestos pipe insulation, drywall joint compound, stucco, and some older window putties. Undisturbed materials within walls or attic spaces pose little risk to occupant health. However, if exposed or disturbed as part of a weatherization program these materials can cause health risks to both the contractor and homeowner. At minimum, contractors and homeowners should consult the following prior to undertaking weatherization work: *It's Your Health—Vermiculite Insulation Containing Amphibole Asbestos*, published by Health Canada; *Asbestos Hazards When Renovating Older Homes* and *Safe Work Practices for Handling Asbestos*, both published by WorkSafeBC and available online: www.worksafebc.com.

1.4: Health and Safety Considerations

Lead Paint

Lead can be found in many paints and coatings used in buildings until the 1980s. Lead-containing paints and coatings do not present a hazard if they are left intact. However, if weatherization work damages or removes materials containing lead, appropriate safety measures must be followed. Further information can be found in *Lead-Containing Paints and Coatings*, published by WorkSafeBC and available online (www.worksafebc.com).

Sprayfoam Insulation

Spray polyurethane foam (SPF) is a commonly used air sealing and insulation material for weatherization work and this guide suggests its use in various applications. Exposure to isocyanates and other chemicals in the sprayfoam during the curing period or for some time after installation may cause health effects in some people. Care must be taken to control exposure to contractors and the homeowner, including possibly vacating the home while sprayfoam is being applied and for up to 24 hours for large applications. In addition, some sprayfoam types (closed cell, medium density products) can only be applied in lifts of up to 2" at a time, should not be used to fill closed cavities, and require a cooling-off period in-between lifts for thicker applications.

Sprayfoam should always be installed by a trained contractor; this guide does not provide information or instruction on SPF installation and safety procedures. Refer to sprayfoam manufacturers for health and safety information. The US EPA has an unbiased website on the use of SPF in the home (www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html).

Materials Containing Solvents and VOCs

Sealants, adhesives, and other products used for air sealing and insulation weatherization work may contain flammable solvents and VOCs that can affect contractor or homeowner health and safety. Low VOC options for many adhesives, paints and sealants are available and should be used when possible for indoor work, though the use of higher VOC products may be required for some applications. Additional health and safety information can be found by reviewing the product literature and manufacturers' material data safety sheets.

Radon Gas

Radon is a colourless, odourless and tasteless radioactive gas that is produced by the breakdown of uranium in soil and rock. Radon is present in outdoor air at low concentrations and is harmless. However, in an enclosed house, radon can build up and create a long-term health risk to occupants. The concentration of radon within a home depends on the radon concentration in the soil below the house, the pressurization of the home (i.e. depressurization pulls radon in through foundation cracks), and the house ventilation rate. Air sealing and insulation weatherization work in a basement or crawlspace (e.g. sealing foundation cracks and gaps) can help reduce radon concentration, though at the same time, air sealing work can lead to a more airtight home that is then prone to more depressurization and poor ventilation (unless addressed).

Radon is more of a concern for homes east of the Coast Mountains in the interior of B.C. than it is for homes in coastal B.C. When performing weatherization work in homes within potentially affected areas, basement and crawlspace sealing is recommended before attic or above-grade work. Where radon is a concern, testing should be performed and is relatively inexpensive. Further information can be found on the HealthLinkBC website (www.healthlinkbc.ca/healthfiles/hfile42.stm).

1.4: Health and Safety Considerations

Mould, Fungal Growth, and Moisture Damage

Fungal contamination and mould can occur in homes and concealed building enclosure assemblies if the materials are exposed to elevated relative humidity levels (typically above 80% RH for extended periods) and/or condensation. Organic materials, such as paper-faced drywall and wood, are susceptible to fungal growth in the home. Fungal growth is also common in bathrooms, but easily removed by regular household cleaning. Fungal growth on window frames may occur if there is excessive condensation due to high indoor relative humidity levels. Fungal growth is also commonly found in crawlspaces, attics, and other damp spaces as a result of elevated relative humidity levels, condensation, rainwater, and plumbing and appliance leaks. Depending on the severity and duration of the wetting, fungal growth can lead to decay and deterioration of wood components. Moisture-damaged wood is unfortunately common in many B.C. homes and is often uncovered during weatherization work.

If significant fungal contamination or mould is present or suspected in the home, it must be removed and cleaned and the contributing source addressed prior to any air sealing and insulation weatherization work. To control and reduce the potential for mould growth, indoor moisture sources and indoor humidity must be controlled. This can be achieved by the combination of a proper ventilation system with good distribution in the home, and source moisture control. Additional information can be found in *Keeping the Heat In*, published by Natural Resources Canada.

A good reference on wood durability, including procedures for the remediation of moisture damaged wood buildings, can be found at the Binational Softwood Lumber Council website (www.softwoodlumber.org/why-wood/wood-durability.html). Where mould growth is severe or moisture damage is extensive, a professional specializing in mould clean-up and structural repair should be retained. The document *Guidelines on Assessment and Remediation of Fungi in Indoor Environments,* published by the New York City Department of Heath and Mental Hygiene, is a good reference for remediation procedures. When cleaning up mould-contaminated building materials, WorkSafeBC occupational health and safety regulations should be followed (Guidelines Part 4 - Indoor Air Quality).

Combustion Safety

Air sealing and insulation weatherization work can affect the combustion safety of a home. Appliances with natural draft chimneys – such as gas or wood-burning fireplaces, or gas and oil-burning appliances like boilers, furnaces, or water heaters – may rely on natural air leakage through the enclosure to provide the make-up air for combustion. Some homes may have dedicated combustion air vents (that must not be sealed during weatherization work). If air sealing and weatherization work is performed on a home with a natural draft chimney, this make-up air may be reduced to a point where the equipment or fireplace may backdraft and spill combustion gases into the home. When weatherization work is undertaken, a direct supply of make-up air for these systems may be required. It can be more difficult to provide make-up air, n homes with unvented fuel heaters or gas fireplaces, so these may need to be removed prior to weatherization work.

Weatherization work in homes with gas, oil, or wood-burning equipment requires special consideration and combustion safety testing. Guidance for addressing combustion safety, testing, and remedial measures are beyond the scope of this guide. Several references are provided in Section 5 at the end of this guide. Contractors performing weatherization work should be trained about these issues prior to performing any work.

1.4: Health and Safety Considerations

Gas Safety

Air sealing and insulation weatherization work typically does not require the movement or relocation of gas lines or equipment. However, if a smell of gas is detected or gas equipment work is required, proper procedures must be followed by a trained contractor. For example, modifications may be required after a failed combustion safety test on a weatherization project. B.C.-specific information can be found at the BC Safety Authority (safetyauthority.ca/regulations/gas) as guidance is not provided here.

Electrical Wiring

Care must be taken when working around electrical wiring so as not to receive a shock, damage the wiring, or cause a fire. Air sealing materials such as sprayfoam should never be applied within electrical boxes or come into contact with bare wires, so use of these materials around electrical connections requires special attention. Always follow product manufacturers' instructions and warnings, and hire an electrician if any electrical work, such as installing a new exhaust fan to provide mechanical ventilation after air sealing work is performed.

Some older B.C. homes may still have active knob and tube wiring. The house must be rewired and the knob-and-tube wiring decommissioned in the affected areas prior to the attic being air sealed and insulated. If in doubt, hire an electrician to review the wiring and perform any necessary work.

Other Considerations

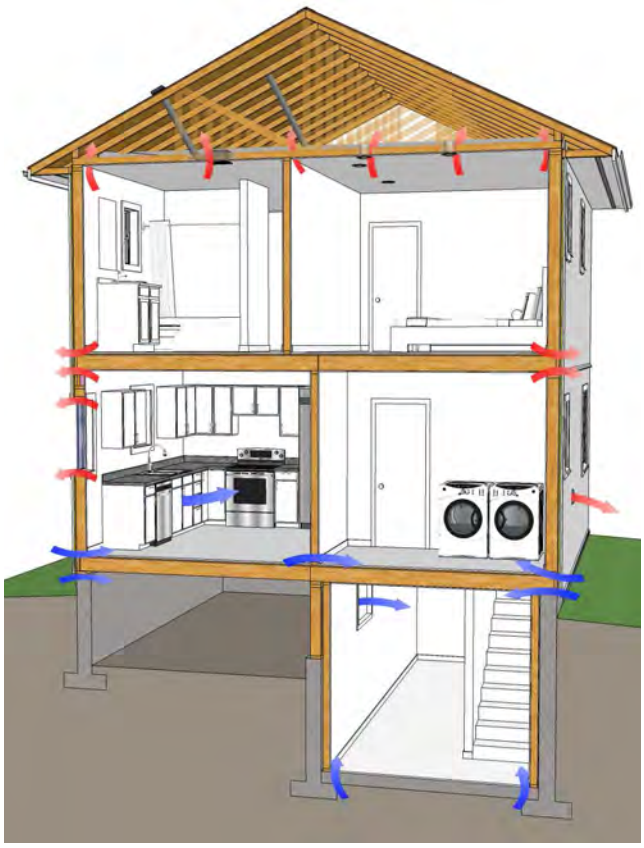
Weatherization work can sometimes uncover other issues in a house. For example, exhaust fans may be directly vented into attics instead of outdoors, or a roof, crawlspace, or basement may be found to be leaking. In these cases, these problems must be addressed before or as part of the weatherization work.

2: Retrofit Project Evaluation

Before starting any retrofit project, it is important to assess all potential environmental hazards related to the project. The HPO-published *Managing Environmental Risks During a Renovation Project* Builder Insight Bulletin to provide guidance with this aspect of the retrofit projects.

While almost every part of an old building can be better insulated and made more airtight, it is important to know which energy efficiency measures could have the largest effect on the performance of the home.

The first concept to understand is the role stack effect plays in the air movement of the house. At the bottom of the house, cold air is drawn in as shown in the adjacent schematic, and at the top, warm air is pushed out into the attic. As a result, air sealing and insulating at the bottom (i.e. basements and crawlspaces) and at the top (i.e. attics and roofs) of a house should be prioritized, and these areas are also often the easiest to access in unfinished spaces.



Schematic of a typical two-storey wood-frame house over part basement and crawlspace with a ventilated attic roof. Arrows show typical air leakage locations to review and address during weatherization work.

Air Sealing

To start, sealing all of the large holes in the house will have the biggest effect. Plumbing, duct work, chimney chases, electrical work, and other service penetrations not intended for airflow or venting should be sealed where possible, no matter where they are in the house. Though it seems obvious, service penetrations are usually the leakiest areas of a house.

Once the large holes are sealed, the focus can be shifted to smaller, less obvious holes. At the basement or crawlspace, the rim joists should be sealed where the exterior wall meets the rim joist, and where the rim joist meets the foundation as they can allow significant amounts of air into the home. Since cold air is drawn through these areas, air sealing can improve the thermal comfort of the home, and decrease heating costs.

At the top of the house, air leakage into the attic occurs through pot-lights, exhaust fans, and partition walls. Pot-lights can be the biggest air leakage path of the small holes since a hot light bulb will draw air up, heat it, and then pull it through the light's housing into the attic like a small chimney. Unsealed service penetrations like plumbing stacks and vents as well as exposed drop ceilings and service shafts, should also be sealed.

Insulating

Where possible, the whole house should be insulated using standard practice insulating techniques to increase the thermal efficiency of the home. Insulation work must be done without compromising the durability of the existing wood-frame structure by creating a risk of condensation, high relative humidity conditions, or moisture entrapment. All insulation work begins with air sealing. Never insulate a wall, roof, or floor without first making sure the air leaks in the vicinity are addressed.

Typically the attic, followed by the crawlspace, are the most cost-effective locations to perform insulating work. Unfinished basements are also easy to insulate. Insulating above- and below-grade finished walls is much more involved and is often better to perform at the time of other renovations, repairs or cladding work.

2.1: Energy Performance Assessment

An energy performance assessment should be conducted prior to performing weatherization work to determine the suitability of the house for improvements and to prioritize different energy efficiency measures. Additionally, this assessment—in conjunction with a "post-retrofit" assessment—can provide detailed information regarding the effectiveness of the weatherization measures. In some cases, this secondary assessment may also qualify a house for rebates as part of utility or government incentive programs.

While it can be difficult to economically justify individual weatherization measures, the costs of these measures are significantly lower when implemented as part of previously planned renovation work, or when rebates are available. Cost effectiveness for the homeowner can also be more easily predicted when a thorough energy performance assessment is conducted prior to starting the upgrades.

Steps for effective use of energy performance assessments in the weatherization process:

1. **Assess the House Prior to Weatherization —** An energy assessment professional such as a Certified Energy Advisor should conduct an energy assessment of the house prior to weatherization work. The assessment should include the building enclosure— including insulation, windows, and doors— as well as the heating, cooling, ventilation, and hot water systems. It should include a whole-building airtightness test to measure the airtightness and help identify air leakage paths. Finally, the assessor should model the energy consumption of the house and generate performance metrics, potentially including an EnerGuide rating.

2. **Implement Weatherization Measures —** Based on the assessment of the house, high priority weatherization (energy efficiency) measures such as air sealing and insulation installation should be selected and implemented.

3. **Assess the House After Weatherization —** An energy assessment professional should conduct a follow-up assessment of the house. This assessment should confirm implementation of the selected energy efficiency measures. The assessments prior to and after weatherization can then be used to apply for relevant rebates.

An EnerGuide Home Evaluation provides a homeowner and contractors with detailed information on a house and also produces an EnerGuide rating, a standard measure of the home's energy performance that enables comparison to other houses. The rating is based on house and equipment energy efficiency, house location, and house size. EnerGuide ratings and airtightness levels are presented in the following table for various house types based primarily on age of construction. Note that the EnerGuide rating system is being completely revamped with the new version expected to be rolled out in 2015 so the table below is subject to change. Additional information on the EnerGuide rating system is available online (oee.nrcan.gc.ca/).

Type of House	Typical EnerGuide Score (0 to 100, higher is better)	Typical Airtightness (ACH50, lower is better)
Zero Energy Home	> 90	0.5
Energy Efficient Home	80 to 84	1.5
New Home	72 to 78	3 to 5
Built 1980 to 2010	66 to 72	5 to 10
Built 1960 to 1979	55 to 66	7 to 10
Built Before 1960	< 55	10 to 20

3: Air Sealing and Insulation Retrofit Procedures

This section provides step-by-step energy efficiency measure procedures for air sealing and insulation work. Where the work is more complex and beyond the scope of this guide (such as full house exterior wall insulating), less detailed conceptual-level procedures are provided. For these larger-scale measures, typically a building enclosure design will need to be performed by a home designer, architect, engineer, or contractor.

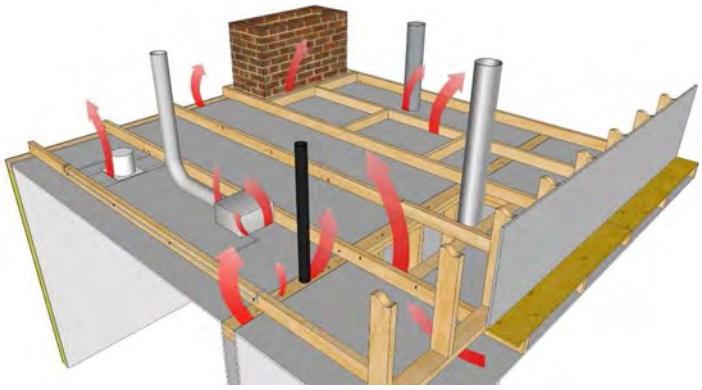
Each procedure contains a list of the necessary materials and tools along with a step by step description of the work. It may also be possible to use alternate materials so long as the intended performance is maintained. Contractors should also refer to the health and safety checklist provided in the appendices.

The information presented in this section is as follows:

- Thorough coverage of accessible attic air sealing measures, typically the easiest and most cost effective to perform as part of weatherization efforts.
- Attic insulation upgrades, and air sealing and insulation options for cathedral ceilings, which are more difficult to seal or insulate without significant interior or exterior construction work.
- Below-grade walls and crawlspaces are discussed in detail, as they are accessible and relatively easy to air seal and insulate.
- Exposed floor solutions are covered.
- Above-grade wall air sealing and insulation procedures are only briefly discussed, as weatherization projects do not typically include this intensive and disruptive work. Additional references and recommended solutions are provided to assist with more disruptive-type projects.

For each of the procedures, it is important that air sealing work always be performed prior to insulating to prevent condensation and moisture related-problems caused by the added or upgraded insulation.

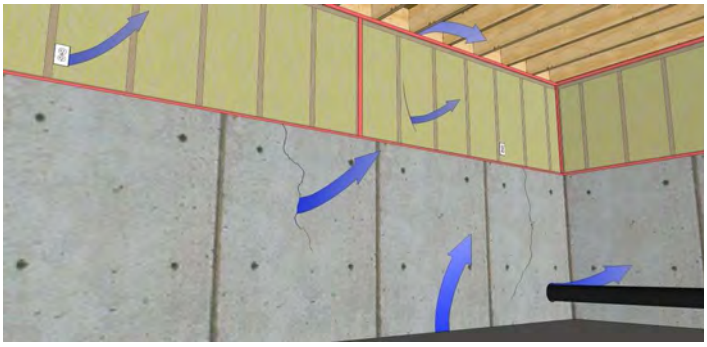
Where more extensive work is planned that may require a building permit such as window or cladding replacement or wall and roof upgrades, homeowners should consult design professionals.



Attic air sealing locations.

Cathedral ceiling air sealing locations.

Above-grade wall air sealing locations.



Below-grade wall air sealing locations.

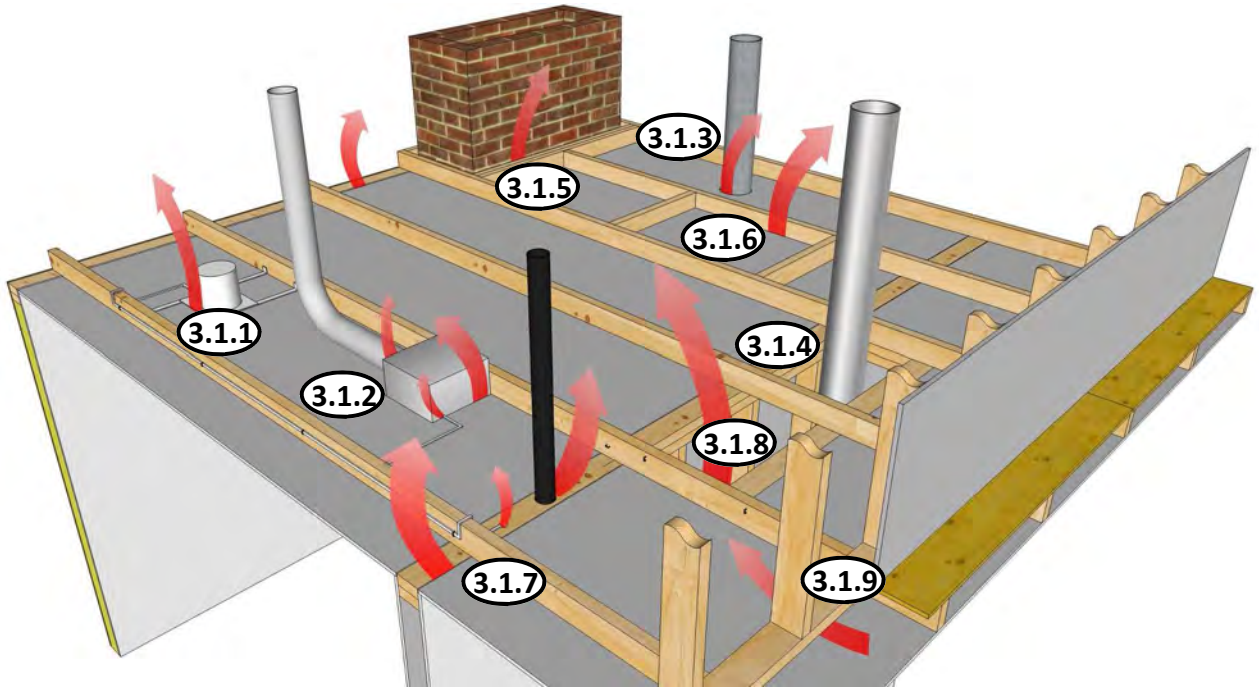
3.1: Attics and Roofs

Air Sealing and Insulation Measures for Accessible Attic Ceiling Spaces

All attic/ceiling energy efficiency measures begin with some ceiling plane air sealing work followed by insulation top -ups or replacement. With proper preparation, air sealing sprayfoam insulation may be used for both purposes. To ensure adequate adhesion when using sealants or sprayfoam for air sealing, clean all areas requiring adhesion. Guidance is provided here to first seal all common ceiling penetrations and interfaces and then to upgrade insulation levels. Additional procedures and a good companion document for the work covered here is the *Guide to Attic Air Sealing* by the Building Science Corporation.

Note that storage in the attic is discouraged because of the risk of compressing the insulation and reducing the insulation R-Value. If storage is planned, a platform should be constructed above the insulation to hold storage items without compressing the insulation.

3.1.1 Recessed Pot/Can Lights
3.1.2 Bathroom Fan and Duct
3.1.3 Kitchen Range, Dryer, or Other Exhaust Duct
3.1.4 Fireplace or Other Combustion Appliance Vent
3.1.5 Masonry Chimney
3.1.6 Attic Hatch
3.1.7 Wall Top Plate and Plumbing/ Electrical Penetrations
3.1.8 Large Openings, Shafts, or Drop Ceilings
3.1.9 Attic Knee Walls



BEFORE YOU START - Do Not Proceed If:

- **The attic has active knob-and-tube wiring.**
- **The attic has vermiculite insulation.**
- **Bathroom or other exhaust fans are vented into the attic.**
- **The house has a leaking roof.**
- **The house has an unvented fireplace.**
- **The house has significant moisture or mould issues.**

IMPORTANT NOTE:

There are some important openings in the attic that should not be sealed. Soffit, ridge, and gable vents are all intentional openings that must be kept open for ventilation.

Only use the joists and rafters to move around on. Do not step on the ceiling.

3.1.1: Attics and Roofs: Recessed Pot/Can Lights

Air Sealing Procedure - Page 1 of 2

Recessed pot/can light housings are one of the most common air leakage points through the ceiling plane into the attic. Air leakage occurs between the housing and the drywall (and poly if present) and through the fixture's housing holes and its electrical connections. Light housings come either rated for insulation contact (IC-rated) or not, and either airtight (AT) or not. Most new homes will utilize AT/IC-rated fixtures, although fixtures in most older homes are non-airtight and non-IC-rated housings. IC-rated fixtures allow for direct contact with insulation (up to 8" deep) whereas non-IC-rated fixtures requires nothing to be within 3" of all sides and the top of the housing to allow for heat dissipation.

This procedure is for leaky non-IC-rated pot-lights, common in most older homes. A similar procedure could also be followed for leaky IC-rated lights. If the light housing is airtight and has been properly sealed to the ceiling air-barrier (either the polyethylene, if present, or drywall), this procedure is not required. Proprietary fire-rated airtight housings are also available that may simplify this procedure. The homeowner may alternately consider replacing the light housings with AT/IC-rated fixtures.

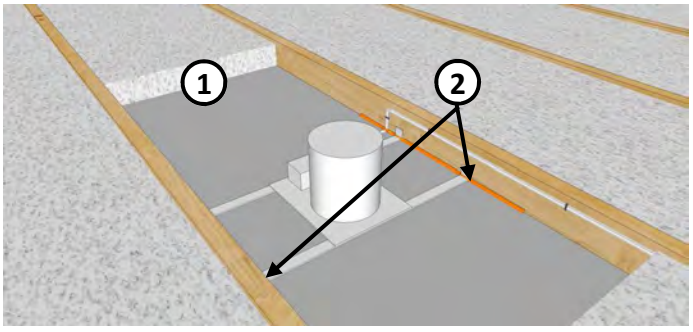
Non-IC-rated air leaky pot-light

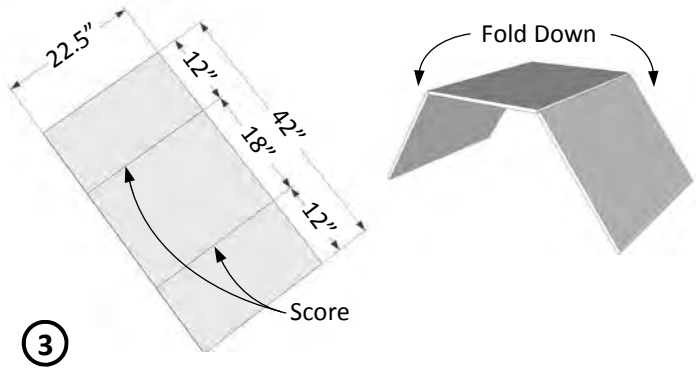
MATERIALS NEEDED

- 5/8" gypsum drywall
- Polyurethane sealant
- Sheathing tape
- Spray polyurethane sealant (spray can or two-part froth pack)

RECOMMENDED TOOLS

- Utility knife
- Caulking gun
- Drywall saw



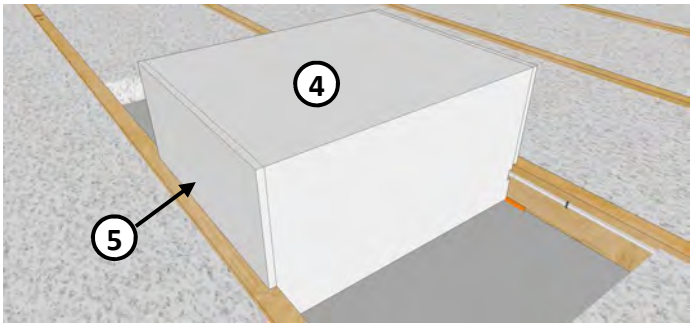


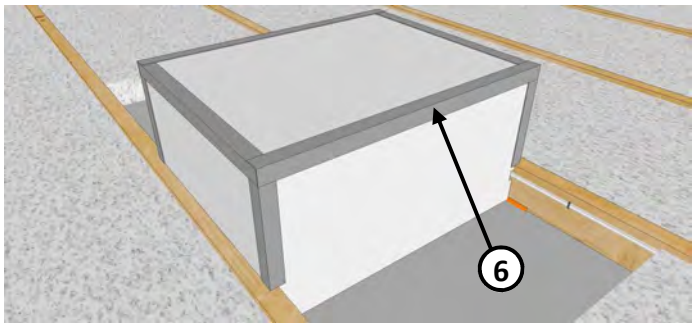
PROCEDURE

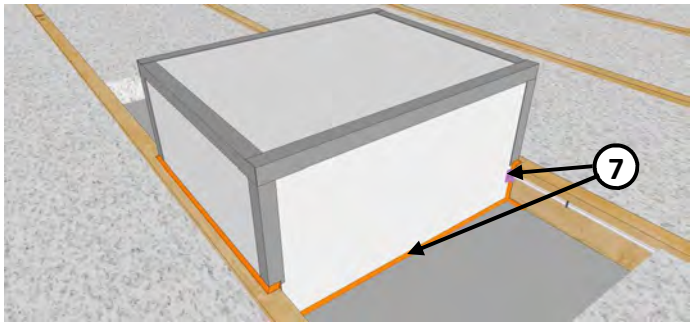
1. Expose the ceiling gypsum board approximately 12" on both sides of the recessed can light.
2. Add sealant at the joist to gypsum board joint, extending past the ends of the gypsum board box to seal the gap between the joist and drywall (or poly if present).
3. Create the gypsum board boxes outside the attic:
   - I. Precut 5/8" piece of drywall 42" long by 22 1/2" wide (for 24" ceiling joist spacing) or 14 1/2" wide (for 16" ceiling joist spacing).
   - II. Score back side of gypsum board at 12" from ends.
   - III. Break along scored lines and form an inverted U-shape of gypsum to keep insulation 3" from light fixture housing.
   - IV. Cut two gypsum board end closures, 18" long by 8.5" wide (for 2x4 framing).

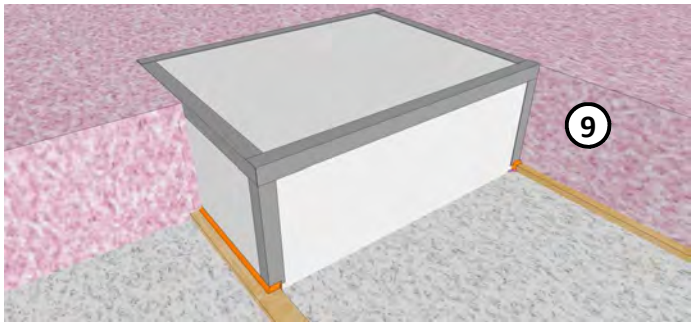
3.1.1: Attics and Roofs: Recessed Pot/Can Lights

Air Sealing Procedure - Page 2 of 2









PROCEDURE (Continued)

4. Install gypsum board box in attic between the ceiling joists. Notch the drywall box to fit around wiring and other framing etc.
5. Install gypsum board end closures.
6. Tape seams of the gypsum board box.
7. Seal the box to the ceiling (or poly if present) with sealant and fill notches and gaps with sprayfoam sealant.
8. Inspect the box to ensure all gaps and joints are taped/sealed and airtight.
9. Replace existing insulation around the sides. Insulation is not to be placed on top of the box unless the light is IC-rated.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure clearance between the pot-light housing and the drywall box is a minimum of 3".**
- **Ensure all electrical wires are properly attached to the fixture and secured to the framing, and that the penetrations through the box are sealed.**
- **Modify dimensions to accommodate on-site conditions while maintaining necessary clearances.**

DO NOT

- **Cover the top of the box with insulation. The box is left uncovered so that heat can dissipate from the pot-light fixture. Only IC-rated fixtures can be insulated over top.**

HOMEOWNER TIPS

- Consider replacing existing light bulbs with compact fluorescents or LED lamps to reduce heat build-up and save electrical energy.
- As an alternate to this procedure, consider installing airtight IC-rated pot-lights. These can be insulated on top and will save energy and reduce potential for condensation.

3.1.2: Attics and Roofs: Bathroom Fan and Duct

Air Sealing Procedure - Page 1 of 2

Bathroom exhaust fan housings and duct connections are common air leakage points through the ceiling plane into the attic. Air leakage occurs between the housing and the drywall (and polyethylene air-barrier if present) and through the fixture housing holes and electrical connections. Air leakage can also occur at the duct connection into the housing. It is important to seal this connection to stop warm moist air from venting into the attic.

This procedure is for exhaust fans mounted to the side of a joist. If the exhaust fan is mounted in the middle of the joist space, the procedure can be adjusted accordingly.

Note: See exhaust duct air sealing and insulation procedure 3.1.3 if exhaust ducts are not insulated or are discharging in the attic.

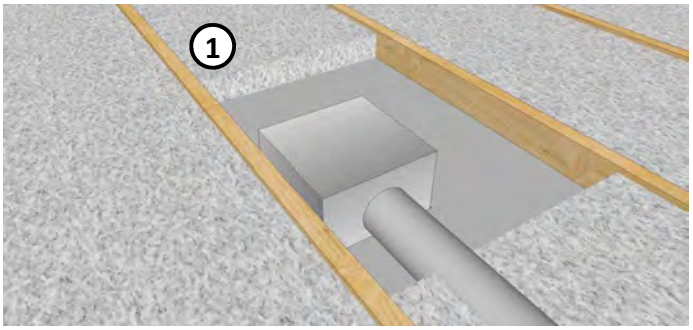
Bathroom exhaust fan venting into the attic. Conditions such as this should be remedied prior to or as part of air sealing and insulation work.

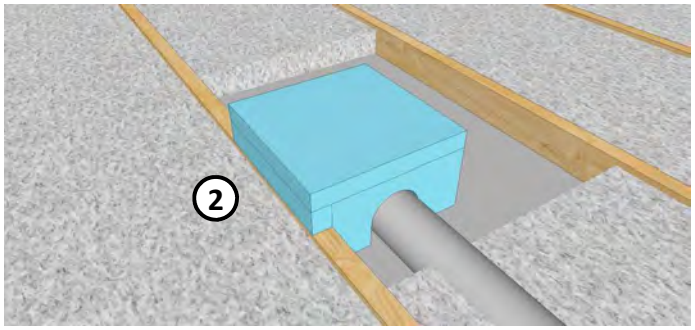
MATERIALS NEEDED

- 1.5” XPS foam insulation board (Alternately, gypsum drywall can be used)
- Polyurethane sealant
- Sheathing or foil tape
- Spray polyurethane sealant (spray can or two-part froth pack)

RECOMMENDED TOOLS

- Utility knife
- Caulking gun





PROCEDURE

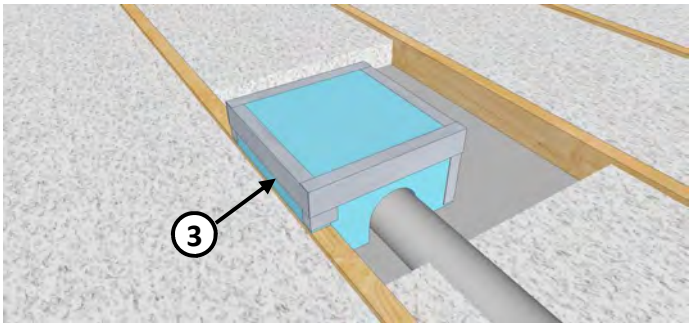
1. Expose the ceiling gypsum board approximately 12” on both sides of the fan housing.

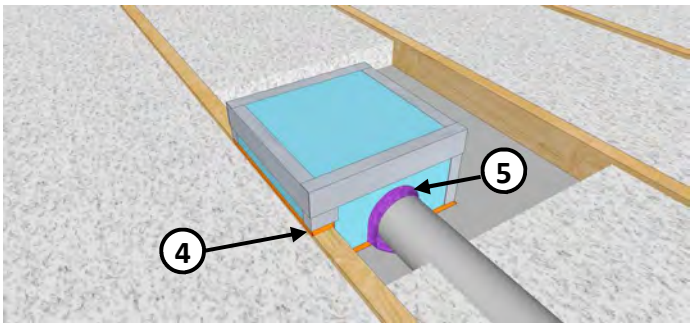
   Note: If the bathroom fan is mounted to the side of a ceiling joist (as shown) it may be beneficial to temporarily move the housing out of the way in order to seal the joist to gypsum board joint. (See Recessed Pot/Can Lights).

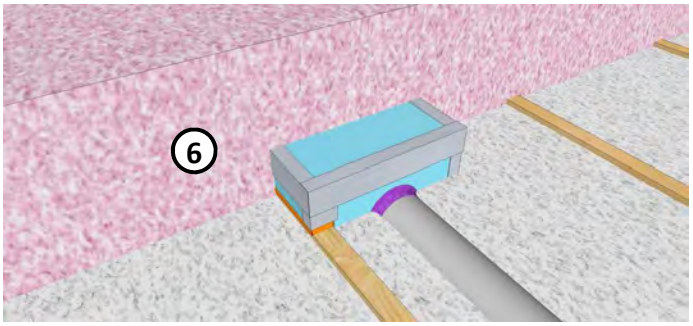
2. Create a five-sided box with extruded polystyrene to fit over the fan housing leaving a minimum 1/2” clearance around the housing. Scribe and cut access in the box for the exhaust duct outlet.

3.1.2: Attics and Roofs: Bathroom Fan and Duct

Air Sealing Procedure - Page 2 of 2







PROCEDURE (Continued)

3. Seal all edges of the insulation enclosure with sheathing tape or foil tape.
4. Seal the enclosure to the ceiling gypsum board and joists with sealant.
5. Seal around the duct penetration and other notches with sprayfoam.
6. Replace existing insulation and, if desired, install additional insulation.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Always make sure power is shut off at the breaker before working with wiring.**
- **Ensure the exhaust duct is sealed, insulated, and is not collapsed throughout the whole attic space.**
- **Ensure all electrical wires are properly attached to the fan and secured to the framing. If they are not, consult an electrician.**

DO NOT

- **Attempt to directly seal or alter the fan housing.**
- **Make electrical repairs without consulting an electrician.**

HOMEOWNER TIPS

- Keep the exhaust fan clean to ensure adequate ventilation. Use a vacuum or duster to regularly clean the fan and inside the housing.
- Consider replacing an old and noisy bathroom fan with a new quieter and more energy efficient model at the time of this work. Look for a fan that is Energy Star® qualified with a noise level of less than one sone.

3.1.3: Attics and Roofs: Kitchen Range, Dryer, or Other Exhaust Duct

Air Sealing Procedure - Page 1 of 2

Kitchen range, dryer, bathroom fan, or other exhaust ducts that don't vent combustion air can be air sealed with relative ease. Besides making the ceiling penetration airtight, it is also important to air seal the duct itself to prevent warm moist air from venting into the attic. All mechanical air ducts (both supply and exhaust) running through the attic should also be insulated in order to avoid condensation within the duct and reduce heat gain into the attic, which can be an issue in colder regions where it may contribute to ice-damming. Flex duct that is not insulated should be replaced with insulated ducts, and rigid ducts should be covered with an insulation sleeve.

This air sealing procedure is for a range or other exhaust duct that penetrates the ceiling without a framed shaft.

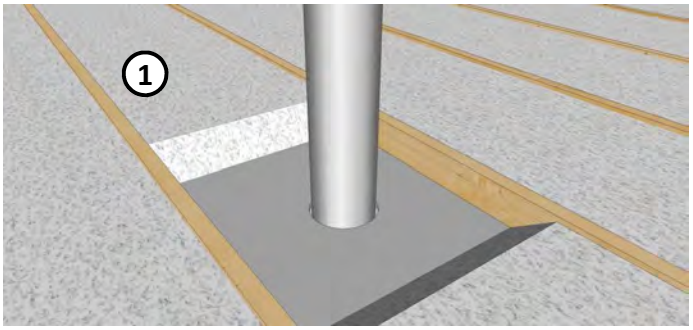
Uninsulated and un-sealed exhaust duct running through an attic, leaking air and heat to the space.

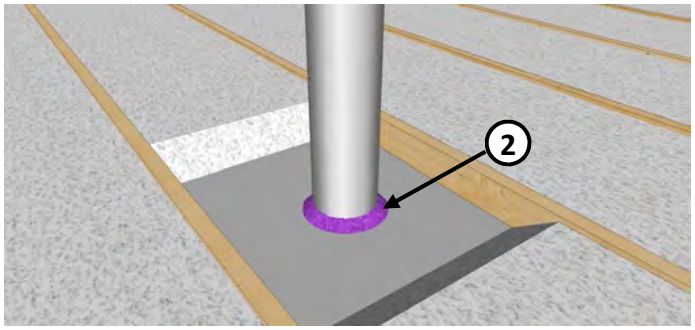
MATERIALS NEEDED

- Spray polyurethane sealant (two-part froth pack) or polyurethane sealant
- Insulated duct sleeve (2" glass fibre insulation) with foil or plastic cover, or insulated flex duct sleeve

RECOMMENDED TOOLS

- Utility knife
- Caulking gun



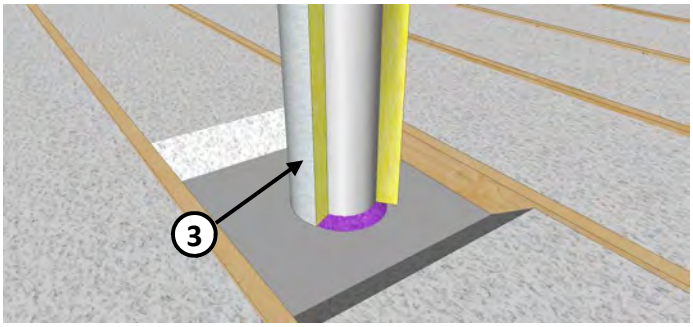


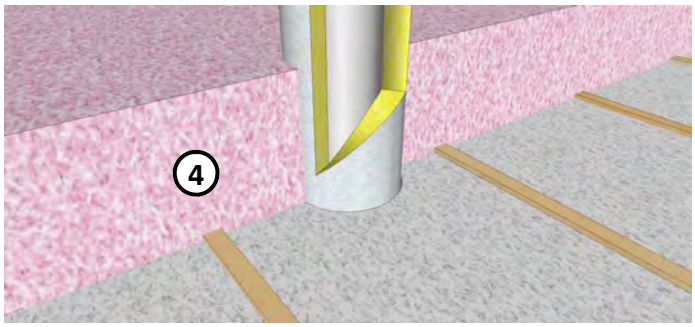
PROCEDURE

1. Expose ceiling gypsum board approximately 12" on both sides of the dryer duct.
2. Install sprayfoam or sealant around the duct penetration at the ceiling gypsum board.

3.1.3: Attics and Roofs: Kitchen Range, Dryer, or Other Exhaust Duct

Air Sealing Procedure - Page 2 of 2





Insulated and sealed exhaust duct in an attic.

PROCEDURE (Continued)

3. Install insulation sleeve along the whole length of the duct inside the attic (if not already present) and seal the sleeve joints with approved tape.

4. Replace existing insulation and, if desired, install additional insulation.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure the outside of the exhaust duct is sealed, insulated, and is not collapsed throughout the whole attic space.**
- **Ensure the sprayfoam or sealant at the ceiling penetration is even and continuous to create an airtight seal.**
- **Ensure connection of duct to the exhaust boot or vent hood is properly sealed.**

DO NOT

- **Use this air sealing procedure for vents that exhaust air from combustion appliances, or if you are unsure.**

HOMEOWNER TIP

- Kitchen range and bathroom fans are used to remove moist air from the house. Ensure they are in use when cooking or using the shower.

3.1.4: Attics and Roofs: Fireplace or Other Combustion Appliance Vent

Air Sealing Procedure - Page 1 of 2

Gas fireplace or other hot exhaust metal chimney/vent penetrations are a source of air leakage into attics. It is important to use only fire-proof sealing materials at locations near or in contact with the chimney. Fire-resistant silicone sealant is required where high temperatures are present. Do not place insulation or other building materials in contact with the metal chimney unless they are approved for that purpose. Do not alter the configuration of the metal chimney or other related components without talking to a professional heating, ventilation and air-conditioning (HVAC) contractor.

This air sealing procedure is for metal exhaust vents that extend through the ceiling into the attic space. Side-vented appliances are not addressed in this guide as these penetrate through above-grade walls.

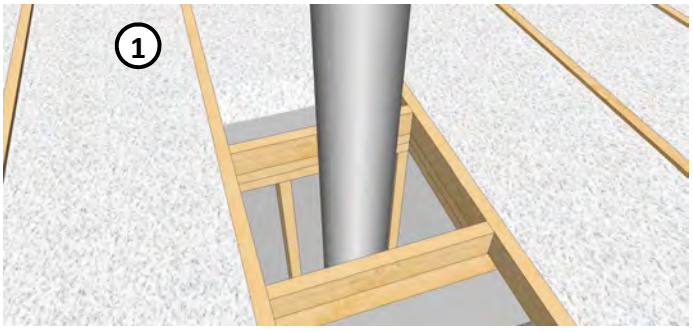
Metal chimney with sheet metal seal over ceiling joists.

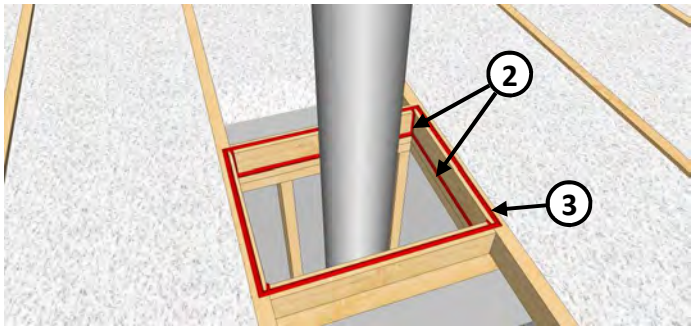
MATERIALS NEEDED

- Fire-resistant silicone sealant
- Sheet metal
- Circular metal duct (approx. 6” larger diameter than vent to be sealed)

RECOMMENDED TOOLS

- Caulking gun
- Sheet metal shears



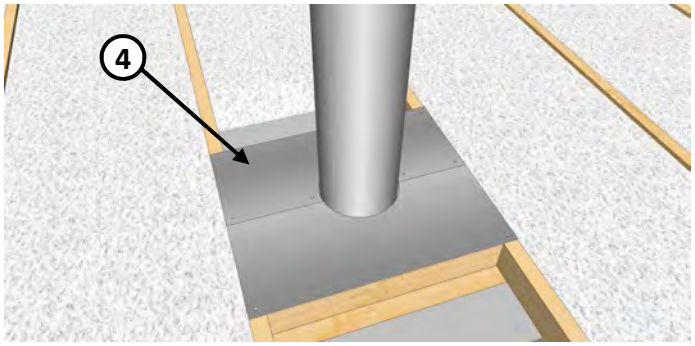


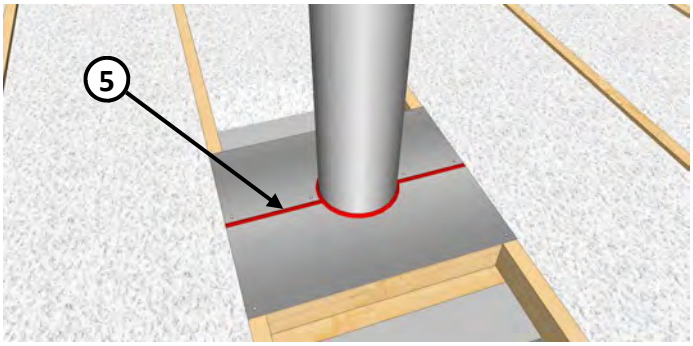
PROCEDURE

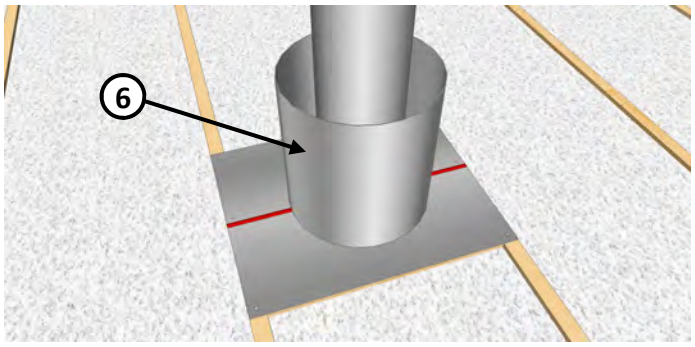
1. Expose ceiling gypsum board and framing on each side of the chimney chase.
2. Install sealant around joists and blocking to seal the chase wall framing to the joist framing and at the corners of the chase.
3. Install sealant along the top side of the joists and blocking in order to adhere and seal the sheet metal closure.

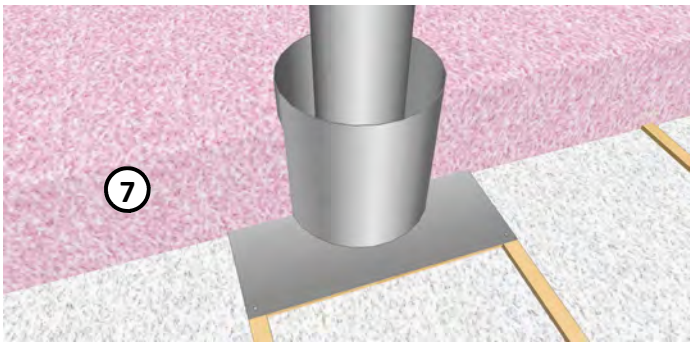
3.1.4: Attics and Roofs: Fireplace or Other Combustion Appliance Vent

Air Sealing Procedure - Page 2 of 2









PROCEDURE (Continued)

4. Cut and install the sheet metal closure to fit over the chimney opening tight to the metal chimney, with overlap at each joint. Apply sealant where the metal closures lap and secure them together as well as to the wood framing with screws.
5. Seal the metal closure to the chimney and at each joint with silicone sealant.
6. Install an insulation guard around chimney using an oversized metal duct. Cut and fold tabs to keep the insulation guard spaced 3" from the chimney on the top and bottom. Size it so that the top edge is above the insulation level, including any additional insulation that may be added.
7. Replace existing insulation and, if desired, install additional insulation around the chimney insulation guard.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure clearance between the chimney and all combustible building materials is 3", unless otherwise instructed by an approved HVAC contractor.**
- **Use only fireproof sealing material in contact with the chimney.**

DO NOT

- **Insulate a hot exhaust flue. Any work on a chimney should only be done with direction from an approved HVAC contractor.**
- **Cover the insulation guard with insulation or place attic insulation in contact with the exhaust vent.**

HOMEOWNER TIPS

- If storage is planned in the attic, ensure that no items come in contact with the vent.

3.1.5: Attics and Roofs: Masonry Chimney

Air Sealing Procedure - Page 1 of 2

Fireplace masonry chimney penetrations are a major source of air leakage into attics. It is important to use only fire proof and non-combustible sealing materials within 3" of the chimney. Fire-resistant silicone sealant is required where high temperatures are present.

This air sealing procedure is for masonry chimneys that extend through the ceiling into the attic space.

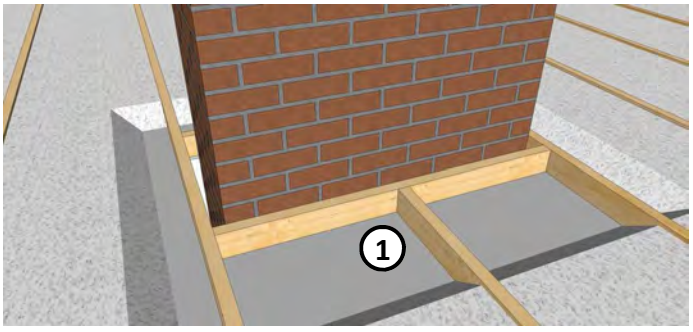
Masonry chimney.

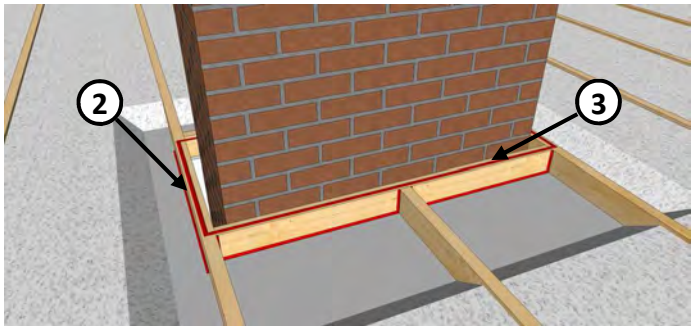
MATERIALS NEEDED

- Fire-resistant silicone sealant
- Sheet metal
- Gypsum board and wood framing
- Screws

RECOMMENDED TOOLS

- Caulking gun
- Sheet metal shears
- Drywall saw
- Drill or screw driver



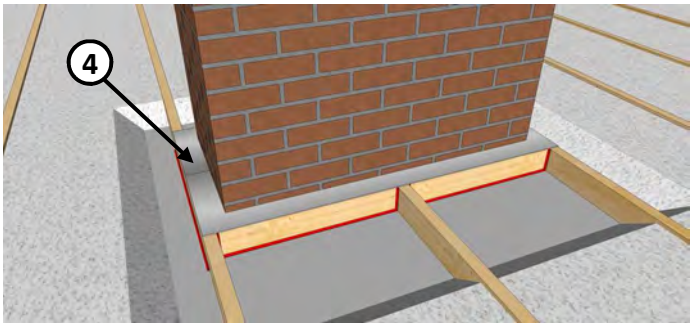


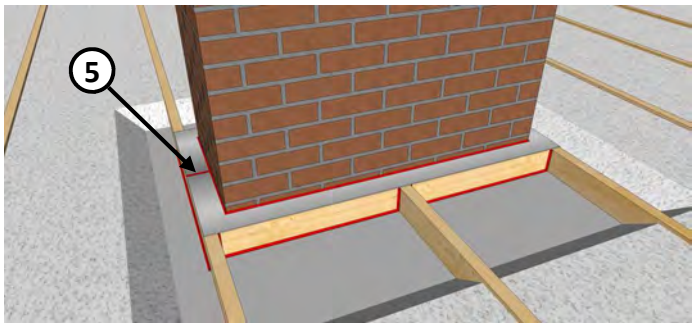
PROCEDURE

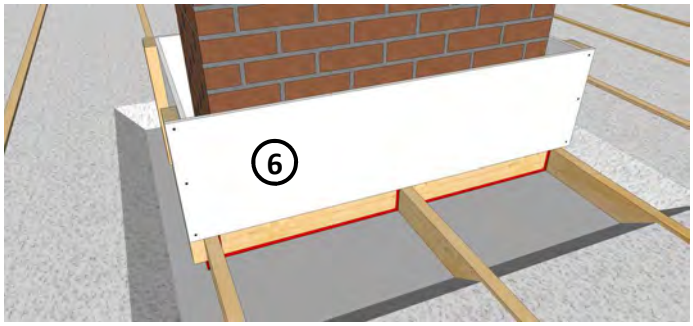
1. Expose ceiling gypsum board approximately 12" on all sides of the chimney.
2. Install silicone sealant around joists and blocking to seal the ceiling gypsum board to the framing.
3. Install silicone sealant along the top side of the joists and blocking in order to adhere and seal the sheet metal closure.

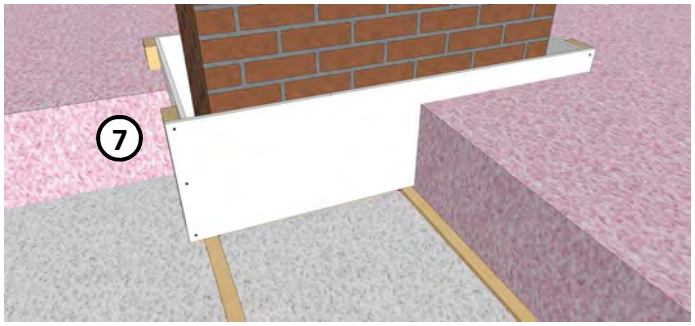
3.1.5: Attics and Roofs: Masonry Chimney

Air Sealing Procedure - Page 2 of 2









PROCEDURE (Continued)

4. Cut and install sheet metal closure to fit over the chimney opening tight to the masonry chimney, with overlap at each joint.

5. Seal metal closure to the chimney and at each joint with silicone sealant. Sealant should be applied between the metal closures prior to installation of the second closure piece to ensure continuity of the air-barrier.

6. Install a framed gypsum board insulation guard around joist framing. Allow 3” clear between the insulation guard and the masonry chimney. Size it so that the top edge is above the insulation, including any additional insulation that may be added.

7. Replace existing insulation and install additional insulation around chimney insulation guard.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure clearance between the chimney and all combustible building materials is 3”.**
- **Use fireproof sealing material when needed, such as when it is in contact with the chimney.**

DO NOT

- **Insulate the chimney. Any work on a chimney should only be done by an approved/certified HVAC contractor.**

HOMEOWNER TIPS

- If storage is planned in the attic, ensure no items come in contact with the chimney.

3.1.6: Attics and Roofs: Attic Hatch

Air Sealing Procedure - Page 1 of 2

Attic hatches can often be overlooked for air sealing work. They present a unique challenge because the hatch has to be airtight while still allowing access to the attic. Air leakage occurs through the joint between the hatch and the ceiling. The hatch is most often a piece of gypsum board cut to size resting on a ledge made from wood trim or the edge of the ceiling drywall inside the opening.

This air sealing procedure is for hatches that rest on the ceiling gypsum or wood-trim ledge. In order to achieve an effective air seal, it is important to ensure that the existing hatch is sized properly so that it has enough contact with the opening ledge.

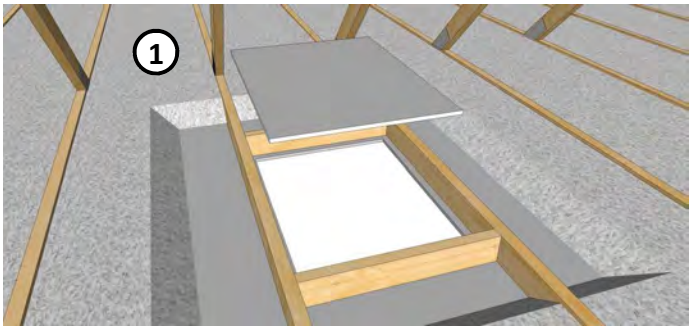
An attic access hatch made from plywood resting on a wood-trimmed opening.

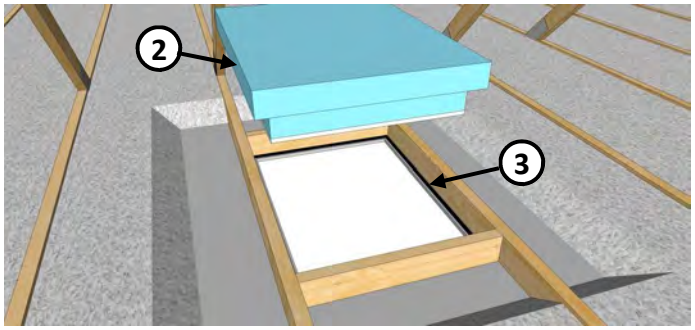
MATERIALS NEEDED

- Extruded polystyrene
- Self-adhered weather stripping
- Plywood or OSB and framing lumber
- Screws
- Adhesive

RECOMMENDED TOOLS

- Utility knife
- Wood saw
- Measuring tape
- Hammer and nails or drill and screws



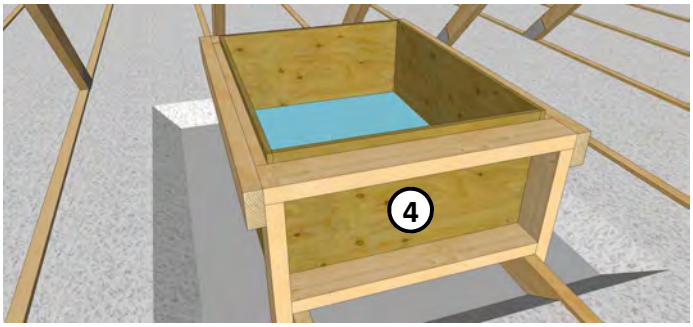


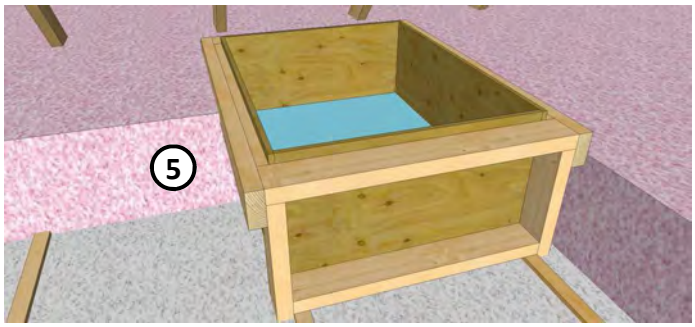
PROCEDURE

1. Expose ceiling gypsum board approximately 12” on all sides of the attic access hatch.
2. Cut two pieces (or more) of rigid foam to adhere to the access cover. Size the rigid foam so there is a layer adhered to the access hatch that fits within the opening joist space and there is a layer of foam that fits overtop of the ceiling joists on all sides.
3. Adhere weather stripping to the ledge of the access opening on all sides.

3.1.6: Attics and Roofs: Attic Hatch

Air Sealing Procedure - Page 2 of 2





PROCEDURE (Continued)

4. Install plywood or OSB box around the opening. Size the box so that the top edge is above the additional insulation level. Notch it to fit around joists and other framing and use additional framing to reinforce the box.

5. Replace existing insulation and, if desired, install additional insulation around the box.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure the attic hatch is fully engaging the edge gasket. If needed, install a latch or hooks on the edge of the hatch to hold it firmly down**
- **Build the insulation guard so that access to the hatch is not impeded and it will remain intact with continued passage into the attic.**

DO NOT

- **Size the rigid insulation on the attic hatch to fit too closely against the surrounding joist framing.**
- **Place heavy items on the hatch to weigh it down onto the gasket.**

HOMEOWNER TIP

- Be careful when entering the attic. Use a flashlight/ headlamp or ensure there is enough light inside the attic to safely enter. Watch for obstructions such as overhead truss members or nails.
- Ensure the hatch is properly seated on the gasket when closing the hatch.

OTHER NOTES

- If the attic hatch has a built-in attic access ladder on the top side, additional insulation cannot be easily placed on the hatch (step 2). The hatch can remain uninsulated, but attention must be paid to the perimeter seals. Ensure the attic hatch sits tightly against the opening seals and keeps an airtight seal when not in use.

3.1.7: Attics and Roofs: Wall Top Plate and Top Plate Penetrations

Air Sealing Procedure - Page 1 of 2

Top plates of interior (and exterior) walls are a common point of air leakage. If the home has a polyethylene sheet at the ceiling level that is not detailed as an air-barrier, it will allow air leakage at every location where the ceiling drywall terminates. In addition, even with a poly air-barrier at the ceiling, service penetrations (e.g. electrical, plumbing) in the top plates of interior walls are often overlooked.

This air sealing procedure is for top plates without a properly detailed air-barrier at the ceiling plane. This procedure is not required if a polyethylene sheet is in place and runs between the two top plates of the wall, though it may still apply to service penetrations.

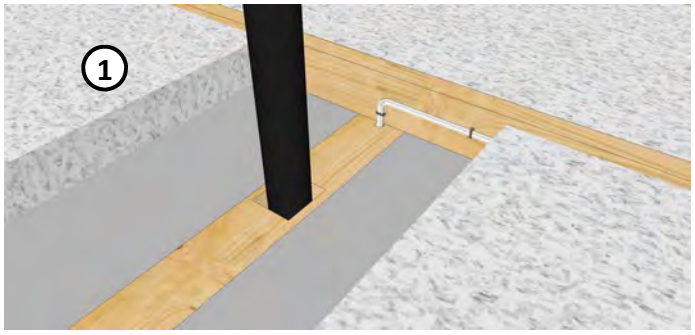
Exposed interior top-plate as viewed from the attic.

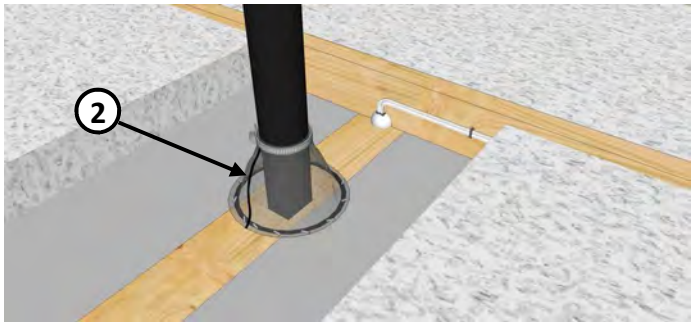
MATERIALS NEEDED

- Spray polyurethane sealant (spray can or two-part froth pack)
- 10 mil polyethylene sheet or flexible gasket
- Acoustical sealant

RECOMMENDED TOOLS

- Utility knife
- Caulking gun
- Staple gun





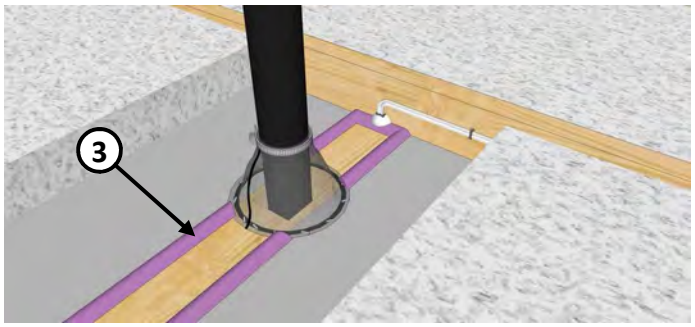
PROCEDURE

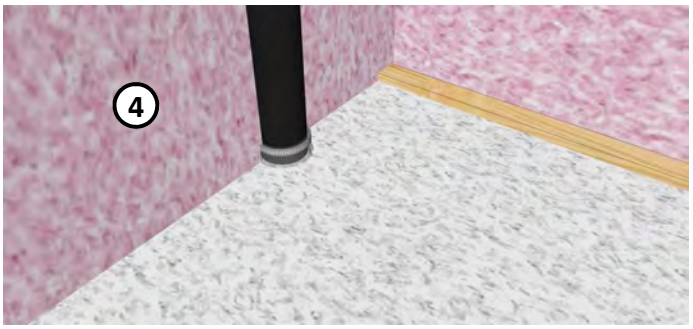
1. Expose ceiling gypsum board approximately 12” on both sides of the top plate. Clean area with brush or vacuum to ensure adequate sealant adhesion.
2. Install flexible gasket or polyethylene sheet around larger penetrations such as plumbing stacks. Seal it with acoustical sealant, staple it to the ceiling, and clamp it to the vent stack with a pipe clamp. This flexible air seal is to accommodate thermal movement of the plastic vent pipe.

   Install sealant around smaller penetrations such as electrical wires.

3.1.7: Attics and Roofs: Wall Top Plate and Top Plate Penetrations

Air Sealing Procedure - Page 2 of 2





Sprayfoam installed over top plate joint.

Top plate penetrations sealed with sprayfoam.

PROCEDURE (Continued)

3. Install sprayfoam over the top plate joints and penetrations where needed to seal the ceiling to the top plate.

4. Replace existing insulation and, if desired, install additional insulation.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Use a flexible air seal like a polyethylene sheet or rubber gasket where movement is expected.**
- **Seal all penetrations with sprayfoam where no movement is expected. Ensure all surfaces are clean to achieve sealant adhesion.**
- **Use a fire-rated silicone sealant if sealing electrical boxes in the attic space.**

DO NOT

- **Use sprayfoam directly in contact with electrical fixtures or uninsulated wires.**

HOMEOWNER TIP

- If performing renovations where new wiring or plumbing stacks are added through the ceiling, ensure a similar procedure is followed for air sealing.

3.1.8: Attics and Roofs: Large Openings, Shafts, or Drop Ceilings

Air Sealing Procedure - Page 1 of 2

Large openings in the ceiling plane, such as for service shafts or drop ceilings, can be a major cause of air leakage in attics.

This air sealing procedure is for openings in the ceiling plane running perpendicular to the ceiling joists. Where the opening runs parallel, a similar procedure can be used with some adjustments.

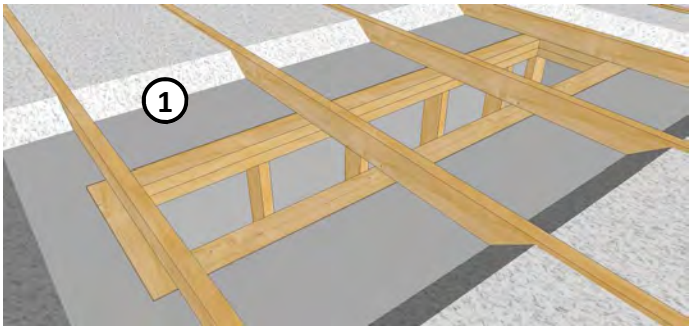
A relatively large hole in the ceiling plane through which two ducts are installed.

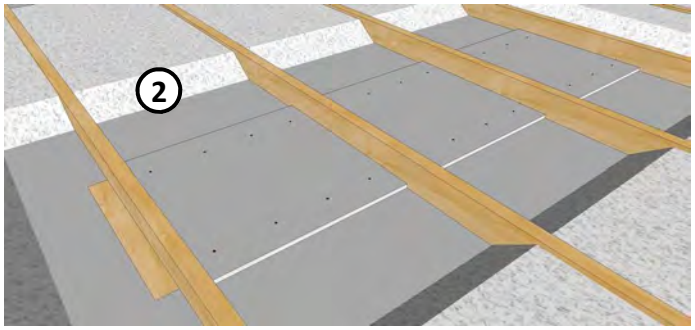
MATERIALS NEEDED

- Spray polyurethane sealant (spray can or two-part froth pack)
- Wood, OSB or gypsum board
- Wood or drywall screws

RECOMMENDED TOOLS

- Wood or drywall saw
- Vacuum or small broom



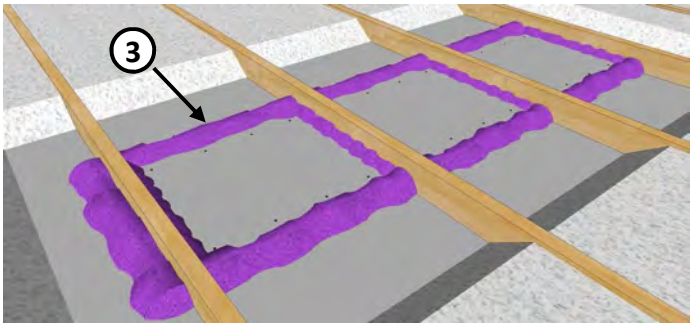


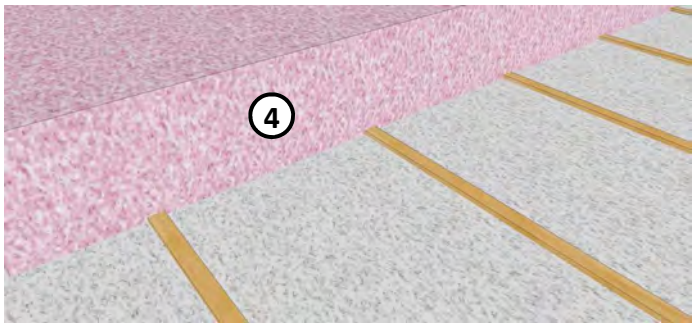
PROCEDURE

1. Expose ceiling gypsum board approximately 12” on all sides of the ceiling opening. Clean area to ensure adequate sealant adhesion.
2. Install wood or gypsum board cover between joists. Screw it down to the top plate or adhere with sealant.

3.1.8: Attics and Roofs: Large Openings, Shafts, or Drop Ceilings

Air Sealing Procedure - Page 2 of 2





Sprayfoam around the edges of a cover, sealing it to surrounding joists and ceiling gypsum board.

PROCEDURE (Continued)

3. Install sprayfoam over the edges of the cover to seal it to surrounding joists and ceiling gypsum board. Seal along the ends of the drop ceiling on either side of the ceiling joist with sprayfoam.
4. Replace existing insulation and, if desired, install additional insulation.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Be careful around the openings of shafts and drop ceilings. Only use the joists and rafters to move around on. Do not step on the ceiling.**
- **Thoroughly seal around the opening cover and all adjacent framing.**

DO NOT

- **Use thin or flimsy material like cardboard or plastic for the cover . The material must be able to support additional insulation and remain airtight.**

HOMEOWNER TIP

- Do not store items in the attic on top of the finished cover. Use an attic stand off platform to keep the storage items above the level of the new insulation.

3.1.9: Attics and Roofs: Attic Knee Walls

Air Sealing and Insulating Procedure - Page 1 of 2

Knee walls that divide interior space from attic space should be treated like exterior walls in how they are air sealed (and insulated). Knee walls are often built directly over upper floor framing, allowing attic/floor joists to run continuously underneath. This allows air leakage under the knee wall bottom plate in every joist space.

This air sealing and insulation procedure is for a knee wall that runs perpendicular to the floor joist framing, and an attic space with or without existing floor boards.

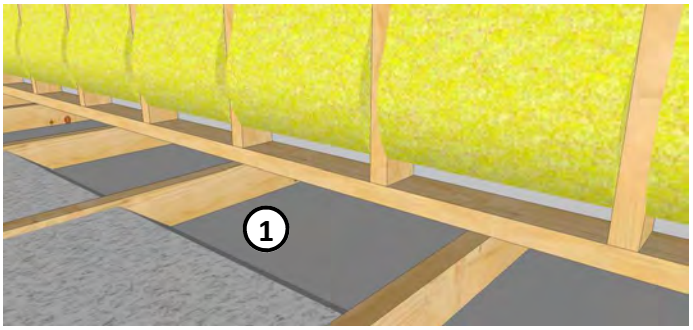
Knee wall framing.

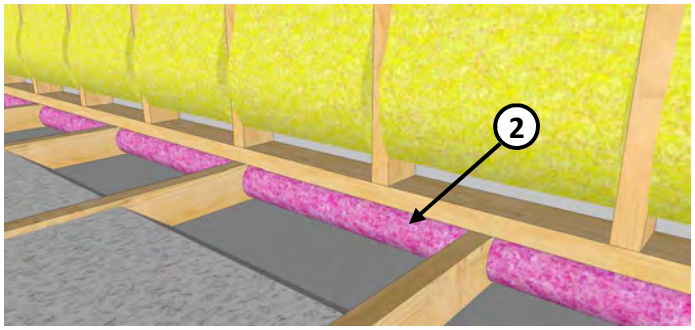
MATERIALS NEEDED

- Spray polyurethane sealant (two-part froth pack)
- Fibreglass or mineral wool batt insulation (or XPS foam board)
- Rigid fibreglass or mineral wool insulation boards

RECOMMENDED TOOLS

- Utility knife





PROCEDURE

1. Remove knee wall insulation (if present) and expose ceiling gypsum board and framing at the knee wall interface.

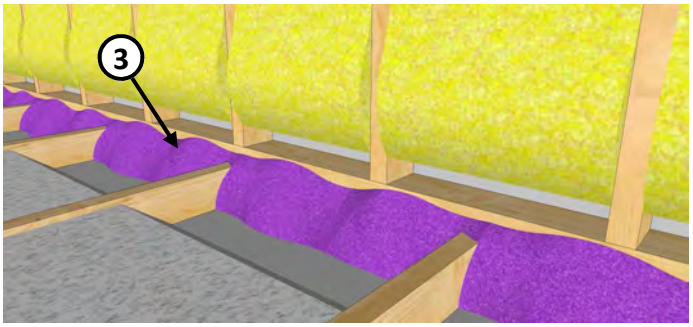
   Note: Cut back any existing attic floor-boards as necessary to expose under the bottom plate of the knee wall framing.

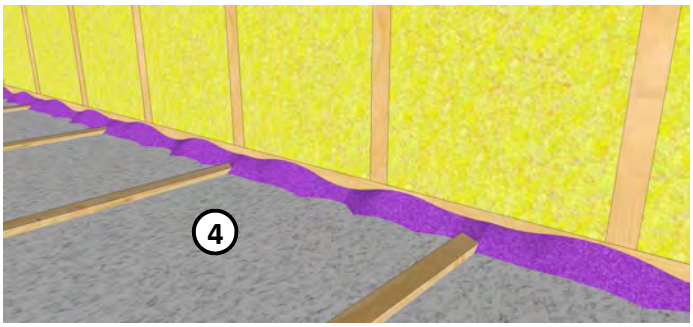
2. Roll batt insulation into the joist space under the knee wall as backer for sprayfoam.

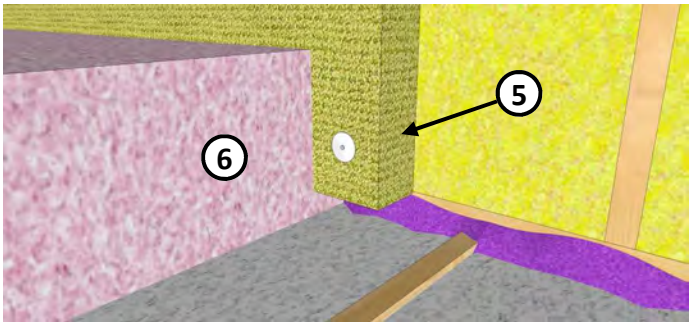
   Alternatively, install rigid foam board under the knee wall in each joist space as a backer for the sprayfoam.

3.1.9: Attics and Roofs: Attic Knee Walls

Air Sealing and Insulating Procedure - Page 2 of 2







PROCEDURE (Continued)

3. Install sprayfoam over the ceiling joist to knee wall interface to create an air seal.

   Note: Wall penetrations should be sealed to the gypsum board making this the airtight element. See wall air sealing measures in Section 3.5.

4. Replace the attic insulation and re-fluff the knee wall insulation where present or install new batt insulation.

5. Install additional rigid fibreglass or mineral wool insulation boards at the knee wall. Additional rigid wall insulation will contain the batt insulation and increase the R-value of the wall.

6. If desired, install additional attic ceiling insulation.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Remove any floor boards or subfloor in the attic space (if present) to expose the joists running under the knee wall.**
- **Seal under the bottom plate of the knee wall along the whole length at each floor joist.**

DO NOT

- **Use rigid foam as additional insulation, as rigid mineral wool or fibreglass boards are preferred in this application (cold side of the knee wall insulation) to avoid a potential vapour diffusion issue.**

HOMEOWNER TIP

- If there is an access door to the attic space in the wall of the upper floor, make sure it is sealed with exterior door weather-stripping.

3.1.10: Attics and Roofs: Adding Insulation

Adding Insulation - Page 1 of 3

Adding insulation to the attic space is often a very effective energy-saving measure. Insulation should only be added in conjunction with air sealing procedures as described in the previous sections. It is important to choose the most appropriate insulation type for the attic, to insulate properly to achieve adequate effective R-values, and to ensure adequate attic ventilation is provided.

Blown-in fibreglass attic insulation.

Insulation Type

If the attic is obstructed and an irregular shape, blown in fibreglass or cellulose may be the best option, as the loose material can fill around obstructions and provide a continuous blanket of insulation. Blown-in insulation can also be combined with batt insulation, with the loose fill above the batt insulation. Ensure that no insulation gets blown into the soffit vent area or comes in contact with heat generating fixtures or chimneys. See Section 3.1.1-3.1.9 for air sealing procedures that allow for insulation guards.

If the attic is a simple shape with joists spaced regularly at 16" or 24", fibreglass or mineral wool batt insulation may be a good option as it is can be easy to install. Be sure to install the insulation with a snug fit but without compressing the insulation. In general, be sure to follow the manufacturers' directions when installing all types of insulation to achieve optimal results. Both blown-in and batt insulation can be combined with sprayfoam in the attic space in a flash-and-fill application. See Section 3.1.11 for Flash-and-fill procedures. Additional information about insulation can be found from product manufacturers and in *Insulation: A Guide for Contractors to Share with Homeowners (2012),* part of the U.S. Department of Energy's *Building America Best Practices Series.*

Insulation Thickness

Blown-in or batt fibrous insulation installed on the ceiling of an attic will typically have an installed R-value of between R-3 to R-4 per inch of thickness depending on the type, manufacturer, and density. See product manufacturers' published data for specific product information. To reach the desired R-value (typically in the range of R-40 to R-60), the insulation should be installed to the desired thickness per the table below. Note that the insulation thickness will be reduced at the eaves due to the slope of the roof sheathing and this will reduce the effective R-value of the ceiling plane. This deficiency can typically be made up by adding a few extra inches of insulation in the centre, unless the roof slope is particularly shallow. If desired, guidance on the reduction calculation can be found in the *Guide for Designing Energy Efficient Building Enclosures* published by FP Innovations.

Insulation R-value/inch	Insulation Thickness				
	12 inches	14 inches	16 inches	18 inches	20 inches
3.0	36	42	48	54	60
3.4	41	48	54	61	68
3.8	46	53	61	68	76
4.0	48	56	64	72	80

3.1.10 Attics and Roofs: Adding Insulation

Adding Insulation - Page 2 of 3

Attic Ventilation

Attic spaces in older homes in B.C. will often have been originally designed as a ventilated space. If the attic is not vented and has not been insulated at the roof plane, it is possible that the original attic vents were at some point blocked off incidentally during re-roofing (e.g. cedar shingle/shake to asphalt shingle conversion) or other home renovations. Attic ventilation is an important factor in controlling moisture in the attic, reducing heat build-up in summer, and reducing ice-damming in snowy climates. Poor attic ventilation, coupled with the leakage of indoor air into the attic, causes most attic moisture and mould problems in B.C.

For attic ventilation to be most effective, outdoor air should enter the attic low at the attic perimeter (i.e. at the soffits) and exit high near the attic ridge (i.e. ridge vents or cap vents installed near ridge). The soffit vents can be provided in the form of perforated soffit material, discrete vents in the soffit material, or—if no soffit is present—button vents near the typical soffit location. If there is a gable end wall, vents may also be placed near the bottom of these walls above the insulation level. Soffit vents must connect through to the attic and past the insulation, typically by the use of insulation baffles or guards. Typically these are placed between trusses at every bay or every second bay, depending on the roof configuration and available soffit area for venting.

The area and size of attic vents can be determined by referencing the BC Building Code, which requires that attics are vented with a net free vent area of 1:300 (2012 BCBC). This means that for every 300 square feet of ceiling area, one square foot of vent is required. Ideally this vent area is split evenly between the soffit and ridge, though the code does allow for up to 75%/25% of the vent area to be distributed at either the top or the bottom. While this is allowed by code, it is generally accepted better practice to evenly distribute the vents between the soffit area and ridge. If it is not possible to balance the venting arrangement, then it is best to install more of the vents at the soffit rather than the ridge to reduce negative attic pressures in the attic as a result of wind. While the 1:300 rule is a minimum code requirement, it should also not be exceeded by a large margin. Providing too much ventilation can cause moisture problems in coastal climates.

Insulation baffles being installed at every second truss bay to provide opening from the soffit vents to the attic space, past the insulation (to be blown-in after).

After air sealing measures have been performed, the amount of air leakage into the attic should be substantially reduced. In addition, the vapour barrier at the ceiling plane (painted ceiling finish, kraft-faced batts or polyethylene) will limit the amount of vapour diffusion into the space.

Attic ventilation may still be beneficial even if the original attic was not ventilated and vents should be added as part of the insulation retrofit. When attic vents are installed through the roofing material, a roofing contractor should be hired to properly install, shingle, and seal the vent in the existing roofing. It is common to see an attic vent cause a roof leak due to a poor installation. Holes are best cut through roofing at the time of re-roofing, but this does not always coincide with weatherization work.

3.1.10 Attics and Roofs: Topping Up Existing Insulation

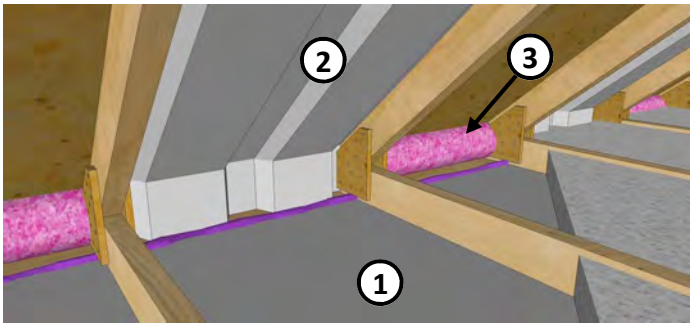
Adding Insulation - Page 3 of 3

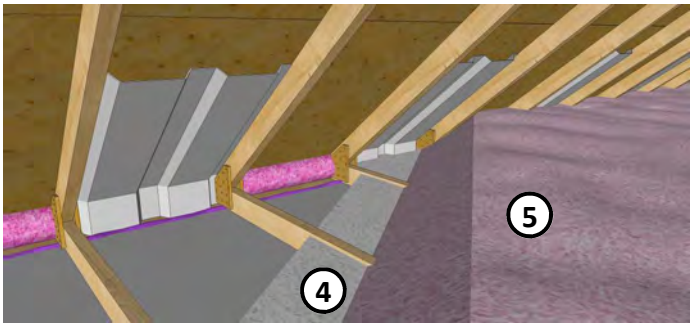
MATERIALS NEEDED

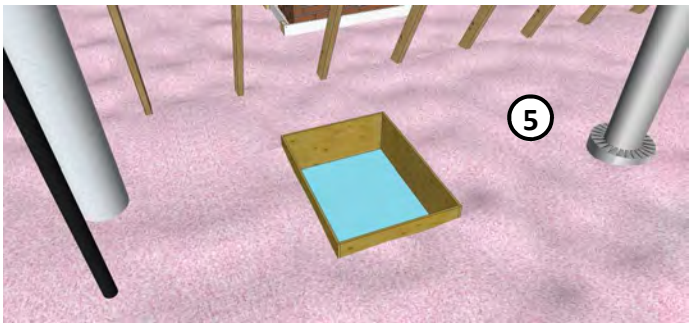
- Blown-in or batt attic insulation
- Preformed insulation baffles

RECOMMENDED TOOLS

- Utility knife
- Staple gun or glue
- Insulation blowing system (if needed)







Blown-in insulation prior to installation and blowing machine.

PROCEDURE

1. Remove existing insulation and air seal the attic as shown in previous Attic and Roof Procedures.
2. Install insulation baffles as required along the roof edge, or above each soffit ventilation port if it is not a continuous soffit vent.
3. Install batt insulation into every empty joist space to block new blown attic insulation from entering the vent space later.
4. Replace existing attic insulation (if present).
5. Install additional attic ceiling insulation per the manufacturer's instructions. See previous page for guidance on the appropriate insulation type, and appendices for guidance on the amount of insulation needed.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure all roof/attic ventilation openings are clear of insulation and debris.**
- **Install the insulation to achieve a continuous, non-compressed blanket of insulation.**

DO NOT

- **Let insulation contact non-IC-rated light fixtures, exhaust venting, or chimneys. See Section 3.1.1, 3.1.4, and 3.1.5 for details.**

HOMEOWNER TIP

- The attic floor should not be used for storage unless a platform is constructed above the insulation. Any compressed insulation should be re-fluffed to the original depth if the attic floor is walked on.

3.1.11 Attics and Roofs: Flash-and-fill Insulation

Air Sealing and Insulating Procedure - Page 1 of 1

The goal of flash-and-fill application in the attic is to simplify the air sealing process in the attic, where there may be many air leakage paths, by achieving a single airtight layer at the ceiling before additional insulation is installed. It is important to review the previous air sealing procedures if there are non-IC-rated pot-lights, service penetrations subject to movement, and chimneys in the attic. Flash-and-fill is especially efficient if the celling is a material with many gaps, like wood panelling or tongue and groove boards. In addition to air sealing the attic, closed cell sprayfoam can provide a continuous vapour barrier at the ceiling plane, further reducing moisture entering the attic from the living space.

This procedure is for the flash-and-fill application in an accessible attic.

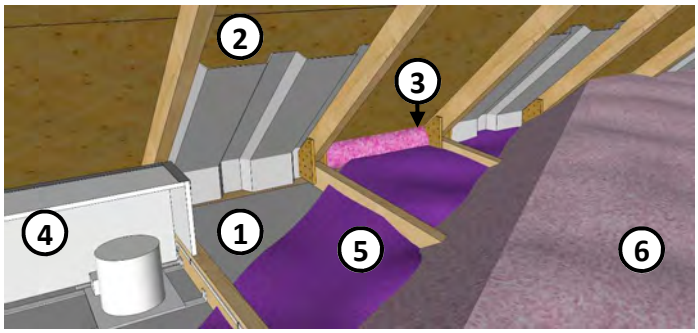
Flash-and-fill attic installation where a few inches of sprayfoam is sprayed to top of ceiling drywall, and then covered with lower cost low-density cellulose or fibreglass insulation fill.

MATERIALS NEEDED

- Spray polyurethane foam
  (large amounts required, use of sprayfoam insulation contractor recommended)
- Preformed insulation baffles
- Blown-in or batt attic insulation

RECOMMENDED TOOLS

- Utility knife
- Staple gun or glue
- Insulation blowing system (if needed)



KEY ITEMS TO CONSIDER

DO

- **Ensure contractor is trained in this application.**
- **Ensure all correct air sealing measures have been taken around heat generating fixtures and other service penetrations prior to flash coat.**
- **Follow all manufacturers instructions when using sprayfoam.**

DO NOT

- **Apply a layer of closed-cell sprayfoam greater than 2” thick or into a concealed void.**

PROCEDURE

1. Remove all the existing attic insulation and thoroughly clean the attic floor.
2. Install insulation baffles as required along the roof edge, or above each attic ventilation port if it is not a continuous soffit vent.
3. Install batt insulation into every empty joist space to block new blown attic insulation from entering the vent space later.
4. Cover non-IC/AT-rated recessed lights and other electrical fixtures in the attic with boxes as needed to make an airtight seal and to avoid contact with insulation. Follow attic air sealing procedures in Sections 3.1.1-3.1.9 as necessary to fill large holes prior to flash coat. Failure to do so can result in sprayfoam in undesirable locations or damage to existing components.
5. Flash coat the entire attic floor with a coat of sprayfoam to create a continuous air seal.
6. Install new attic ceiling insulation.

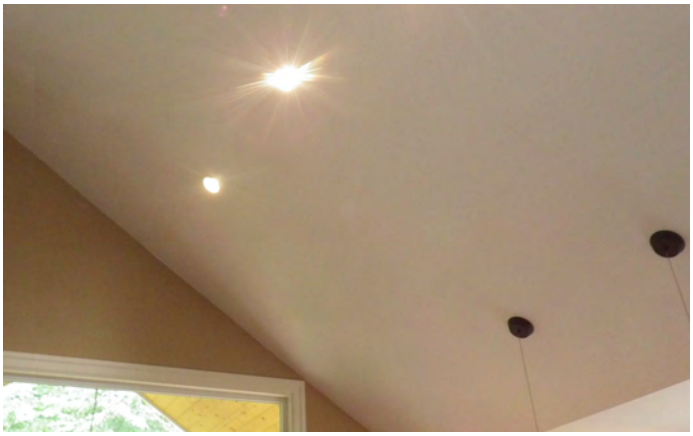
COMPLETE

3.1.12 Attics and Roofs: Vaulted and Flat Roofs, Inaccessible Attics

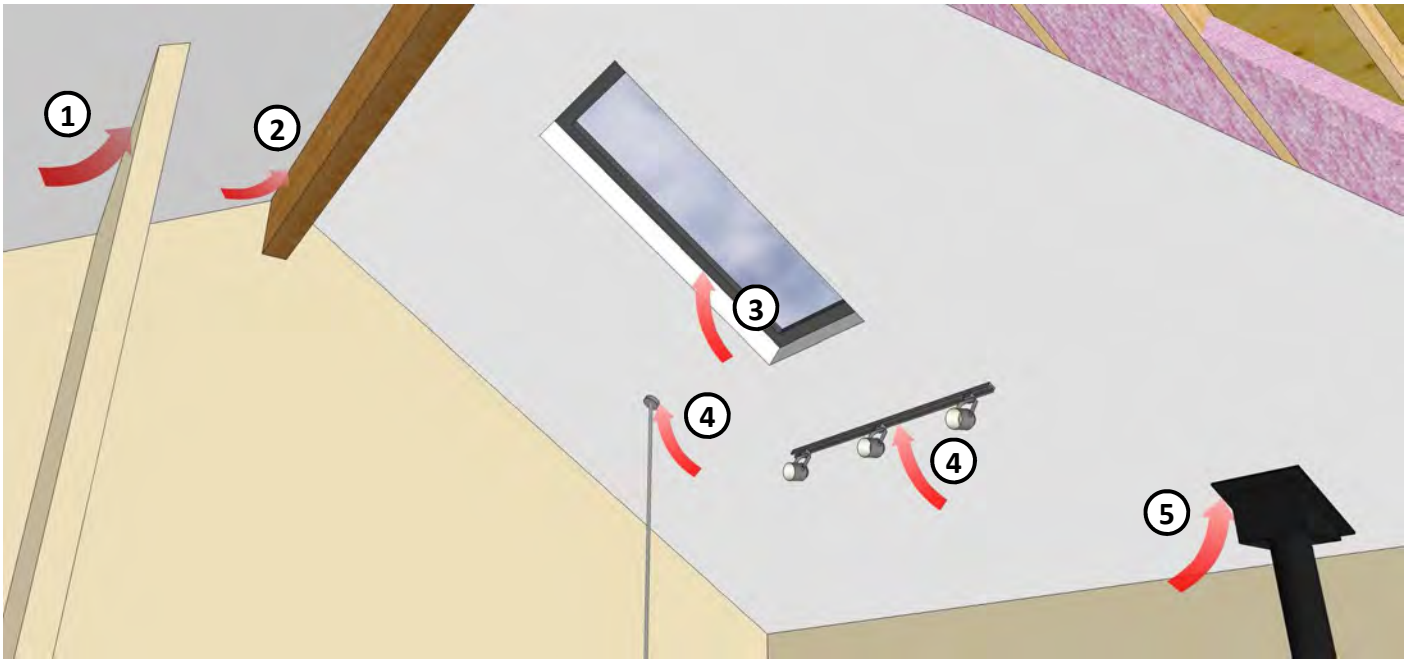
Air Sealing - Page 1 of 1

Air sealing a vaulted ceiling below ceiling joists with no attic space is most feasible from the interior side. If no major ceiling removal work is planned, it is best to seal all penetrations in the ceiling finish with appropriate sealants. A gypsum board ceiling is a good air-barrier material, so sealing the penetrations is important to make most of the ceiling airtight.

These air sealing locations are for vaulted ceilings, ceilings below flat roofs, or ceilings that do not have an accessible attic space above them.



Vaulted gypsum board ceiling with face-mounted and recessed light fixtures.



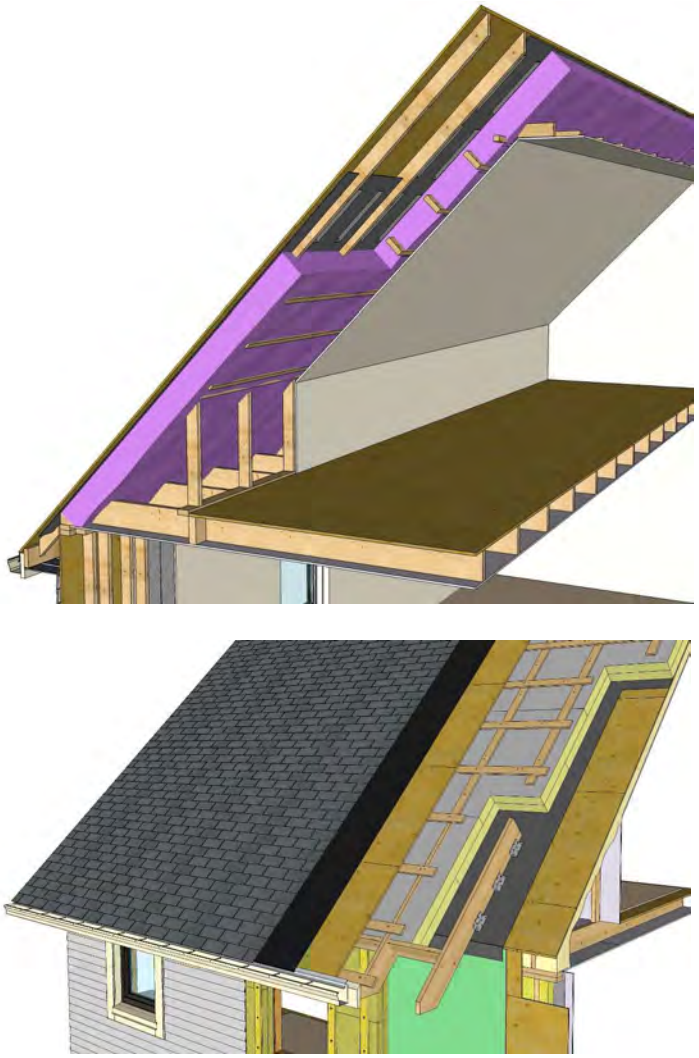
TYPICAL AIR-SEALING LOCATIONS

1. Seal tops of partition and exterior walls at the ceiling with paintable polyurethane sealant.
2. Support structures like beams and columns sealed with paintable polyurethane sealant.
3. Seal skylight frames with polyurethane sealant.
4. Seal electrical receptacles, light fixtures, and other ceiling fixtures behind the trim plates with acoustical sealant (to prevent permanent adhesion).
5. Seal exhaust vents and chimney openings with fire-resistant silicone sealant. Fire-resistant silicone sealant needs to be used at all hot and combustion air exhaust vents and chimney penetrations.

3.1.13 Attics and Roofs: Vaulted Ceilings and Inaccessible Attics

Interior vs. Exterior Insulation

The building enclosure can be retrofitted from either the exterior or the interior. Which method is most appropriate for a given application depends on the house's interior and exterior finishes, layout and construction, lot-line setback requirements, other renovation needs, and whether the house will be occupied during the work. For example, if the cladding is being replaced as part of previously planned renovations, an air sealing and insulation program applied from the exterior is likely most appropriate. Whereas, interior renovations may more easily facilitate retrofit work.



Interior and exterior insulating strategies as part of retrofitting procedures for the whole house.

An important advantage of interior retrofits is they can typically be carried out year-round, as the cladding and weather resistive barriers are not impacted by the work. Additionally, this type of retrofit may be necessary if property-line setbacks do not allow for increasing the thickness of the enclosure on the exterior. For vaulted ceilings or inaccessible attics, insulating from the interior is best suited for spaces where interior remodelling is already taking place, and headroom is not limited.

Since existing roof joists are not usually deeper than eight to 10 inches, adding rigid insulation to the underside of the joists to increase the R-value of the roof should be considered. Adding insulation below the joists will lower the level of the existing ceiling finish and potentially impact headroom. Insulating from the interior also presents the opportunity to inspect the existing elements of the roof for decay or damage. As with all assemblies where insulation is added on the interior, particular attention must be paid to the air-barrier and vapour retarder as increased insulation levels can decrease sheathing and framing temperatures, consequently increasing the risk of condensation and associated moisture damage.

An exterior retrofit can be most appropriate when interior floor area is limited, when exterior renovation work is planned, and to limit disturbance to house occupants. This method also provides an opportunity to detect and repair water entry problems. As well as air sealing and installation of insulation on the exterior of a house have a number of technical advantages. It is often easier to avoid large thermal bridges such as studs and joists in exterior insulation that makes the insulation more effective, and air sealing from the exterior is often simpler as there are fewer penetrations to accommodate. Additionally, exterior insulation increases the temperature of sheathing and framing, which reduces the potential for condensation and associated damage. Insulating the roof/attic from the exterior is most applicable when the existing roof is too shallow to accommodate target insulation levels or when other work on the roof is also planned.

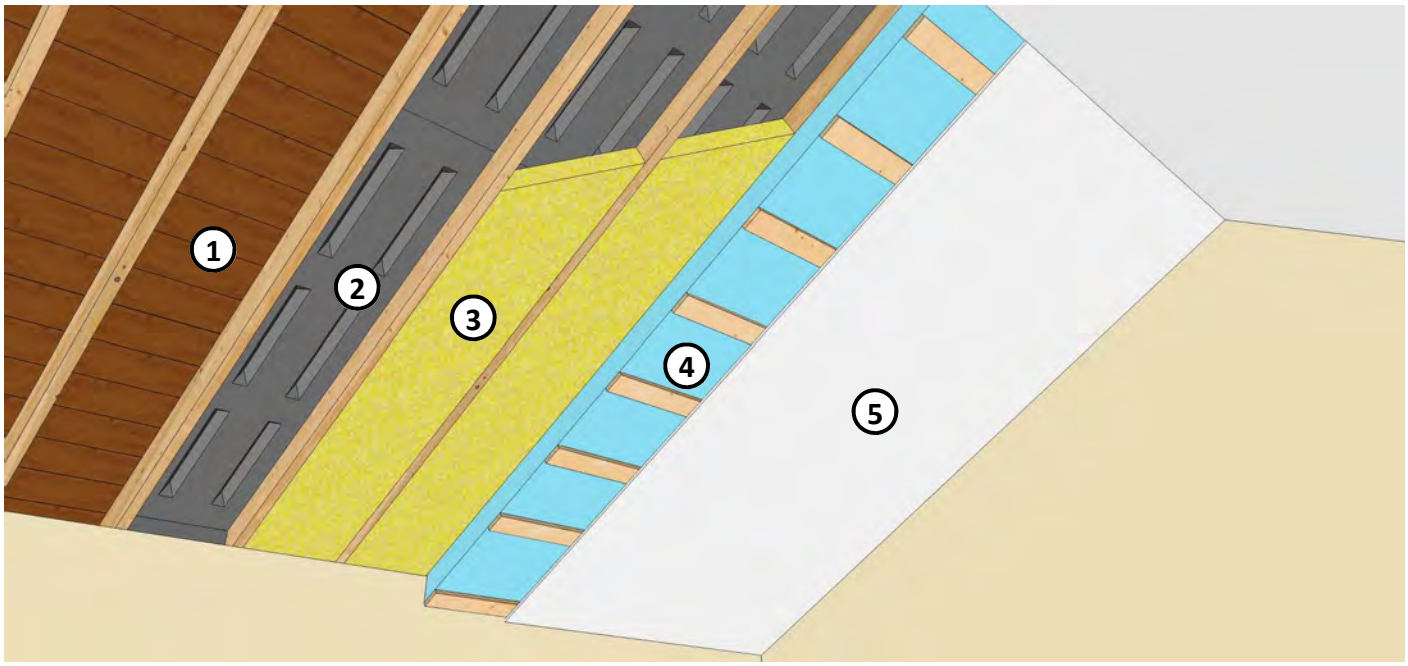
The following sections cover two conceptual roof insulation retrofits for an existing wood frame home using either an interior or exterior insulation approach. Many industry references provide additional information and details for this type of more extensive work.

3.1.14 Attics and Roofs: Vaulted Ceilings and Inaccessible Attics

Interior Insulation - Conceptual - Page 1 of 1

Insulating a vaulted ceiling from the interior requires removal of the interior finish. The joist space must be accessed to ensure adequate ventilation against the underside of the existing sheathing. Blown-in cellulose or fibreglass insulation should not be installed blind from the inside into vaulted ceilings or flat roofs. Ventilation is required to inhibit condensation and allow the wood structure to dry, and is particularly important in a retrofit application. Since the ceiling finish must be removed anyway, it is advisable to add interior insulation to increase the R-value of the roof assembly. However, this is not required. Additional insulation can be installed on the underside of the existing roof joists, or extra framing can be added to increase the roof joist depth.

Moisture Control for Dense-Packed Roof Assemblies in Cold Climates: Final Measure Guideline by Building Science Corporation is a good source of further guidance regarding interior insulation of vaulted ceilings.



DESIGN CONSIDERATIONS

1. Remove interior finish and insulation (if any) and expose existing roof sheathing. Inspect and repair framing and sheathing as needed.
2. Use vapour-permeable baffles such as 1/4" ply-wood or perforated baffles to create a vent on the underside of the sheathing.
3. Install batt insulation to the depth of the roof joist against the baffles.
4. Install rigid foam insulation against the underside of the roof joists. Tape joints to ensure airtightness. Fasten insulation to the underside of the roof joists with wood strapping.

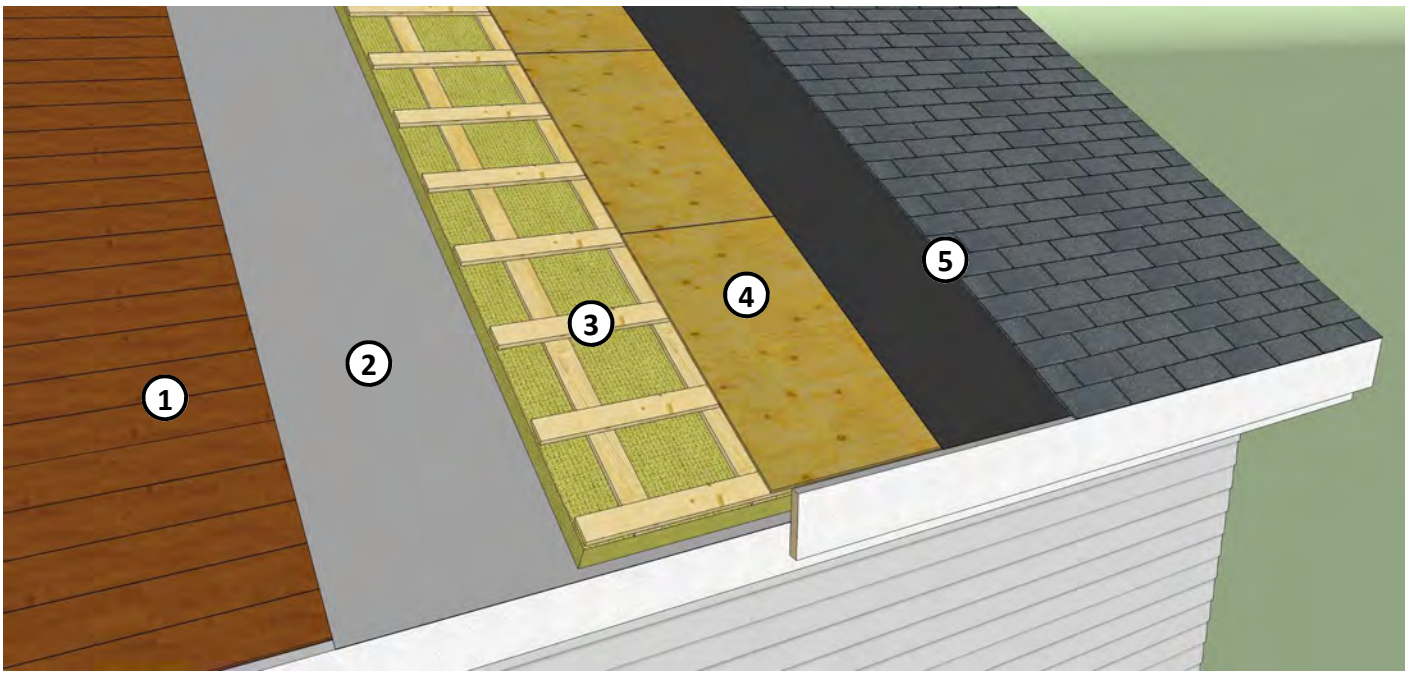
   Option: Use gypsum board with gaskets to create airtight drywall. If no rigid foam is installed or if rigid mineral wool is used in place of rigid foam, a vapour barrier such as polyethylene or vapour retarder paint on drywall must be installed at the interior side of the insulation .
5. Install interior finish.

3.1.15 Attics and Roofs: Vaulted Ceilings and Inaccessible Attics

Exterior Insulation - Conceptual - Page 1 of 1

Insulating a sloped roof from the exterior requires gaining access to the existing roof sheathing and re-roofing. Where exterior roofing work is already required, or if there is no interior access, insulation should be added to the exterior of the roof. The amount of insulation to add depends on local requirements (maximum height restrictions) and cost effectiveness. Note that the addition of exterior insulation to a roof that is already insulated on the interior is acceptable. Ventilation is recommended between the insulation and the sheathing to allow moisture to dry out and reduce ice-damming issues in snowy regions. Adding exterior insulation requires overhangs to be re-constructed and may change the appearance of the house.

Numerous references and suggestions for details are available for exterior roof retrofits, including several from the Building Science Corporation.



DESIGN CONSIDERATIONS

1. Remove existing roofing and underlay. Inspect and repair framing and sheathing as needed.
2. Install new self-adhered airtight membrane over existing sheathing. Use vapour impermeable air barrier if no vapour retarder is present in the existing roof assembly.
3. Attach rigid mineral wool or foam insulation over the air-barrier with strapping to allow for cross ventilation over the insulation.
4. Install new sheathing over the strapping.
5. Install new underlay and roofing.

Note: A ventilation path must be present for the cross strapping to allow ventilation over the insulation and at the underside of the new roof sheathing.

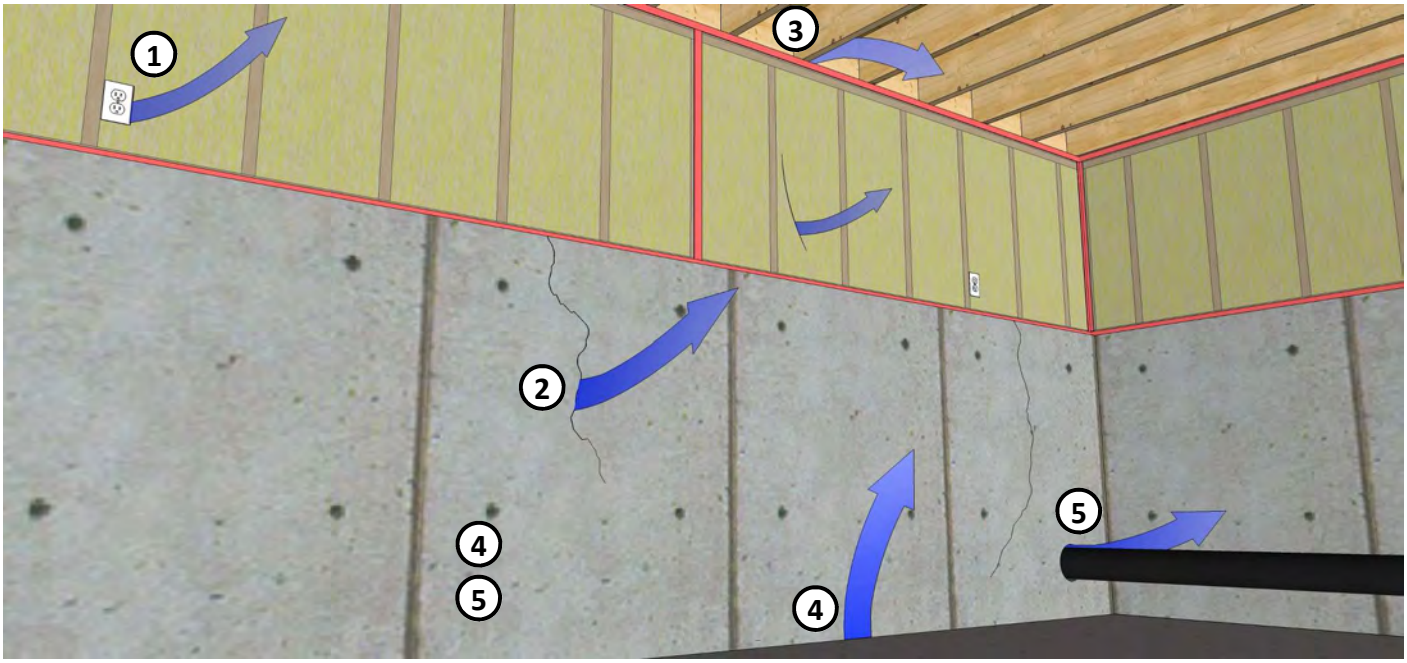
Note: Continuity in the air-barrier must be present between the underside of the roof and the top of the exterior wall. Sprayfoam or other sealing methods should be used. See references section for published details for additional sources.

3.2.1 Below-grade Walls: Basement Wall Interior

Air Sealing- Page 1 of 1

Air sealing at the basement level is important to the whole house airtightness. Air sealing measures at below-grade walls are possible only from the inside, unless work is planned to expose the foundation wall from the outside.

There are typically many unsealed and exposed penetrations in an unfinished or partially finished basement. If finishing work is planned in conjunction with air sealing measures, see Section 3.2.3 for interior insulation measures. The main focus of air sealing should be at the rim joist around the perimeter of the basement.



TYPICAL AIR-SEALING LOCATIONS

1. Seal penetrations in any wood frame walls above basement pony walls, including any discontinuities in the poly sheet using acoustical sealant and sheathing tape (at polyethylene joints).
2. Seal cracks in the foundation with polyurethane sealant.
3. Seal floor joists at the rim joist with foam board and sprayfoam (see Section 3.2.2).
4. Apply polyurethane sealant between the foundation wall and basement slab to seal gaps between the concrete slab and wall.
5. Seal service penetrations in the basement foundation wall with sprayfoam, polyurethane, or silicone sealant.

   Note: If foundation cracks or penetrations are leaking water from the exterior, a foundation waterproofing contractor should be retained.

3.2.2 Below-grade Walls: Basement Wall

Interior vs. Exterior Insulation Placement

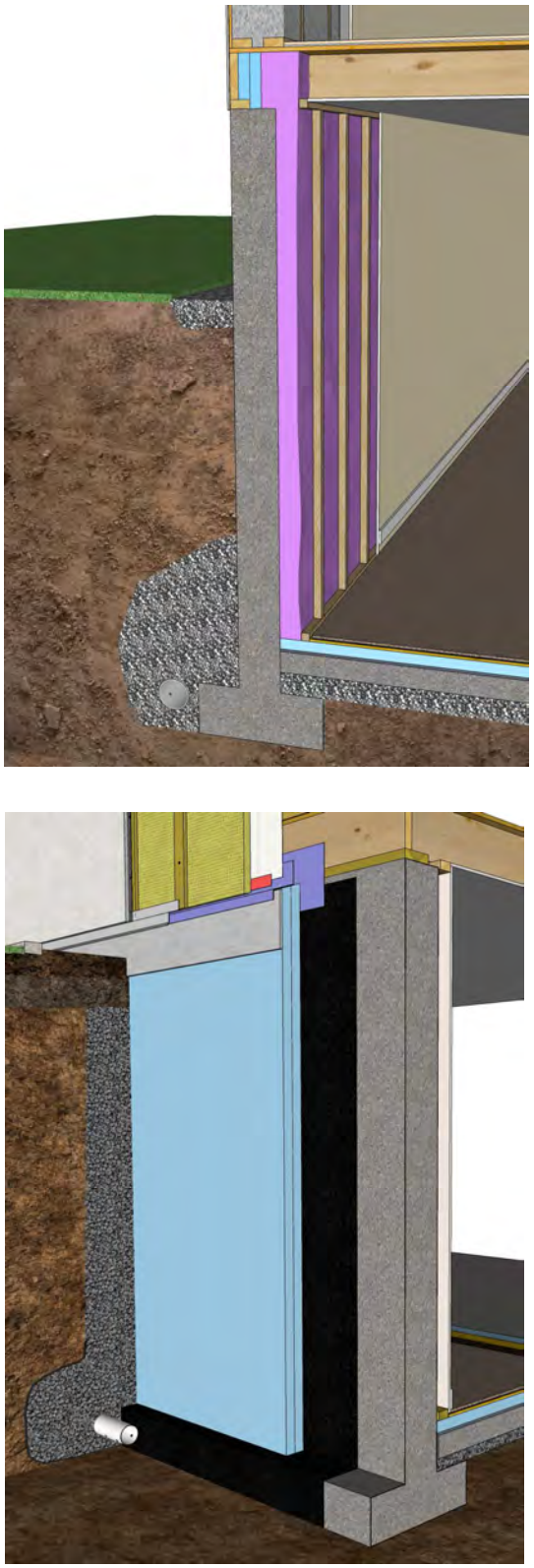
Below grade walls should be insulated and air sealed as part of the energy efficiency measures for the whole house. An insulated basement can reduce energy consumption and associated costs, and create a more comfortable living space.

Insulating below-grade walls from the interior is best suited for basements where interior finishing or re-finishing is planned. It can also be more economical than exterior insulation methods, which require excavation around the foundation walls. Rigid foam insulation boards or sprayfoam can be installed on the interior side of the foundation wall. As with all interior insulation methods, it is important to prevent relatively warm moist interior air from contacting the concrete foundation wall, as this can pose a significant condensation risk.

Insulating foundation walls from the exterior often provides the best performance, but can be cost prohibitive unless installed in conjunction with other exterior foundation work, such as perimeter drainage or dampproofing. However, if the wall is excavated for other work, installation of exterior insulation is straightforward. Exterior insulation on the below-grade walls is most effective when done in conjunction with exterior insulation on the above-grade walls, as it greatly simplifies transition detailing and limits the potential for thermal bridging. As with other types of assemblies, exterior insulation on below-grade walls increases the temperature of the foundation wall and reduces the potential for condensation on the interior.

Basement slabs are generally airtight unless large cracks or holes are present, but it is recommended that the slab be insulated with rigid foam and finished. Many of the considerations for floor-slab insulation are similar to those for insulation of the below-grade walls. However, the floor-slab insulating procedure is not included in this guide.

The following two sections cover two conceptual below-grade wall insulation retrofits for an existing home on a concrete foundation, using either an interior or exterior insulation approach.



Below-grade insulating strategies as part of retrofitting procedures for the whole house.

3.2.3 Below-grade Walls: Basement Wall

Interior Insulating Procedure - Page 1 of 2

Insulating the interior of the basement walls prior to finishing is an effective way to increase the thermal performance and airtightness of the house. The basement is prone to excessive air infiltration due to stack effect, which can create negative pressures at the basement, drawing in cold air from the ground and outside. Prior to insulation, air sealing must be done on any large openings and around service penetrations. If foundation cracks or penetrations are leaking water from the exterior, a foundation waterproofing contractor should be retained.

This insulating procedure is for below-grade foundation walls that will be receiving an interior finish. If the basement is not going to be used but is still accessible, this procedure should be altered to avoid the use of foamed plastics in locations where they will not be covered with finishes, as the building code does not allow exposed foam plastics.

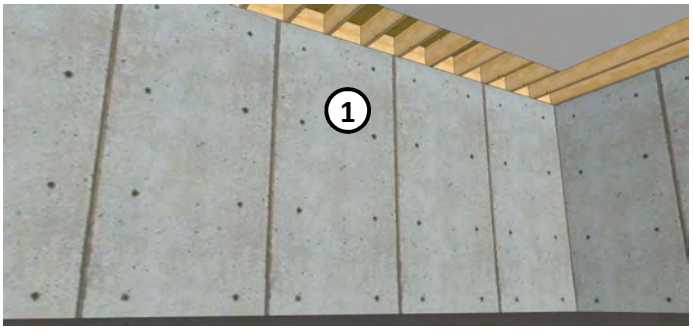
Exposed below-grade wall at floor rim joist.

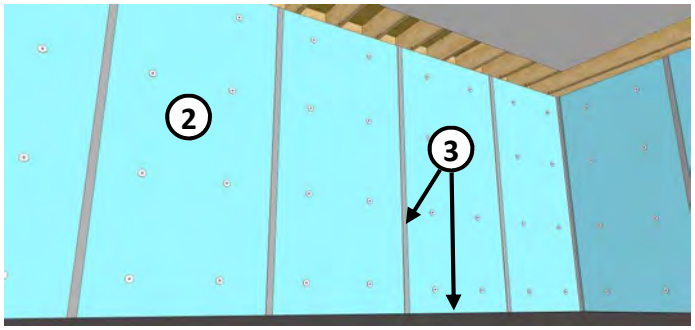
MATERIALS NEEDED

- Rigid XPS foam board insulation.
- Spray polyurethane sealant (two-part froth pack)
- Sheathing tape and sealant
- Wood framing and gypsum board

RECOMMENDED TOOLS

- Utility knife
- Insulation attachment system or glue
- Tools for framing and drywall finishing



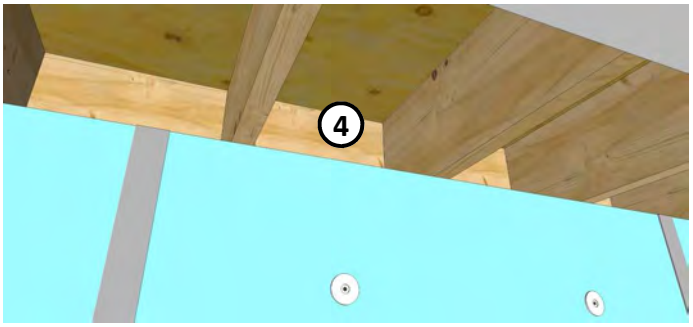


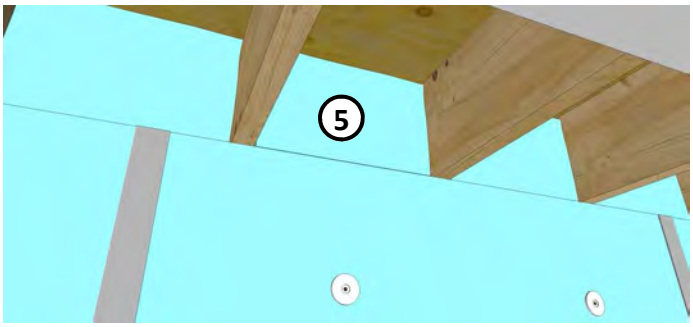
PROCEDURE

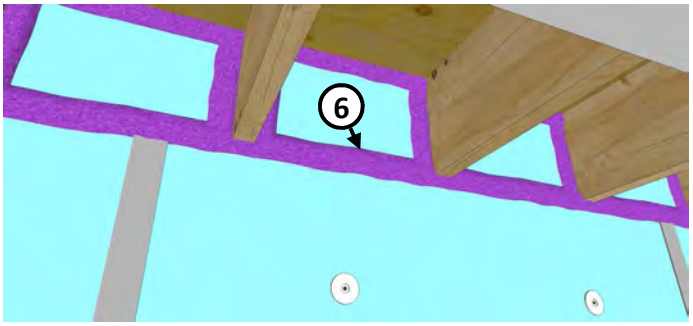
1. Expose the basement foundation wall and floor joists. If required, remove existing finishes and cut back the ceiling finish at the edge to expose the rim joist.
2. Install rigid foam insulation on the basement walls per manufacturer's instructions.
3. Tape the joints of the insulation with sheathing tape and seal the bottom edge of the insulation to the basement floor slab.

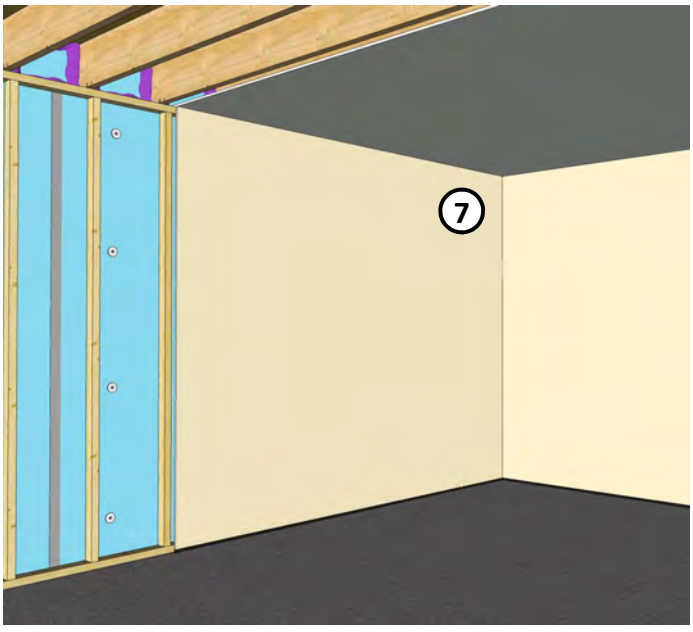
3.2.3 Below-grade Walls: Basement Wall

Interior Insulating Procedure - Page 2 of 2









PROCEDURE (Continued)

4. Expose and clean the rim joist and floor joists. Remove existing insulation (if present).
5. Install rigid insulation into each joist space. Size each piece to fit snugly in the joist space and cut around penetrations. Use multiple layers to achieve the desired insulation value.
6. Install sprayfoam around the perimeter of the rim joist insulation, sealing it to the subfloor above, floor joists, and wall insulation.
7. Install or reinstall the ceiling finish. Install wood furring and drywall finish on the foundation walls. Rigid foam board cannot be left exposed in living spaces. Ensure there is a gap between the gypsum and the concrete floor slab.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure an airtight assembly is used in conjunction with installing insulation. Special attention should be paid to air sealing the rim joists.**
- **Spray polyurethane foam insulation could be used as an alternate to the XPS board insulation.**
- **Ensure there is a gap between the basement wall finish and the slab, to prevent moisture uptake in the drywall.**

DO NOT

- **Leave the rigid foam exposed in the basement. Refer to the building code for guidance on exposed foamed plastics. Typically a layer of gypsum board is sufficient to cover the foam.**
- **Install fibreglass insulation against the concrete wall. Fibrerglass is not recommended in this application.**

HOMEOWNER TIP

- Regularly inspect the perimeter of the basement floor at the foundation wall to make sure no leaks or condensation are entering the living area.

3.2.4 Below-grade Walls: Basement Wall

Exterior Insulating Procedure - Page 1 of 2

Insulation on the exterior of the foundation wall can be the easiest way to increase the thermal performance of the below-grade walls, providing exterior foundation work is already taking place. In most cases, the concrete wall will act as the air-barrier. Regardless, cracks and penetrations must be sealed before insulating. In addition, the foundation dampproofing must be continuous in order to create an effective air-barrier. If exterior siding work is also taking place, the wall air-barrier can be tied into the foundation air-barrier, simplifying the air sealing procedure at the rim joist. If siding work is not planned, care must be taken to ensure the new materials properly tie in to the existing above-grade wall with positive laps. Air sealing at the rim joist is likely still needed in this case.

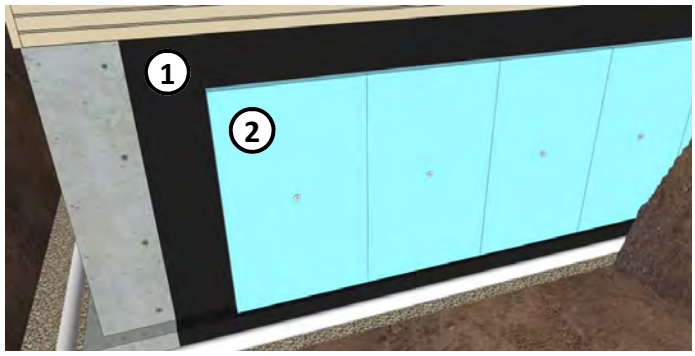
This insulating procedure is for below-grade walls that will be backfilled and exposed at the top edge.

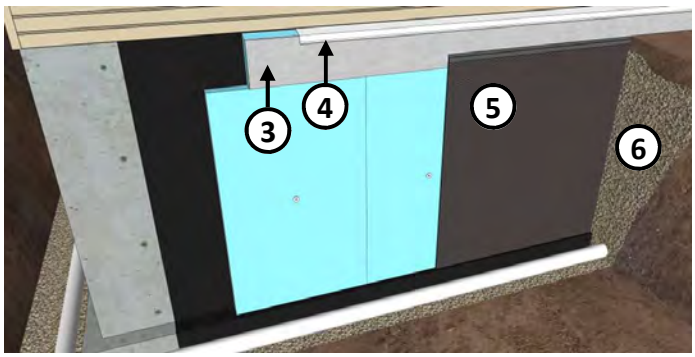
MATERIALS NEEDED

- Rigid foam board insulation
- Rigid foam board insulation with concrete coating
- Drain mat
- Flashing and nails
- Wall membrane materials (if required)

RECOMMENDED TOOLS

- Utility knife
- Insulation attachment system
- Sheet metal sheers
- Hammer





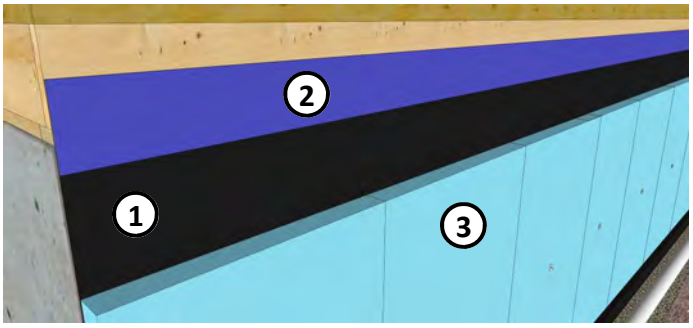
PROCEDURE (NO SIDING WORK)

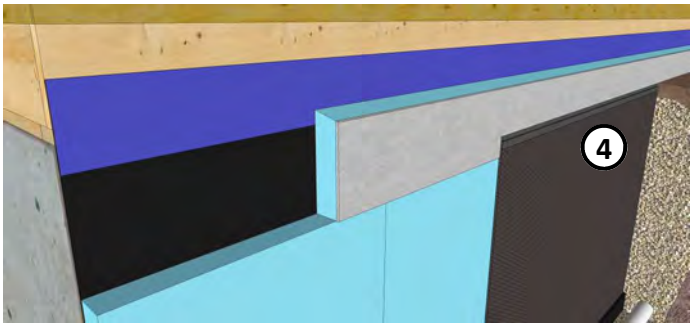
1. Ensure there is a continuous coating of foundation dampproofing membrane.
2. Install rigid foam board in the field of the foundation wall. Attach with insulation pins as required to temporarily hold the insulation to the wall.
3. Install insulation board with concrete coating where the foundation wall will be exposed above-grade.
4. Install flashing over the top edge of the insulation board and properly lapped behind the existing cladding and sheathing membrane.
5. Install drain mat over the insulation.
6. Back fill as required.

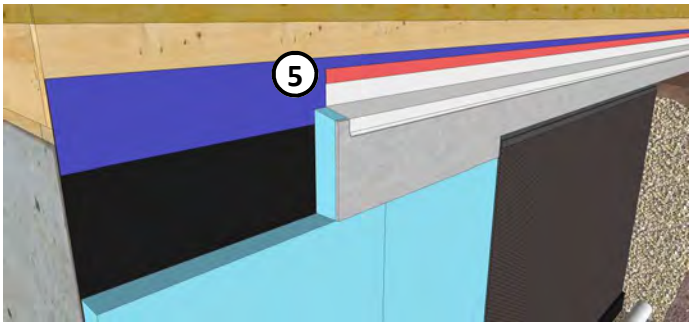
COMPLETE

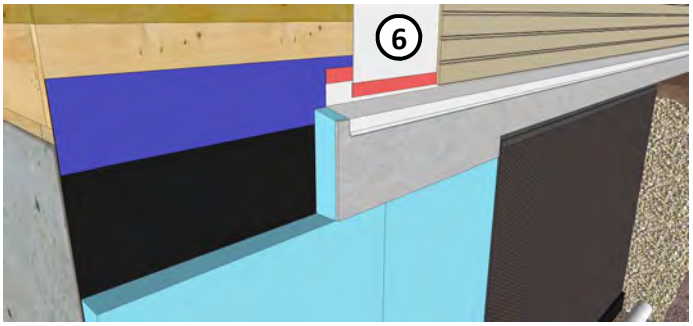
3.2.4 Below-grade Walls: Basement Wall

Exterior Insulating Procedure - Page 2 of 2









PROCEDURE (WITH SIDING WORK)

1. Ensure there is a continuous coating of foundation dampproofing membrane.
2. Install a strip of self-adhered membrane over the rim joist and sill plate, and on to the foundation wall.
3. Install rigid foam board in the field of the foundation wall. Attach with insulation pins as required to hold the insulation to the wall.
4. Install insulation board with concrete topping. Install drain mat and back fill as required.
5. Install flashing over the insulation board. Tape the top edge of the flashing to the self-adhered membrane strip.
6. Install the airtight sheathing membrane over the wall. Tape the bottom edge to the flashing and install siding as required.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure there is a continuous air-barrier at penetrations and cracks in the foundation wall. Repair leaky holes as needed prior to installing insulation.**
- **Ensure the top edge of the flashing above the insulation is properly tied in to the existing wall above.**

DO NOT

- **Insulate over the foundation footing or drain tile as this will block drainage of the foundation wall.**

HOMEOWNER TIP

- Consider installing exterior wall insulation as part of a whole house insulation retrofit. See Section 3.5.5 for exterior insulating walls.

3.3.1 Crawlspaces: Suspended Floors over Crawlspaces

Air Sealing and Insulating Procedure - Page 1 of 1

Air sealing of the suspended floor over a crawlspace mainly consists of sealing all penetrations and large holes with appropriate materials like sprayfoam, sealant, wood, and gypsum board. See attic air sealing procedures in Section 3.1.1-3.1.9 for guidance. In most cases the subfloor and flooring acts as the main air-barrier and vapour retarder, separating the conditioned space from the crawlspace. Insulating the joists can be challenging if there are services and lateral bracing in the joist space. It is important to install the insulation with a snug fit around all crawlspace obstructions.

This air sealing and insulating procedure is for floors above-vented crawlspaces.

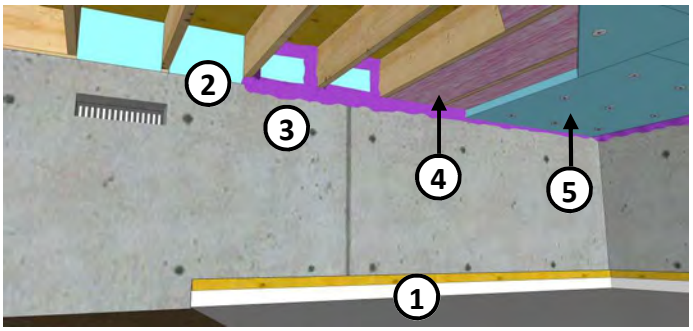
Air vent in the rim joist in an insulated vented crawlspace.

MATERIALS NEEDED

- Spray polyurethane sealant (two-part froth pack)
- Rigid XPS foam board
- 15 mil polyethylene sheet and wood strapping
- Fibreglass or mineral wool batt insulation
- Rigid mineral wool board insulation and clips
- Materials needed for air sealing

RECOMMENDED TOOLS

- Utility knife
- Wood saw
- Hammer
- Insulation attachment pins or washers and nails



KEY ITEMS TO CONSIDER

DO

- **Seal around all penetrations in the floor and insulate all water lines and ducts in the crawlspace.**
- **Ensure the batt insulation fits snugly into the joist space, without being compressed.**

DO NOT

- **Seal the exterior crawlspace vent(s). Ventilation is required in an unheated crawlspace.**

PROCEDURE

1. Install 15 mil polyethylene sheet on the crawlspace floor and mechanically fasten it to the exterior walls and all other upturns at the floor and seal laps on the floor.
2. Install two layers of rigid foam board between joists at the rim joist. Size them to fit snugly between floor joists.
3. Install sprayfoam around all joints at the rim joist and seal to the wall insulation (see Section 3.2.3).
4. Install batt insulation in the floor joist space.
5. Install XPS foam board attached to the underside of the joists to secure the batt insulation.

COMPLETE

HOMEOWNER TIP

- Protect the polyethylene sheet with carpet or rubber mats if foot traffic is expected in the crawlspace.

3.3.2 Crawlspaces: Vented to Unvented Crawlspace Conversions

Air Sealing and Insulating Procedure - Page 1 of 1

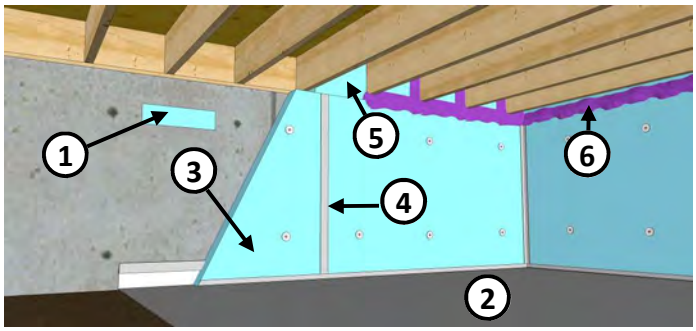
Air sealing and insulating the crawlspace walls can often be a simpler approach than air sealing and insulating the floors, as the services running in the floor space do not have to be insulated. In a heated crawlspace, the crawlspace walls are insulated to make the space conditioned like the rest of the home. Ventilation from the exterior is not needed and existing vents should be sealed. Also, steps must be taken to stop moisture from the ground from entering the crawlspace. The main focus for air sealing is the rim joists and is similar to the interior approach to insulating a basement (Section 3.2.3).

This air sealing and insulating procedure is for the interior approach only. Similar results can be achieved from the exterior.

Uninsulated crawlspace interior walls and floor.

MATERIALS NEEDED

- Spray polyurethane sealant (two-part froth pack)
- Rigid XPS foam board
- 15 mil polyethylene sheet and sheathing tape
- Materials needed for air sealing (tape, acoustical sealant)



KEY ITEMS TO CONSIDER

DO

- **Seal around all penetrations in the crawlspace walls.**
- **Use sprayfoam and rigid foam board at the joists to achieve higher insulation levels and a proper air seal.**

DO NOT

- **Proceed if the crawlspace is damp or water is present on the floor.**
- **Use exposed foam board where fire protection of combustibles is needed. (Cover foam with gypsum board where required.)**

RECOMMENDED TOOLS

- Utility knife
- Insulation attachment system
- Tools needed for air sealing

PROCEDURE

1. Close off and seal exterior crawlspace vents against water and air.
2. Install 15 mil polyethylene sheet on the crawlspace floor and seal it to the exterior walls and all other upturns at the floor and laps on the floor with acoustical sealant and tape.
3. Install rigid foam board on the exterior wall and attach with mechanical fasteners.
4. Tape all insulation joints with sheathing tape to make airtight.
5. Install two layers of rigid foam board between joists at the rim joist. Size them to fit snugly between floor joists.
6. Install sprayfoam around all joints at the rim joist and seal to the wall insulation (see Section 3.2.3).

COMPLETE

HOMEOWNER TIP

- Protect the polyethylene sheet with carpet or rubber mats if foot traffic is expected in the crawlspace.

3.4.1 Exposed Floors: Overhanging Floors

Air Sealing and Insulating Procedure - Page 1 of 1

Air sealing and insulating overhanging floors is important to the overall building energy performance and thermal comfort of the home. The exposed underside of the floor can be a significant source of heat loss, due to air leakage and conduction. It can also create cold floors and walls, causing discomfort. The exposed floor is similar to a floor over an uninsulated crawlspace, and it is expected the subfloor and flooring will act as the bulk of the air-barrier and vapour retarder. Air sealing is required at all joints and penetrations, in addition services in the overhang also must be insulated.

This air sealing and insulating procedure is for exterior overhanging floors. A similar procedure should be used for floors over car ports or other exposed floors.

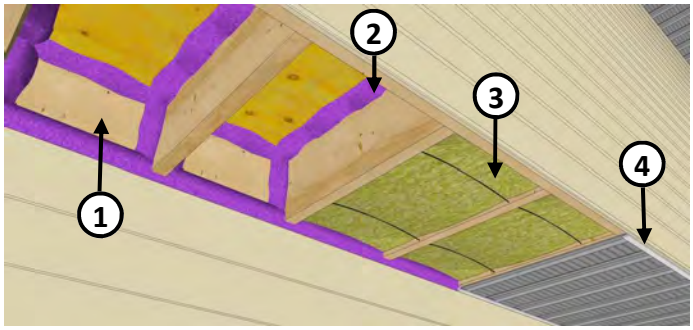
Overhanging floor under a bay window.

MATERIALS NEEDED

- Spray polyurethane sealant (two-part froth pack)
- Fibreglass or mineral wool batt insulation
- Wire insulation supports or nylon string and screws

RECOMMENDED TOOLS

- Utility knife
- Screw driver



KEY ITEMS TO CONSIDER

DO

- **Seal at the rim joist and around all penetrations in the floor overhang.**
- **Use insulation supports if a flexible soffit like perforated vinyl is being used.**
- **If duct work is exposed in the floor overhang, insulate and air seal (see Section 3.1.3).**

DO NOT

- **Rely on friction fit for the batt insulation to stay in place in the floor joist.**

PROCEDURE

1. Expose the underside of the overhang, remove existing insulation (if any), and clean the framing and subfloor.
2. Install sprayfoam sealant around all penetrations and joints at the subfloor and rim joist.
3. Install batt insulation in each joist space and secure it in place with insulation supports.
4. Re-install the soffit material.

COMPLETE

HOMEOWNER TIP

- Ensure garden sprinklers are directed away from the walls and overhang soffit to avoid excessive wetting.

3.4.2 Exposed Floors: Protected Porches over Living Space

Air Sealing and Insulating Procedure - Page 1 of 2

In many older homes, there is a porch over the foundation wall and basement or crawlspace that is protected by an overhanging roof. This is essentially an exterior floor and must be made airtight. If major exterior work is planned, the porch should be made airtight and insulted from the exterior if space permits. Where the existing exterior finishes and membranes are to be left in place, the assembly must be made airtight and insulated from the interior.

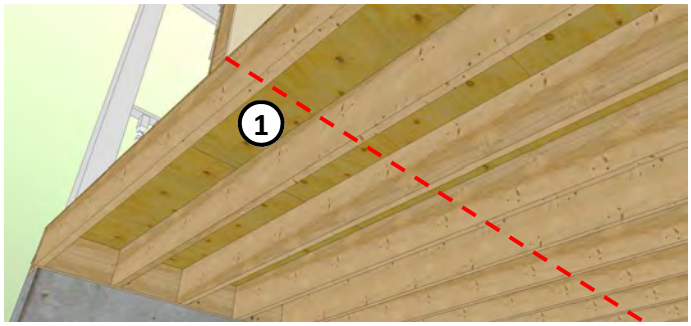
This air sealing and insulating procedure is meant for exposed protected porches over living space at the house perimeter that cannot be readily vented. It should not be used for conventional flat roofs or vaulted ceilings. For guidance on air sealing and insulating ceiling from the interior, see Section 3.1.14.

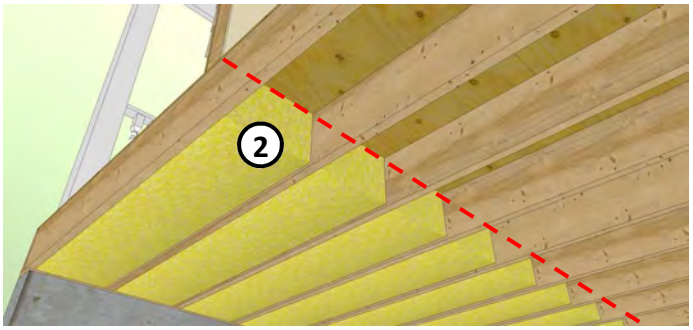
MATERIALS NEEDED

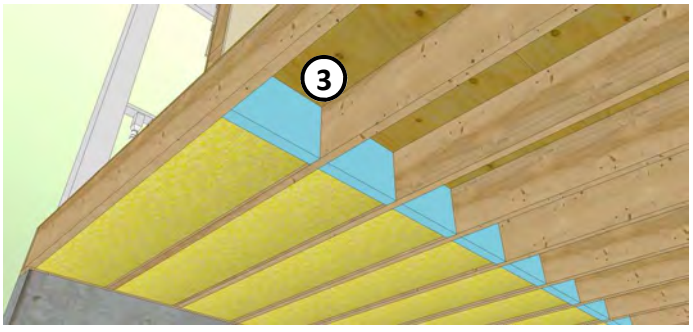
- Fibreglass or mineral wool batt insulation
- Rigid XPS foam board
- Spray polyurethane sealant (two-part froth pack)
- Materials needed for gypsum board finish
- Polyurethane sealant
- Vapour-retarding interior paint

RECOMMENDED TOOLS

- Utility knife
- Tools needed for gypsum board finish
- Caulking gun
- Painting tools





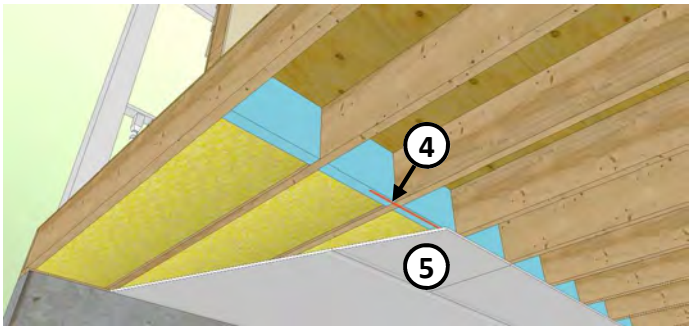


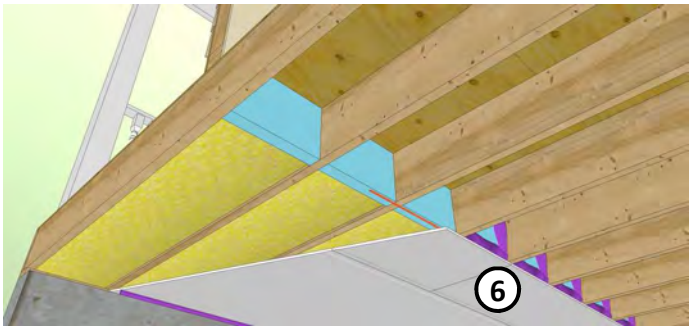
PROCEDURE

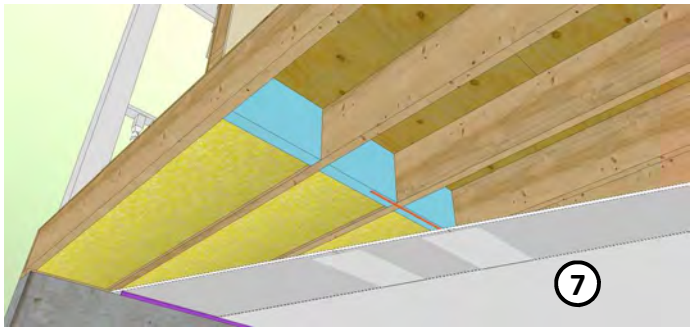
1. Expose the underside of the existing floor sheathing. Inspect the framing and sheathing for damage or decay and repair as needed.
2. Install batt insulation to the depth of the floor joists. Insulation is only needed the extent of the exposed exterior floor.
3. Install rigid foam insulation at the end of the insulation where it lines up with interior space above.

3.4.1 Exposed Floors: Exterior Floors

Air Sealing and Insulating Procedure - Page 2 of 2







HOMEOWNER TIP

- Consider enclosing existing perimeter decks over living space to make the deck space interior space and avoid exposed exterior floors.

PROCEDURE (Continued)

4. Apply sealant along the perimeter edge of the gypsum board where the air-barrier is required, to create an edge air seal.
5. Install gypsum board over the floor insulation, extending the edge past the rigid foam board. Install the insulation in an airtight manner, with sealed edges where airtightness is required.
6. Install sprayfoam sealant around the rigid foam, sealing it to the floor sheathing, floor joists, and the top side of the gypsum board. Seal along the edge of the ceiling gypsum board at the exterior wall.
7. Install additional gypsum boards to finish the ceiling. Tape and mud all joints and paint the ceiling with a vapour-retarding paint.

COMPLETE

KEY ITEMS TO CONSIDER

DO

- **Ensure a continuous air-barrier by sealing the perimeter of the gypsum board as needed and finishing the joints.**
- **Ensure an effective vapour retarder is installed by using vapour-retarding paint as the ceiling finish.**

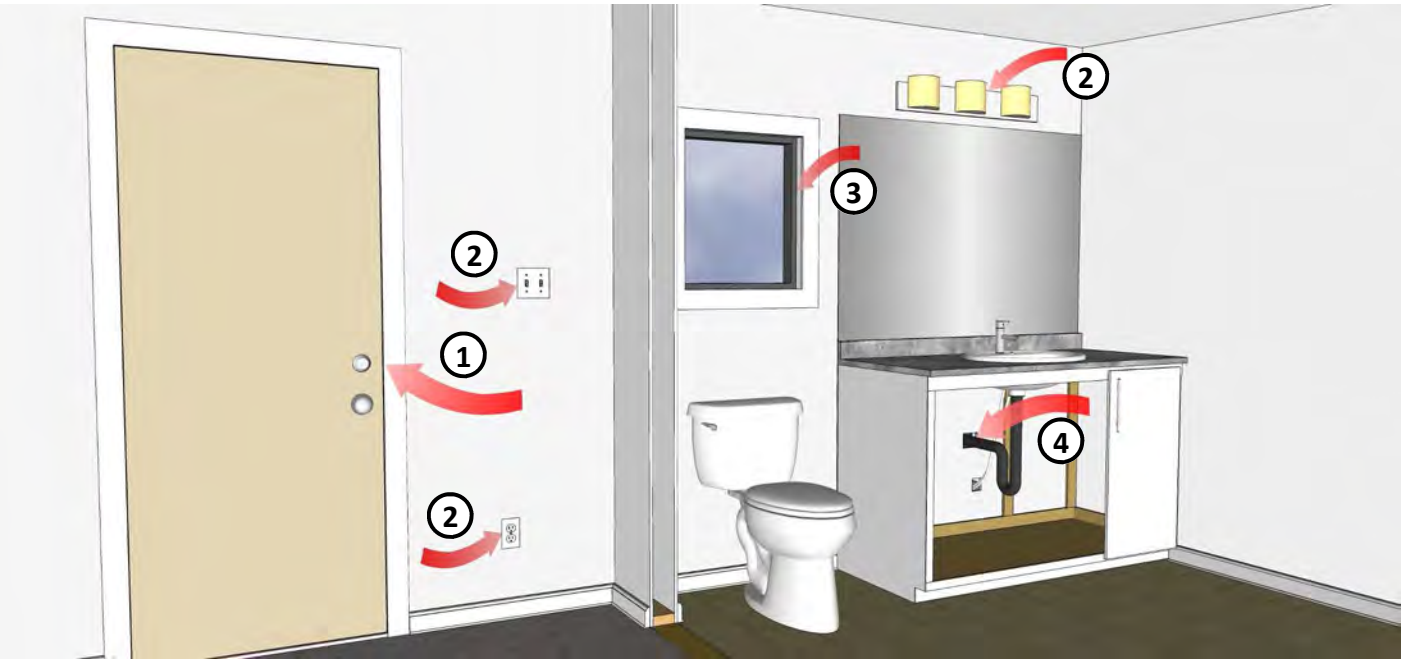
DO NOT

- **Perform this work if there is water damage to the existing assembly.**
- **Use this approach on an unprotected horizontal surface (i.e. no overhanging roof) that should instead be designed as a roof.**

3.5.1 Above-grade Walls: Interior

Air Sealing - Page 1 of 1

Air sealing the walls of a house consists mainly of sealing all large openings and service penetrations. Exterior doors and windows can be significant sources of air leakage, and small electrical fixtures and service penetrations can also contribute to air leakage. Most air sealing can be accomplished with gaskets, sealants, and sprayfoam, but if larger holes are to be sealed, more robust air sealing procedures may be needed. Refer to Section 1 for guidance on specific air sealing procedures.



TYPICAL AIR-SEALING LOCATIONS

1. Seal and adjust exterior doors using adhered weather stripping and gaskets.
2. Seal electrical receptacles, light fixtures, and other small wall fixtures behind the trim plates with acoustical sealant (to prevent permanent adhesion).
3. Seal window frames with polyurethane sealant. Adjust and seal operable windows using adhered weather stripping and gaskets.
4. Seal mechanical, plumbing, combustion venting, and other services penetrating exterior walls with polyurethane sprayfoam or sealant.

   Note: Use fire-resistant silicone sealant around hot exhaust vents and chimneys.

   Note: Other interfaces like rim joists and wall intersections are not included due to the extensive work required. If major interior work is planned, see Section 3.5.3-3.5.5 (includes insulation) and Section 3.2.3 (sealing rim joists).

3.5.2 Above-grade Walls: Stud Bay Insulating (Blown-in Insulation)

Insulating Procedure - Page 1 of 2

Insulating the wall stud space with blown-in insulation can be an economical way to increase the thermal performance of the exterior above-grade walls without major intrusion. The work should only be done if there is very little or no existing wall insulation. In addition, the interior side must be made airtight and should be painted with a vapour-retarding paint in order to avoid condensation on the exterior sheathing. This procedure can be completed from the interior or the exterior, depending on the exterior siding and whether interior disruption is possible. It is important to ensure the stud bays are completely filled by using multiple ports in each stud space. This also includes stud spaces above and below windows and doors.

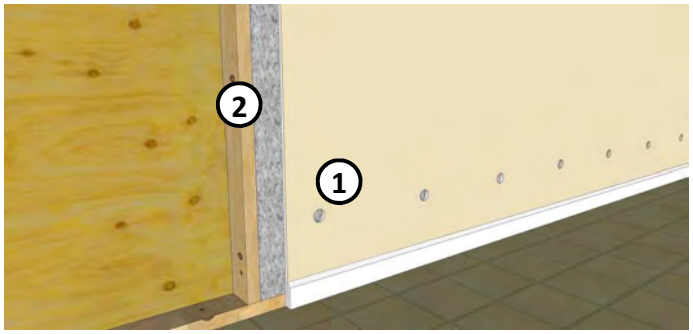
This insulating procedure is for exterior walls where increased wall R-value is desired but major insulation retrofit work is not possible. It is recommended that this work be completed by an insulation contractor.

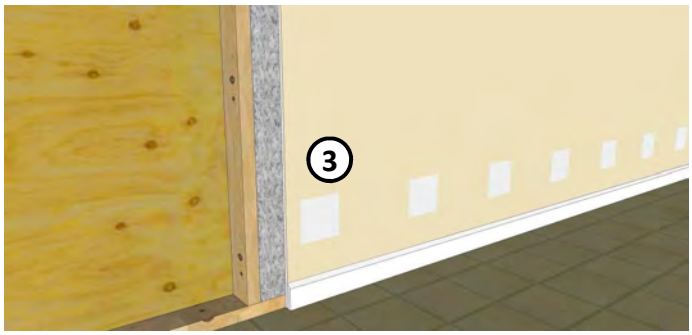
MATERIALS NEEDED

- Blow-in cellulose or fibreglass insulation
- Sheathing tape
- Nails
- Drywall/plaster repair materials (if needed)
- Vapour-retarding interior paint

RECOMMENDED TOOLS

- Utility knife
- Drill and hole saw bit
- Hammer
- Other siding removal tools as needed
- Interior repair tools (if needed)





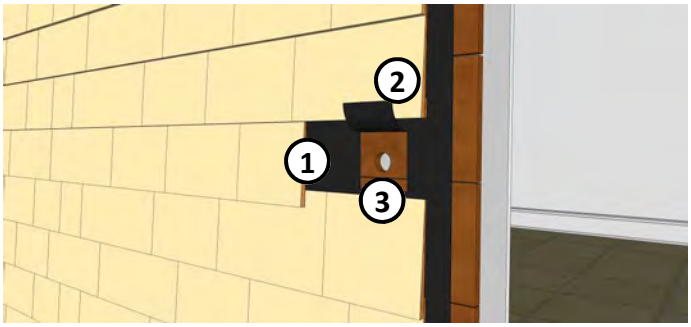
PROCEDURE (INTERIOR)

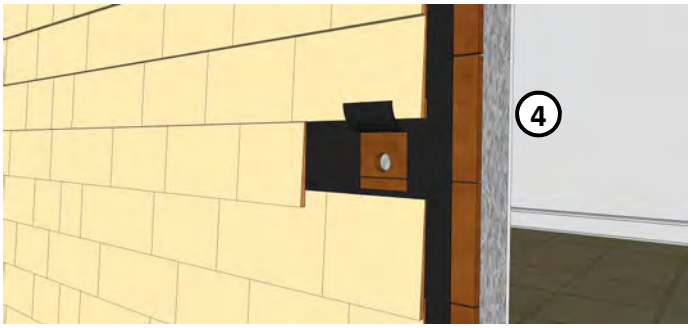
1. Drill a hole in the interior finish at the top and bottom of each stud space.
2. Install blow-in insulation in each stud space as needed.
3. Install an interior patch and finish as needed.

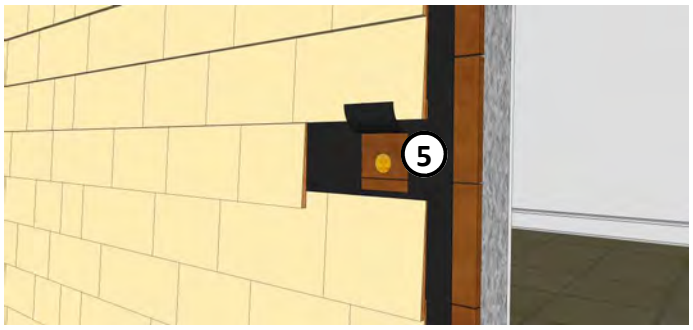
COMPLETE

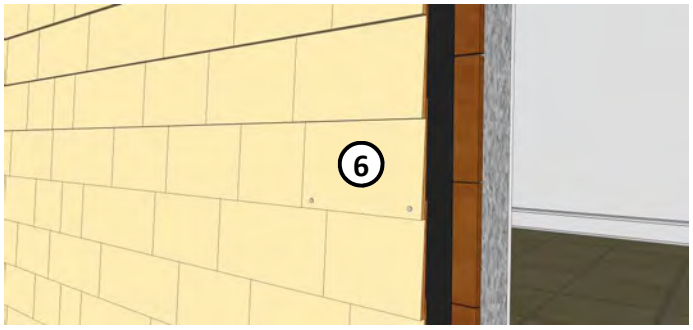
3.5.2 Above-grade Walls: Stud Bay Insulating (Cellulose/Fibreglass Fill)

Insulating Procedure - Page 2 of 2









HOMEOWNER TIP

- Consider removing the exterior siding and installing exterior insulation. Alternatively, consider an interior insulation retrofit. See Section 3.5.3-3.5.5.

PROCEDURE (EXTERIOR)

1. Locate each stud space and remove the siding in the centre of the stud space at the top and bottom of the wall.

   Note: For shingles and wood siding, a piece should be cut out and removed or drilled out. Use an unlocking tool for vinyl siding, and a zip cutter for aluminum. Masonry cannot readily be removed.

2. Cut away the existing sheathing membrane to make a fold-up flap above where the hole is to be drilled.

3. Drill a hole into the exposed sheathing sized for the insulation nozzle. Ensure the hole is roughly centered in the stud space.

4. Fill the lower portion of the stud bay until the nozzle stops blowing insulation. Move the nozzle to the upper hole and fill the rest of the space.

5. Insert a plug in the sheathing holes and fold down the sheathing membrane. Tape the sides and bottom edge of the membrane flap.

6. Reinstall the siding and repair as needed. Shingles and wood siding can be reinstalled with nails and painted. Vinyl and metal siding can be reinstalled and repaired as needed.

COMPLETE

KEY ITEMS TO CONSIDER

DO:

- **Ensure the insulation has uniformly filled each stud space. Centre both the top and bottom holes in each cavity as much as possible using a stud finder.**
- **Ensure the wall is airtight and will not pose a risk of condensation at the exterior sheathing.**
- **Ensure holes are not drilled where electrical wires or other services are located.**

DO NOT:

- **Leave holes open or unsealed. Care must be taken to adequately repair each exterior hole to avoid water penetration. Interior holes should be repaired so that they are airtight.**

3.5.3 Above-grade Walls: Exterior Wall Retrofit

Interior vs. Exterior Insulation

Insulating exterior walls as part of energy-efficiency measures for the whole house can significantly reduce energy consumption and save heating and cooling costs. While major insulation retrofits are generally more cost effective when combined with interior or exterior work already taking place, the potential energy savings can also be a compelling reason to initiate work.

As with all major insulation retrofit work, insulating the walls from the interior side is best suited when interior remodelling is taking place, and when some loss of floor space is acceptable. Older homes do not generally have sufficiently thick walls to accommodate added insulation in the stud space. In order to make the energy savings retrofit worthwhile, additional wall framing is likely necessary on the interior side of the existing framing to provide a larger wall cavity to accommodate more insulation and a higher R-value. The advantage of insulating from the interior is that no exterior work is needed. The main disadvantages are the increased risk of condensation and reduced drying ability due to colder exterior sheathing temperatures and a loss of living space. Special care must be taken on the interior plane of airtightness to avoid air leakage and vapour-diffusion condensation.

Exterior insulating makes the most sense when exterior work is already taking place and the existing cladding and wall membrane is removed. Ensure property setback distances will not be encroached when considering the exterior insulation thickness to achieve the desired R-value. Insulating from the exterior is also the best way to ensure a proper air-barrier is installed on the exterior walls, to increase the airtightness of the home, and to simplify the air sealing procedures. One major advantage of exterior insulation is that the insulation can be installed in a single plane without thermal bridging from studs or floor joists. In addition, the existing framing and sheathing is kept warm, reducing the risk of condensation and decay.

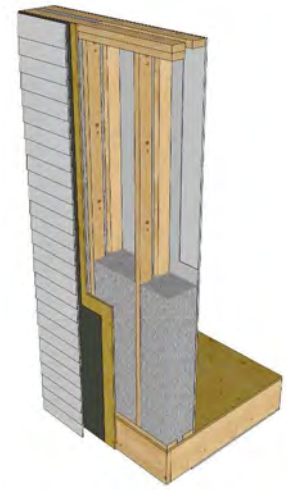
The exterior insulation attachment strategy is important to the integrity of the whole wall system. Special care must be taken to ensure the insulation and siding will remain attached to the wall and will not allow excess moisture into the system.

The following two sections cover two conceptual interior and exterior insulation retrofits that could be performed on an existing wood-frame home. The retrofit work on the exterior walls can be extensive and therefore it is recommended that the work be completed by experienced contractors. Refer to the HPO's *Best Practices for Window and Door Replacement in Wood-Frame Buildings* on how to integrate windows into the insulation retrofit project.

Interior and exterior insulating strategies as part of retrofitting procedures for the whole house.

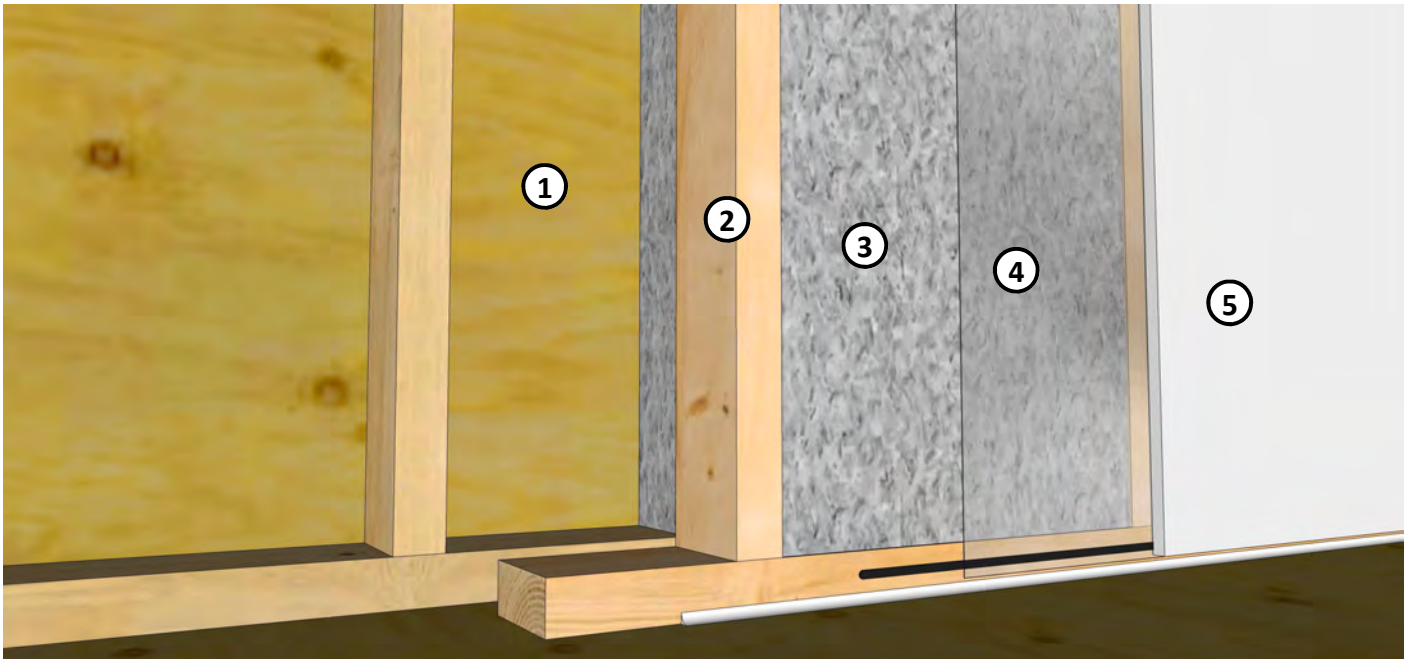
3.5.4 Above-grade Walls: Interior Insulation

Insulating Procedure - Conceptual - Page 1 of 1



An interior insulation retrofit is best performed in conjunction with other interior demolition or remodelling work. A double-stud approach is used to ensure the wall cavity is deep enough to achieve adequate wall R-value, and to avoid excessive thermal bridging. The main focus with all interior insulation retrofits is making the interior plane properly airtight and closed to vapour diffusion, as deep stud walls present a relatively high risk of condensation on the exterior sheathing.

The following design considerations are for a double-stud retrofit. The information is meant to give an overview of the wall assembly and work required.



DESIGN CONSIDERATIONS

1. Remove existing finishes and insulation (if any) tp expose the exterior wall assembly. Inspect and repair framing and sheathing as needed.
2. Construct inner stud wall with framing as required, with a gap between the interior and exterior stud wall sized according to the desired R-value. Seal all edges along the floor and ceiling with polyurethane sealant.
3. Insulate stud space iwith blow-in or batt insulation.
4. Install polyethylene air-barrier/vapour retarder and seal all joints and laps, at all penetrations, and seal to the interior framing.

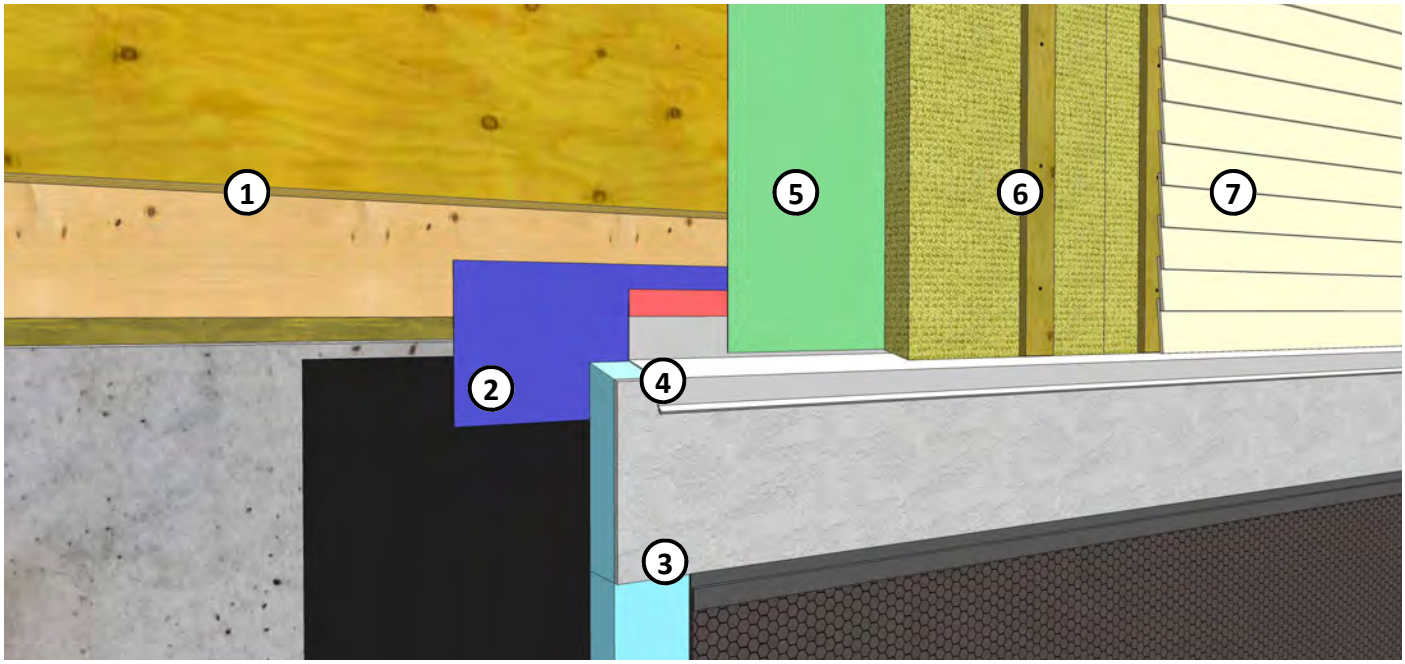
   Note: The polyethylene should run across the plane of the interior framing where interior dividing walls intersect with the exterior wall, ensuring air-barrier continuity. Alternate materials may be used as long as the air-barrier system is continuous.
5. Install and finish interior gypsum board as required.

3.5.5 Above-grade Walls: Exterior Insulation

Insulating Procedure - Conceptual - Page 1 of 3

An exterior insulation retrofit is most economical when done in conjunction with other exterior remodelling work. It is important that the existing wall is stripped down to the sheathing. In addition, the interior wall assembly should be verified to ensure the exterior work will not create a risk of condensation or trap moisture in the assembly. As a general rule, only vapour-permeable air-barrier membranes and insulation should be used on the exterior of the wall. The following design considerations are for an exterior insulation retrofit. The information is meant to give an overview of the wall assembly and work required.

Foundation Wall to Above-grade Wall Transition



DESIGN CONSIDERATIONS

1. Remove existing siding and wall membrane to expose exterior wall assembly. Inspect and repair framing and sheathing as needed.
   Expose below grade wall assembly. Repair concrete and waterproof membrane/damp-proofing as needed.
2. Use self-adhered membrane at the floor joist/ foundation to create the air-barrier transition.
3. Install below grade wall exterior insulation with protection board over exposed insulation.
4. Install flashing and tape it to self-adhered membrane to maintain air-barrier continuity.
5. Install vapour-permeable air-barrier membrane (sheet, self-adhered, or liquid applied). Seal laps and penetration (if needed) and cover down rim joists and interfaces to the below-grade wall transition.
6. Place rigid mineral wool insulation over air-barrier membrane. Use pressure-treated wood strapping (or plywood) over exterior insulation aligned with stud spacing where possible. Attach with screws through the insulation into the existing wall.
7. Install exterior siding. Most cladding types are well supported by screws and strapping. Heavy weight cladding like stone veneer or brick may require extra support.

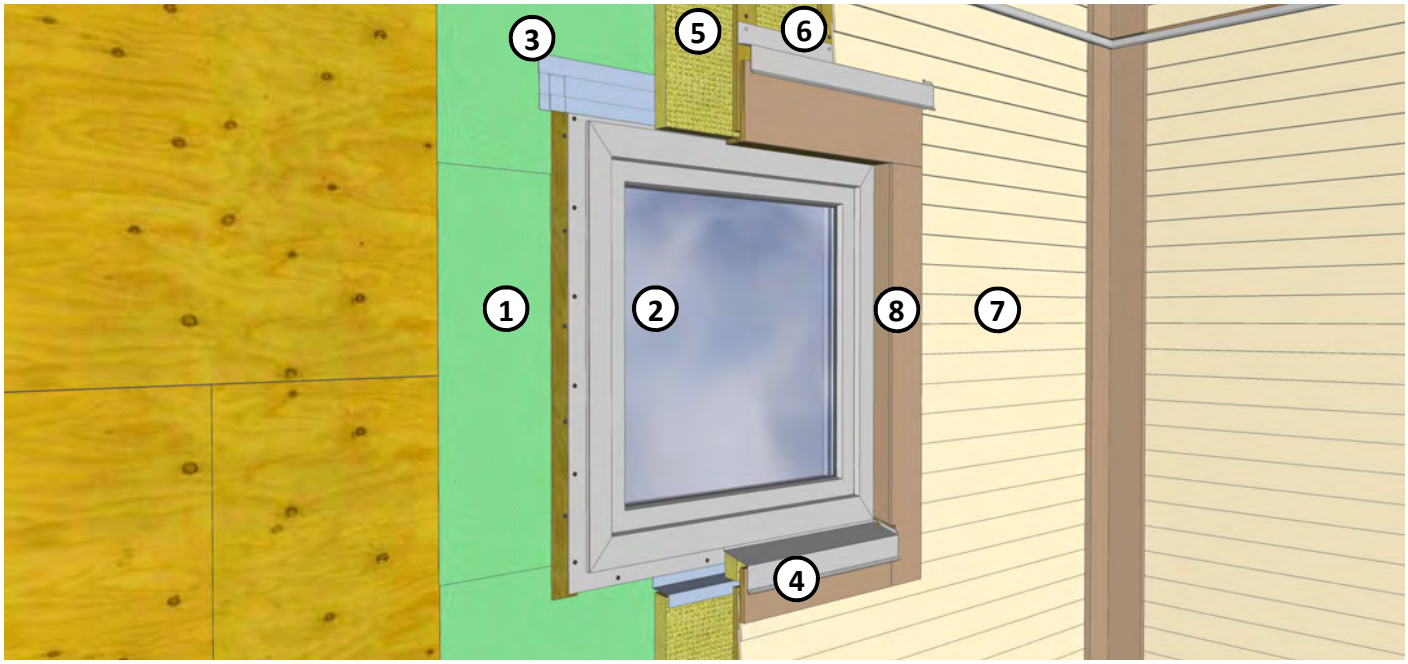
   See reference documents for additional considerations and details.

3.5.5 Above-grade Walls: Exterior Insulation

Insulating Procedure - Conceptual - Page 2 of 3

Windows and doors should be removed and reinstalled, or replaced in conjunction with the exterior insulation work, in order to achieve adequate air- and moisture-barrier detailing.

Flanged Window



DESIGN CONSIDERATIONS

1. Apply vapour-permeable air-barrier membrane (sheet, self-adhered, or liquid applied) onto the rough window opening and surrounding wall area. Install extended membrane flashing at the window sill to shed water from the window rough opening out over the exterior insulation.
2. Installed flanged window and fasten through strapping at the head and jambs, and intermittent blocking at the sill flange for drainage.
3. Install self-adhered membrane flashing over the window head flange.
4. Install metal flashing at the window sill to extend over exterior insulation and siding.
5. Place rigid mineral wool insulation over air-barrier membrane. Use pressure-treated wood strapping or plywood aligned with stud spacing where possible. Attach with screws through the insulation into the existing sheathing.
6. Install metal flashing onto strapping above the window head to deflect moisture out over the window.
7. Install exterior siding. Most cladding types are well supported by screws and strapping. Heavy-weight cladding like stone veneer or brick may require additional support.
8. Install finish trim (or cladding returns) where needed to cover the depth of the sides of the exterior insulation on all exposed sides.

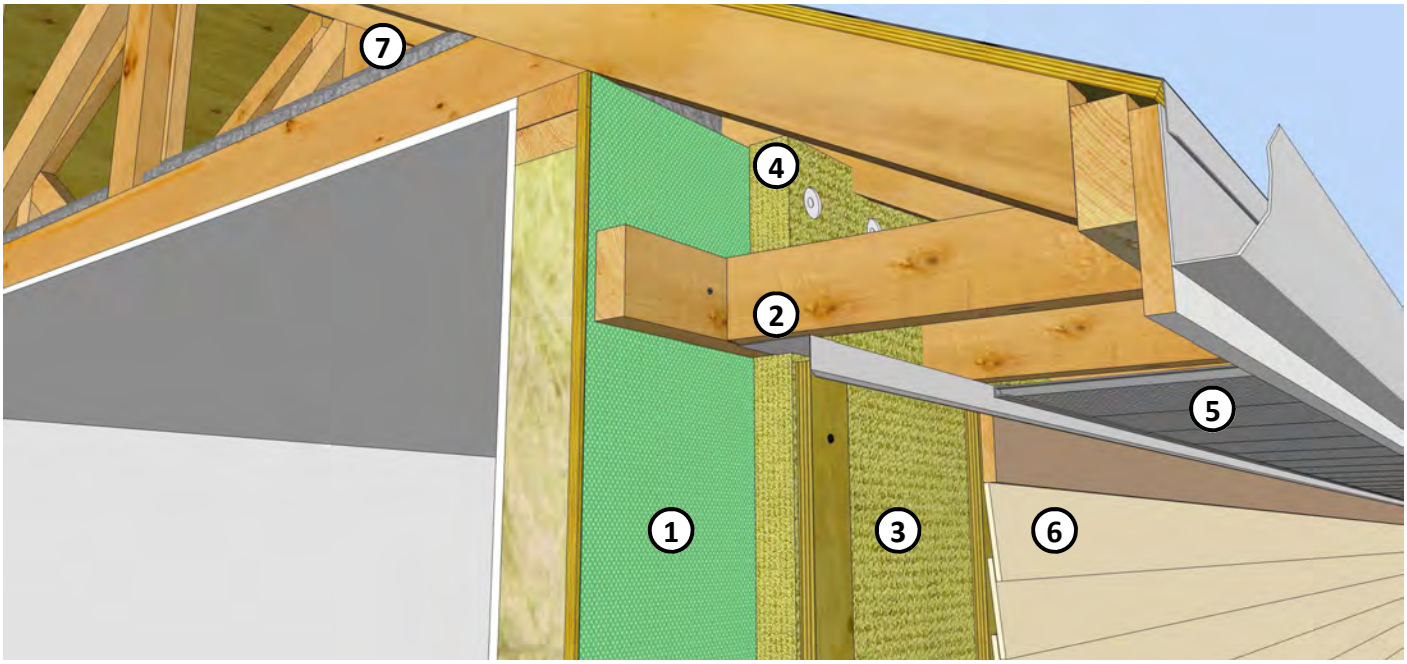
See reference documents for additional window rough opening preparation sequencing information, including other building enclosure considerations and details.

3.5.5 Above-grade Walls: Exterior Insulation

Insulating Procedure - Conceptual - Page 2 of 3

Air-barrier continuity is important at the interface between the top of the above-grade wall and the attic/ceiling plane. Special attention must be paid to this transition in order to ensure the exterior wall air-barrier ties into the ceiling air-barrier membrane/plane of airtightness. This can be achieved with exterior self-adhered membrane, sealants, or spray foam at the top of the wall framing. See Section 3.1.10 to 3.1.13 for further guidance.

Above-grade Wall at Sloped Roof Interface



DESIGN CONSIDERATIONS

1. Apply vapour-permeable air-barrier membrane (sheet, self-adhered, or liquid applied) onto the exposed wall sheathing. Install self-adhered membrane (if needed) at the top of the wall to create air-barrier continuity between the sheathing membrane and the wall sheathing.
2. Install closure flashing above the wall insulation and strapping to separate wall drainage cavity from attic ventilation inlet.
3. Place rigid mineral wool insulation over air-barrier membrane. Use pressure-treated wood strapping or plywood aligned with stud spacing where possible. Attach with screws through the insulation into the existing wall.
4. Place rigid mineral wool insulation at the top of the wall, cut to fit around soffit framing up to the roof framing. Attach with fasteners through plastic washers or strapping and screws.
5. Install perforated panel or ventilation ports at the soffit to allow ventilation into the attic.
6. Install exterior siding. Most cladding types are well supported by screws and strapping. Heavy-weight cladding like stone veneer or brick may require extra support.
7. Complete exterior insulation work in conjunction with air sealing and insulation work at the attic/ceiling plane (see Section 3.1.1 to 3.1.13).

   See reference documents for additional considerations and details.

4.1 Additional Resources

WEATHERIZATION AND BUILDERS' CONSTRUCTION GUIDES

Best Practices for Window and Door Replacement in Wood-Frame Buildings, 2013. Homeowner Protection Office, A Branch of BC Housing. Available online: www.hpo.bc.ca

Canadian Home Builders' Association Builders' Manual. 2013. Canadian Homes Builders' Association. Ottawa, Ontario. Available online: www.chba.ca/buildermanual.aspx

Energy Out West, Weatherisation Field Manual, Best Practices for the Weatherisation Assistance Program, 2005. Department of Energy—Seattle Regional Office, and Energy Outwest. Available online: www.energyoutwest.org/eow_library/__presentations_docs/_policy_specifications/EOWFieldGuide.pdf

Guide to Attic Air Sealing, 2010. Joseph Lstiburek, Building Science Corporation. Available online: www.buildingscience.com

Illustrated Guide to Energy Efficiency Requirements for Houses in British Columbia, 2014. Homeowner Protection Office. Available online: www.hpo.bc.ca

Illustrated Guide to R22+ Effective Walls in Wood-Frame Construction in British Columbia, 2015. Homeowner Protection Office. Available online: www.hpo.bc.ca

Insulate and Weatherize. 2002. Tauton Press - Build Like a Pro™ Series, author: Bruce Harley.

Keeping the Heat In, 2012. Natural Resources Canada. Available online: oee.nrcan.gc.ca

Mass Save Deep Energy Retrofit Builder Guide. 2013. Building Science Corporation. Available online: www.buildingscience.com

MATERIAL SPECIFICATIONS, CERTIFICATION and STANDARDS

Fire-rated Sealants

Required Certification - UL Certification—UL1479.

Relevant Test Methods: ASTM 814

Insulation Products

Relevant Test Methods: CAN/ULC-S701, CAN/ULC-S702, CAN/ULC-S703, CAN/ULC-S704, CAN/ULC-S705, ASTM C177, ASTM C518, ASTM C976, CFR Title 16 - Part 460, ICC-ES AC12, ICC-ES AC377, ASTM E84

Sealants for Air Sealing

Relevant Test Methods: Foam sealants: ASTM C1642, Acrylic silicone and urethane caulking: ASTM C920

Required Certification: Water based duct sealant: UL-181A-M, UL 181B-M

Tapes (for Ducts)

Required Certification: UL-181

Tapes (for Air Sealing)

Relevant Test Methods: ASTM D3330, ASTM D882

Weather-stripping

Relevant Test Methods: ASTM C509

4.1 Additional Resources

HEALTH and SAFETY

Managing Environmental Risks During a Renovation Project Builder Insight Bulletin, 2014. Homeowner Protection Office. Available online: www.hpo.bc.ca

Combustion and Gas Safety

CAN/CGSB51.71 The Spillage Test--Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel -Fired; Space Heating Appliances; Water Heaters, and Fireplaces, 2005. Canadian General Standards Board

Guide to Attic Air Sealing, 2010. Joseph Lstiburek, Building Science Corporation. Available online: www.buildingscience.com

Keeping the Heat In, 2012. Natural Resources Canada. Available online: oee.nrcan.gc.ca

Lead Paint

Lead-Containing Paints and Coatings—Preventing Exposure in the Construction Industry. WorkSafeBC Publication. Available online: www.worksafebc.com/publications/high_resolution_publications/assets/pdf/bk93.pdf

Asbestos Hazards

Asbestos Hazards When Renovating Older Homes. WorkSafeBC Publication. Available online: www.worksafebc.com

Safe Work Practices for Handling Asbestos. WorkSafeBC Publication. Available online: www.worksafebc.com

Health Canada - It's Your Health Website. www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/asbestos-amiante-eng.php

It's Your Health—Vermiculite Insulation Containing Amphibole Asbestos. Health Canada publication. Available online: www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/prod/insulation-isolant-eng.pdf

Mould and Moisture

A Brief Guide to Mold, Moisture, and Your Home. United States Environmental Protection Agency Publication. Available online: www.epa.gov/iedmold1/moldguide.html

Guidelines on Assessment and Remediation of Fungi in Indoor Environments. New York City Department of Health and Mental Hygiene. 2008. Available online. www.nyc.gov/html/doh/downloads/pdf/epi/epi-mold-guidelines.pdf

WorkSafeBC OHS Guidelines - Part 4 Indoor Air Quality. Available online: www2.worksafebc.com/Publications/OHSRegulation/GuidelinePart4.asp?ReportID=31162

Radon

Radon in Homes and Other Dwellings. HealthLink BC Publication. Available Online: www.healthlinkbc.ca

Sprayfoam Insulation

Spray Polyurethane Foam (SPF) Home—Design for the Environment, an EPA Partnership Program. United States Environmental Protection Agency. Available online: www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html

Home Ventilation

Heat Recovery Ventilation Guide for Houses, 2015. Homeowner Protection Office. Available online: www.hpo.bc.ca

TECA Quality First Ventilation Guidelines, 2008. TECA, Surrey, B.C. Available online: www.teca.ca/

Canadian Home Builder's Association Builders' Manual—Chapter 18 Ventilation Systems. 2013. Canadian Homes Builders' Association. Ottawa, Ontario. Available online: www.chba.ca/buildermanual.aspx

4.2 References

In addition to the previously noted specifications, standards and suggested further information and guides, the following references were consulted in the development of this guide:

Air Sealing Homes for Energy Conservation. 1984. Canada Energy, Mines and Resources Canada. Building Energy Technology Transfer Program. Prepared by Marbek Resource Consultants.

Building Enclosure Design Guide—Wood-frame Multi-Unit Residential Buildings. 2011. Homeowner Protection Office. Available for purchase at: www.hpo.bc.ca

Energy Conservation Assistance Program (ECAP) Program Specifications, 2013. BC Hydro and Fortis BC

Guide for Designing Energy-Efficiency Building Enclosures for Wood-Frame Multi-Unit Residential Buildings in Marine to Cold Climate Zones in North America. 2013. FP Innovations. Available online: www.fpinnovations.ca/ResearchProgram/AdvancedBuildingSystem/designing-energy-efficient-building-enclosures.pdf

Insulation: A guide for Contractors to Share with Homeowners. May 2012. US Department of Energy—Building Technologies Program. Volume 17, Building America Best Practices Series. Prepared by Pacific Northwest National Laboratory & Oak Ridge National Laboratory. Available online: apps1.eere.energy.gov/buildings/publications/pdfs/building_america/insulation_guide.pdf

Sealing caulking and weatherstripping. Manitoba Hydro. www.hydro.mb.ca/your_home/resources/1_sealing_caulking_weatherstripping.pdf

Moisture Control for Dense-Packed Roof Assemblies in Cold Climates: Final Measure Guideline. 2012. Building Science Press. Research Report 1308 - Authors Chris Schumacher and Robert Lepage. US Department of Energy & Renewable Energy Building Technologies Program. Available online: www.buildingscience.com

Near Net Zero Energy Retrofits for Houses. 2011. Canada Mortgage and Housing Corporation. Prepared by RDH Building Engineering Ltd. Available online: ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Research_Reports-Rapports_de_recherche/eng_unilingual/Ca1_MH_11N25_w.pdf

Retrofit Techniques and Technologies: Air Sealing—A Guide for Contractors to Share with Homeowners. 2010. Pacific Northwest National Laboratory and Oak Ridge National Laboratory. Available online: http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_airsealing_report.pdf

Maine Weatherization Standards. January 2005, State of Maine. Available online: http://www.waptac.org/data/files/Website_Docs/technical_tools/MaineFieldStandards.pdf

Weatherization Assistance program Standard Training Curricula. 2010. US Department of Energy. Available online: http://www.waptac.org/Training-Tools/WAP-Standardized-Curricula.aspx

Standard Work Specifications for Single Family Home Energy Upgrades. March 2013. US Department of Energy. Available online: https://sws.nrel.gov/sites/default/files/sws_singlefamily_0.pdf

Building Technologies Program. US Department of Energy. Website: www1.eere.energy.gov/buildings/residential/

Vermont's Weatherization Program Technical Policies & Procedures Manual. 2010. Vermont Department for Children & Families, Office for Economic Opportunity. Available online: http://dcf.vermont.gov/oeo/weatherization_manual

Appendices

Contractor Checklist - Home Air Sealing and Insulation Procedures

Home Address	City	Contractor

Location	Section Number	Inspection Guideline	Inspected and Acceptable	Correction Needed	Not Observed/ Not Applicable	Note
Attic and Roofs	3.1.1	Recessed pot-lights are covered				
	3.1.2	Bathroom fan and ductwork is sealed and insulated				
	3.1.3	Kitchen range, dryer vent or other duct work is sealed and insulated				
	3.1.4	Fireplace or combustion appliance duct				
	3.1.5	Masonry chimney air-sealing				
	3.1.6	Attic hatch				
	3.1.7	Top plate & service penetrations				
	3.1.8	Large openings, shafts or exposed ceilings				
	3.1.9	Attic knee wall insulation				
	3.1.10	Insulation top-up/continuous air barrier				
	3.1.11	Flash-and-fill				
Vaulted Ceilings	3.1.12	Air sealing (interior)				
	3.1.13	Interior versus exterior insulation assessment				
	3.1.14	Interior insulation installation				
	3.1.15	Exterior insulation installation				
Below-Grade Walls	3.2.1	Air sealing joints & cracks				
	3.2.2	Interior versus exterior insulation assessment				
	3.2.3	Interior insulation installation				
	3.2.4	Exterior insulation installation				
Crawl-space	3.3.1	Air sealed and insulated suspended floor				
	3.3.1	Vented to unvented assessment				
Exposed Floor	3.4.1	Air sealed and insulated overhanging floor				
	3.4.2	Air sealed and insulated exterior floors				
Above-Grade Walls	3.5.1	Air sealing penetrations				
	3.5.2	Stud bay insulation				
	3.5.3	Interior versus exterior insulation assessment				
	3.5.4	Interior insulation				
	3.5.5	Exterior insulation				

Contractor Checklist - Health and Safety

As discussed in Section 1.4 of this guide, there are various health and safety considerations for weatherization work. This page provides a checklist as a reference for contractors. The checklist does not provide comprehensive coverage of all health and safety considerations for performing this type of work as it is expected that the contractor will be adequately trained and aware of the relevant safety risks.

Potential health and safety considerations:

Ventilation while Performing Work
Many commonly-used construction materials release potentially harmful chemicals, and adequate ventilation should be provided during work to maintain the health and safety of the workers.

Ventilation of the Home
Adequate ventilation of the home should be maintained after weatherization work to maintain a healthy and comfortable indoor environment.

Radon Gas
Radon gas is a colourless, odourless gas that, when present in significant concentrations can create long-term health risks for occupants. When performing work in areas where radon is a potential concern, testing should be performed.

Combustion Safety
Weatherization work can affect the combustion safety of a home. Appropriate measures should be taken to ensure that adequate make-up air is provided for combustion appliances to avoid spillage of combustion gases in to the home.

Weatherization Materials
Common weatherization materials such as sprayfoams, sealants, and adhesives can contain various harmful substances that may negatively impact the health of both workers and home occupants. Material selection and placement, and ventilation should be considered to mitigate these potential negative effects.

Structural Elements and Connections
These elements should not be compromised during weatherization work.

Mould, Fungal Growth, and Moisture Damage
Moisture damage and associated mould and fungal growth are a significant health and building durability concern that should be addressed prior to or as part of weatherization work. It is important to address the root cause of these issues, and not only the symptoms.

Asbestos and Lead
Older building materials commonly included potentially harmful constituents such as asbestos and lead. When these materials are present, appropriate abatement strategies should be implemented.

Electrical Safety and Wiring
Care must be taken to avoid electrical hazards while performing work. Also, in some older homes knob and tube type wiring may still be active and should be removed prior to weatherization work.

Gas Safety
Qualified contractors should be retained when weatherization work requires the temporary movement or permanent relocation of gas lines or equipment.

Glossary of Terms and Materials

ACH50	The number of times the air in a space changes in an hour (air changes per hour) when the space is pressurized or depressurized to 50 Pa.
acoustical sealant	A standard sealant designed for interior use where it will not be exposed to exterior conditions that may negatively affect its performance.
air-barrier	The materials and components that together control the airflow through an assembly and limit the potential for heat loss and condensation.
air leakage	The uncontrolled flow of air though the building enclosure (i.e. infiltration or exfiltration) as the result of pressure differences and lack of enclosure airtightness.
airtightness	A measure of the air permeance of the assemblies that make up the building enclosure at a certain pressure difference. Airtightness can be visualized in terms of an equivalent-sized hole in the building enclosure. Typically, airtightness is measured at a standard test pressure of 50 or 75 Pa to overcome the effects of wind and stack effect, and to obtain a repeatable measurement.
assembly	The arrangement of more than one material or component for the purpose of performing specific overall functions.
ASTM	American Society for Testing and Materials
AT rated	A designation for electrical appliances that identifies them as airtight.
batt insulation	Typically relatively low-density fibrous insulation and designed for installation between studs.
BCBC	British Columbia Building Code
below-grade	The portion of a building that is below the ground surface level.
bottom plate	The lower horizontal member of a wood-frame wall on that the bottom of the wall studs and the floor-framing members rest. Also called a sill plate.
building enclosure	Referred to in building codes as one type of environmental separator, it comprises the parts of the building that separate inside conditioned space from unconditioned or outside space while facilitating climate control. Also referred to as a building envelope.
cellulose insulation	Insulation made from processed wood fibers, commonly used as blow-in insulation in attics or between studs.
combustible construction	Construction that does not meet the requirements for non-combustible construction.
condensation	The appearance of moisture on a surface caused by air coming into contact with a surface that is at or below its dew point.
detail	A location in a building enclosure assembly where the typical assembly construction is interrupted by a penetration of the assembly or by interfaces with an adjacent assembly.
dew point	The temperature at which air is saturated with water vapour (100% relative humidity, or RH). An adjacent surface at a temperature lower than the dew point will lead to the formation of condensation on the surface.

Glossary of Terms and Materials

drain mat	A sheet typically consisting of dimpled plastic or similar that facilitates the drainage of water between adjacent materials.
drying	A water management principle that utilizes features and materials to speed diffusion and evaporation of water from materials that get wet in an assembly.
EEM	Energy Efficiency Measure
extruded polystyrene insulation (XPS)	A rigid foam plastic insulation product that can be used in various applications including those where airtightness is required (when joints appropriately sealed).
fire-resistant silicone sealant	A silicone sealant designed specifically for use in high temperature applications. These sealants are commonly used as part of fire and smoke control strategies.
foil tape	Tape with aluminum facer that can be used for air sealing. The aluminum facer can also provide a suitable substrate for application of sealants.
gypsum drywall (gypsum wall board)	Gypsum boards typically faced with paper for interior applications (other facers available for exterior applications), which can be used as part of an air-barrier system and is also widely used to provide interior finishing.
HDD (Heating Degree Days)	Heating Degree Days is a measure that is intended to indicate the relative demand for heating of a building. It is derived from the exterior temperature and the amount of time for which the temperatures occur.
insulation baffle	Insulation baffles are typically preformed foam plastic products and are used at soffits to maintain ventilation space between the roof sheathing and attic insulation so that the insulation does not restrict ventilation of the attic space.
penetration	An intentional opening through an assembly for duct, electrical wires, pipes, fasteners, etc., to pass through.
polyethylene sheet	Plastic sheet commonly used as a vapour barrier, and in some applications may also be used as an air-barrier when appropriately sealed.
polyurethane sealant	Urethane-based sealant that can be suitable for both air- and water-sealing applications.
relative humidity (RH)	The ratio of the amount of water vapour in a volume of air to the maximum amount of water vapour that volume of air can hold at a given temperature.
sealant	An elastomeric material that is used to form an airtight (or waterproof) bond at a joint of opening.
sheathing	A material that is used to provide structural stiffness to the wall framing and structural backing to the cladding and sheathing membrane. Oriented strand board (OSB) or plywood is typically used.
sheathing tape	Tape typically used for air sealing of the joints between sheet and board products.
sill plate	See bottom plate.

Glossary of Terms and Materials

spray polyurethane sealant/foam (SPF)	A urethane-based spray-applied foam plastic product used for air sealing and insulation, and in some cases also used as a water resistant barrier. This product comes in two primary types: open-cell and closed-cell, which are also commonly referred to as half-pound and two-pound foams (corresponding with their densities per cubic foot), or one-part and two-part foams. Open-cell foams are typically most applicable for the air sealing of relatively small openings, and relative to closed-cell foams, open cell foams expand more when applied, and are more flexible and more vapour-permeable once they are cured. Closed-cell foams are most applicable for larger applications such as insulating between floor joists and other large penetrations. Closed-cell foams are typically vapour impermeable.
stud	A vertical framing member used in walls and partitions.
TECA	Thermal Environmental Comfort Association
VOC	Volatile Organic Compound
vapour retarder	A material with low vapour permeability that is located with an assembly to control the flow of water vapour. Also sometimes referred to as the vapour barrier.
vapour-retarding paint	Typically interior paint that is relatively vapour impermeable (approximately <1 perm).
ventilation	The process of supplying air to or removing air from a space for the purpose of controlling air–contaminate levels, humidity, or temperature in the space.