

# Keeping the Heat In

## 5 Roofs and attics

### 5.1 General considerations for all attics

### 5.2 Easily accessible attics

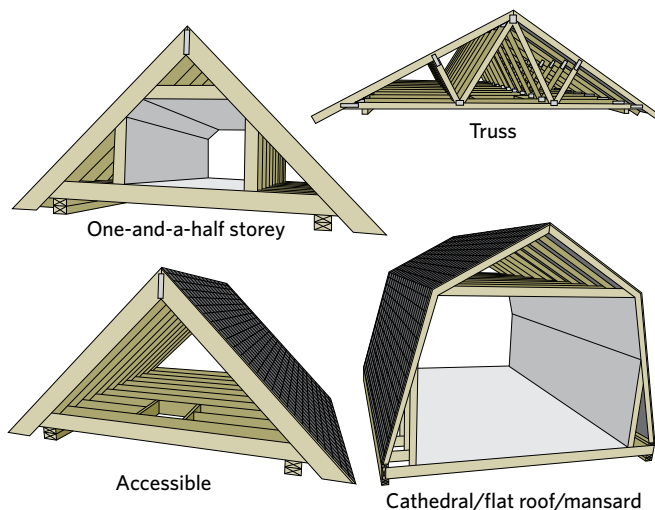
### 5.3 Houses with half storeys

### 5.4 Cramped attics, cathedral ceilings and flat roofs

### 5.5 Ice dams

### 5.6 Renovations and repair

**Figure 5-1** Types of attics



## ROOFS AND ATTICS

Relatively easy access has made the attic a favourite starting point to insulate for many homeowners, despite the fact that most other areas, such as basements and uninsulated walls, lose more heat than the typical attic. Even if an attic is already insulated, there may still be an opportunity to improve the energy efficiency and soundness of the house through air sealing. Air leaks into the attic can account for substantial heat loss and can lead to a variety of moisture-related problems.

The importance of air sealing cannot be overstated. Read this entire chapter if you are upgrading your attic for helpful tips and other relevant information.

## 5.1 GENERAL CONSIDERATIONS FOR ALL ATTICS

Regardless of the type of attic or ceiling your house has, there are a number of things to examine before beginning work. A thorough inspection of the following features will help you to develop your retrofit strategy.

### *Accessibility*

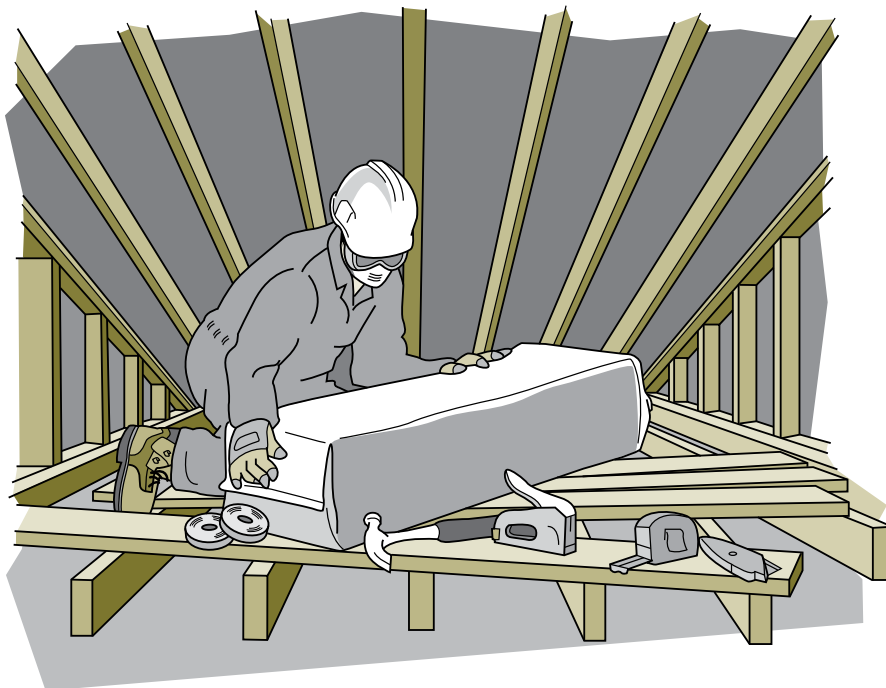
Most houses with accessible attics have an interior ceiling hatch, although exterior roof or wall-mounted entries are not uncommon. A hatch should be large enough to allow you to bring in materials. If not, or if there is no access, you may be able to cut a hole in the ceiling in an inconspicuous place such as a closet. Exterior-mounted, gable-end entries represent one less opening that will have to be air sealed, which offers ready access to firefighters in the event of a fire.

Check the roof space for obstructions and ease of movement. Vertical clearances of less than 1 m (39 in.) will not allow you to move freely. Attics or roofs without a working space are covered later in this chapter, in Section 5.4, Cramped attics, cathedral ceilings and flat roofs.

### *Assessments*

In addition to checking for structural problems, check the condition of the roof framing, sheathing, finish and the soffit and fascia for signs of moisture problems such as leaks, stains, mould, flaking or rot. Uncorrected moisture problems will reduce the effectiveness of insulation and can lead to structural damage such as wood rot or split rafters. Mould or rot are sure signs of advanced condensation problems. Identify the cause and correct it before adding insulation.

**Figure 5-2** Some attics are easier to work in than others



Moisture can come from the outside due to failure of the roof or flashing. Typical problem areas include poor flashing at a hip, valley or the chimney and ice dam leaks. Pay particular attention to water marks on the underside of the sheathing or along rafters.

Moisture can also come from inside the house, carried into the attic as water vapour by air leakage. Typical problem areas occur around bathroom and kitchen vents that penetrate the ceiling, around plumbing stacks and chimney chases and at wiring penetrations and pot lights. A tell-tale sign of air leakage is the discolouration of insulation, so do not hesitate to look under existing insulation to locate air leaks.

Check the attic during or just after a cold snap for condensation buildup, which will appear as frost in cold climates. Some frost buildup is to be expected, but if it is particularly heavy buildup (10 mm [2 in.] or more), look to make sure ventilation is present and not blocked with insulation. Checking the attic during or just after a rainstorm will help determine whether moisture problems are generated by interior or exterior sources.

Examine the existing insulation for type, condition (dry, wet, compact, etc.), average depth and coverage. If it has been damaged or contaminated by mould or vermin, remove it. However, do not disturb vermiculite insulation (see Section 1.4, Health and safety considerations).

If the insulation is wet, do not cover it until the source of moisture is removed and the insulation is dry. If the insulation is dry, it will probably be all right to leave it in place. Generally, there is no problem in using two types of insulation. Check the depth of the insulation to determine its insulating value. Compare this with the recommended insulation values in Section 2.2, Control of heat flow.

Make sure that the insulation is distributed evenly and that there is full depth coverage, especially around the perimeter of the attic above the wall plates. Uninsulated areas will cause a cold spot where the wall and ceiling meet, which can lead to moisture and mould problems.

### ***Existing air and vapour barriers***

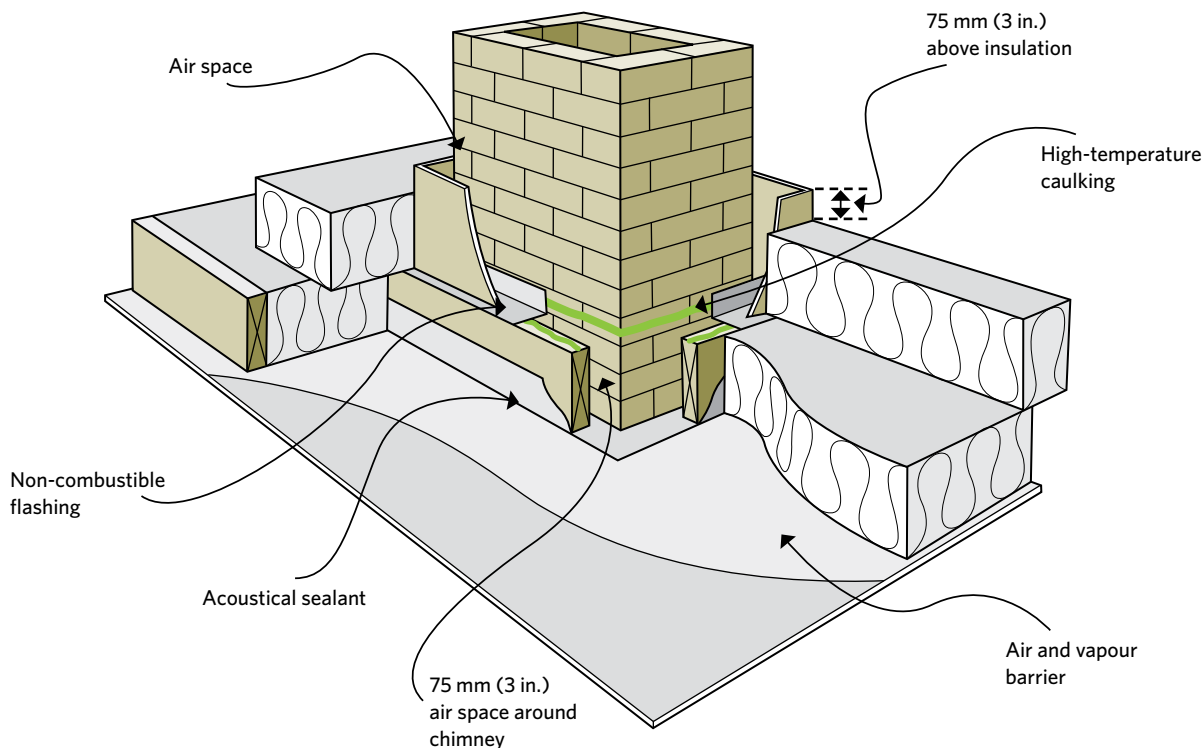
Houses should have a vapour barrier on the warm side of the insulation. In older homes, the vapour barrier might have been provided by wax paper, kraft paper-backed batts or layers of paint. Newer houses usually have a polyethylene sheet vapour barrier, but overall, very few houses have an effective air barrier.

If there is an air barrier, locate it and determine its condition. Remember, an air barrier must be continuous; holes or tears must be repaired, and penetrations sealed. Do not hesitate to pull back existing insulation where leakage sites might be found and seal these areas. However, do not disturb vermiculite insulation as previously warned.

Increased insulation means a colder attic, which in turn means that any vapour escaping into the attic can condense before it can be vented. It is essential to air seal the attic to prevent moist indoor air from getting in.

If there is no air and vapour barrier, concentrate on comprehensive air sealing. Create an effective air barrier by using caulking, gaskets and weatherstripping to seal the joints between building components. Do not rely on batt, blown-in or poured insulation to reduce the need for proper air sealing.

**Figure 5-3** Keep combustibles away from a masonry chimney



### 5.1.2 Fire and other hazards in attics

**SAFETY WARNING:** Certain areas in the attic can pose serious fire and health hazards. Before air sealing and insulating an attic, ensure you or your contractor address the following health and safety concerns.

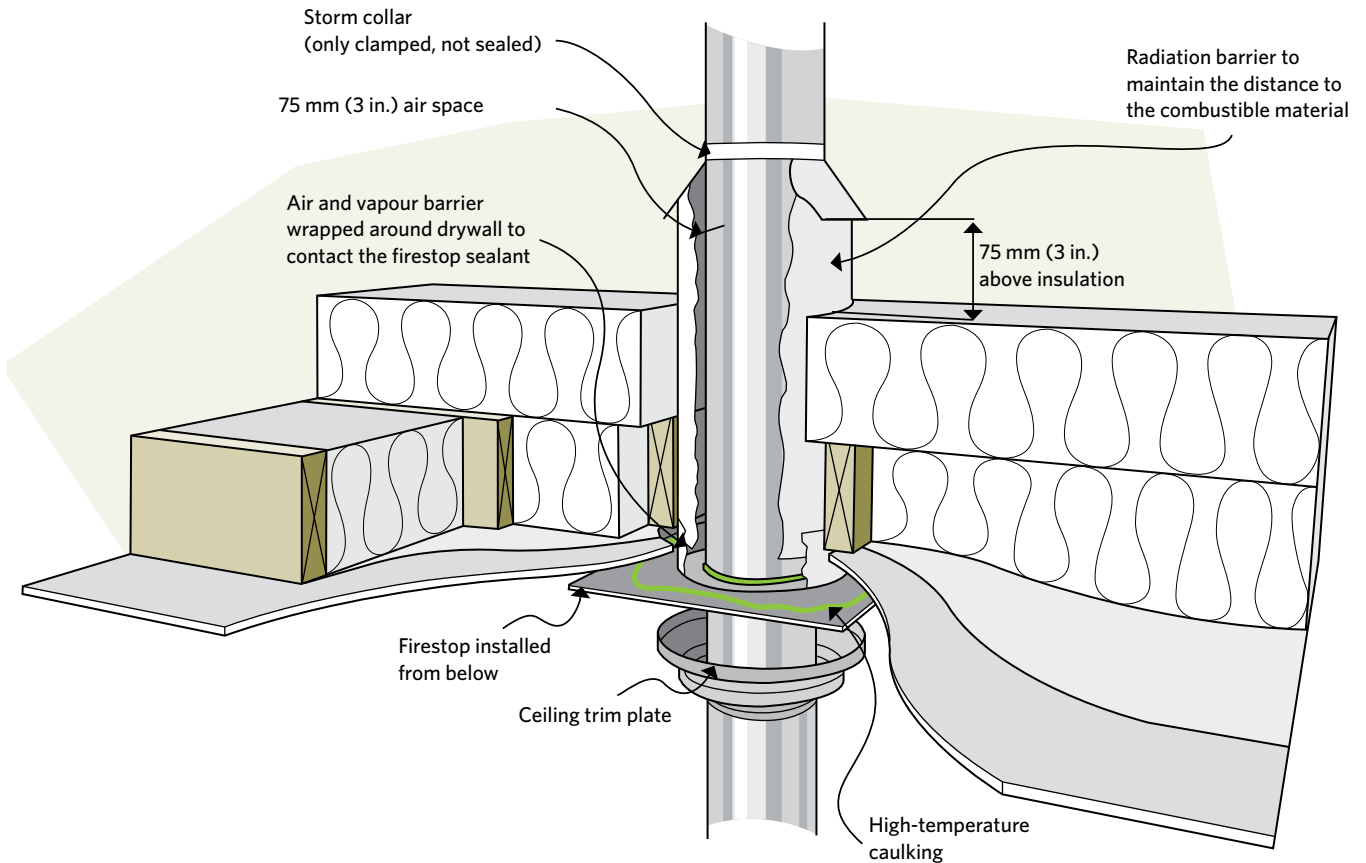
#### *Masonry chimneys*

Check the chimney and surrounding framing for signs of charring, soot deposits, crumbling masonry or mortar, or evidence that the chimney lining is

deteriorating. Do not insulate it if the chimney is suspect. Have a chimney specialist repair, seal and insulate it at the same time.

Commonly a gap exists where a masonry chimney passes through the attic. To air seal this area, first install sheet metal flashing to bridge this gap and then seal all the joints with a non-combustible sealant (ensure the product is rated for this application). To prevent insulation, especially blown-in insulation, from coming into contact with the chimney, construct a barrier 75 mm (3 in.) from the face of the masonry chimney and a minimum 75 mm (3 in.) higher than the top of the insulation.

**Figure 5-4** Keep combustibles away from a metal chimney

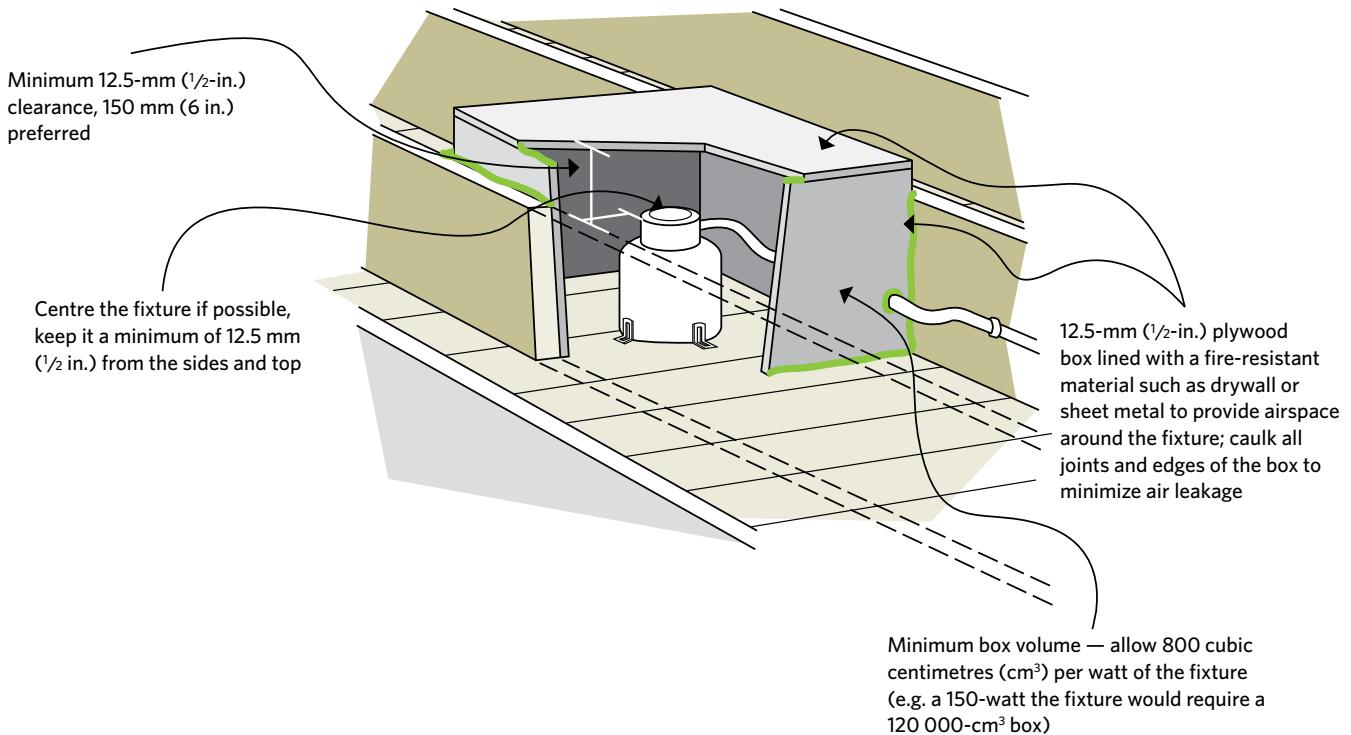


### ***Metal chimneys***

Factory-built metal chimneys should be kept from contacting insulation by a minimum 75 mm (3 in.) unless otherwise specified by manufacturer or local authorities. Install a non-flammable radiation shield that maintains a 75-mm (3-in.) air space between the chimney and insulation. To reduce air leakage, first air seal the fire stop to the air and vapour

barrier with non-combustible sealant. The top of the radiation shield should also be a minimum of 75 mm (3 in.) higher than the level of existing or new insulation to be added. To prevent insulation from falling behind the shield, attach a clamp-type storm collar without sealant at the top of the radiation shield.

**Figure 5-5** Keep insulation away from a recessed light fixture by creating a barrier



### *Electrical installations*

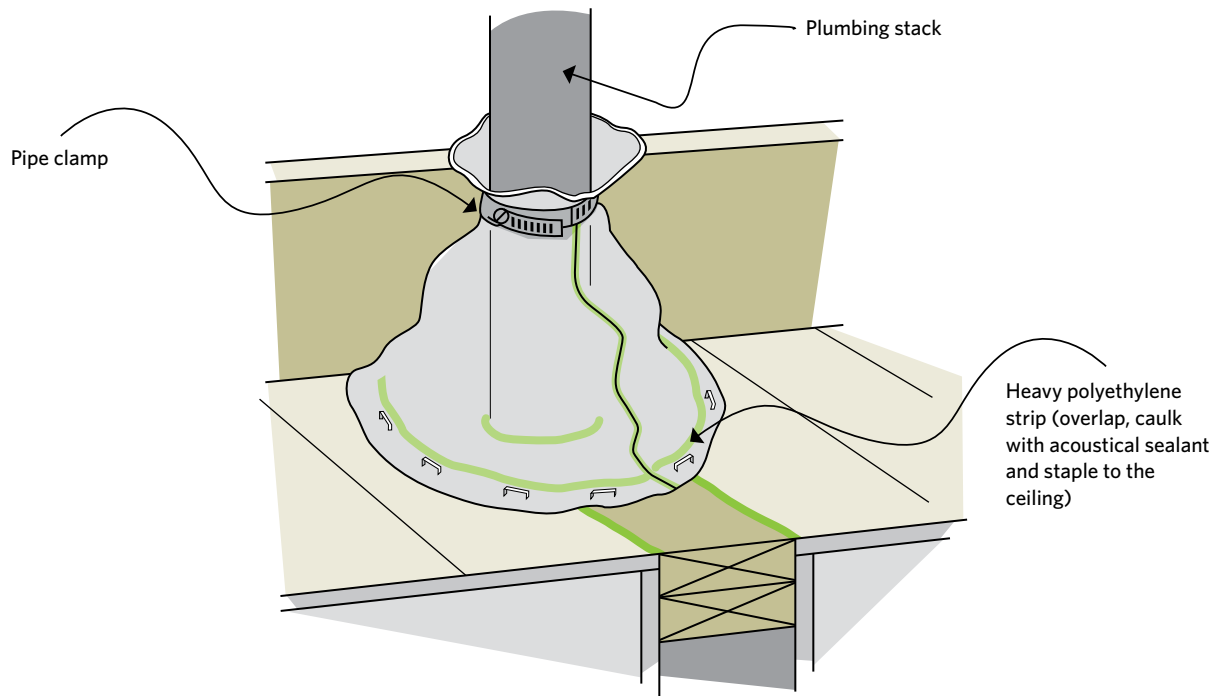
Work safely around electrical wiring (turn off the power). Consult with an electrical contractor if questionable wiring or corroded electrical connections are present.

### *Recessed lighting*

Standard interior recessed lights are difficult to air seal effectively and can become a fire hazard if covered with insulation. Replace with approved airtight recessed fixtures or covers that can be installed safely under insulation.

### *Animal droppings*

If you find a significant amount of animal droppings and vermin in the attic, do not disturb them because they can harbour easily airborne moulds, parasite eggs and bacteria that can cause severe illness. See Section 1.4, Health and safety considerations, for more information.

**Figure 5-6** Sealing the plumbing stack

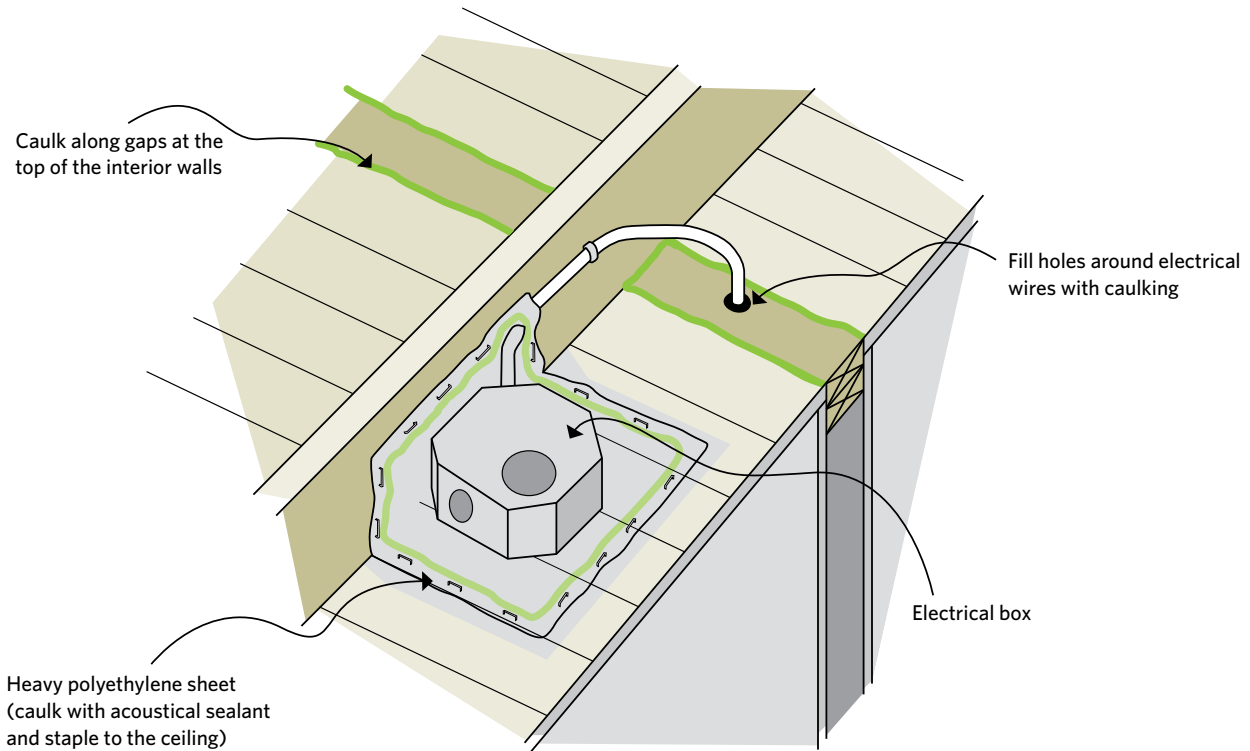
### 5.1.3 Air sealing

Seal the following areas:

- Around the plumbing stack and any other pipes. For plastic plumbing stacks that move up and down due to thermal expansion, use a flexible gasket or a polyethylene sleeve sealed to a plywood collar (see Figure 5-6).
- Around wires or ceiling light fixtures that penetrate the attic floor and partition and exterior wall top plates (see Figure 5-7 and Figure 5-8.) See Section 5.1.2, Fire and other hazards in attics, on how to deal with recessed lights.
- Around ducting that enters the attic from inside the house. Seal duct joints with aluminum duct tape or paint or mastic. Seal the gaps where ducts penetrate the ceiling. The ducts should stay below the insulation or should be wrapped with insulation and be protected from being crushed. Exhaust fans should always discharge to the outside but not directly below the eave vents.
- At the junction of the ceiling and interior wall partitions, pull back the insulation to locate and caulk cracks along interior walls (see Figure 4-4).
- At the top of interior and exterior walls, check to see if all wall cavities are blocked from the attic (usually by a top plate). Block any open spaces in the exposed cavity with a piece of rigid board insulation and caulking. If the top plate is cracked or poorly fitted, use caulking and polyethylene to create a tight seal (see Figure 5-7).

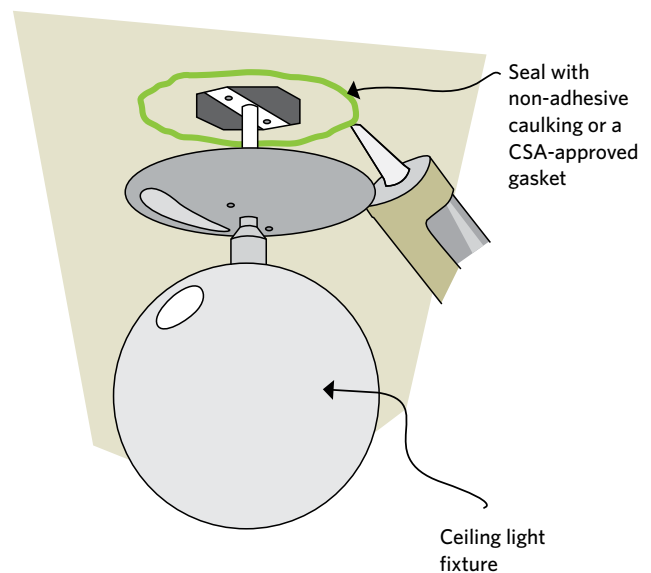
**Figure 5-7** Sealing an electrical box

(Note: See Figure 5-5 for the special case of recessed lighting electrical boxes.)



- Around attic hatches (see Figure 4-7).
- Around the chimney. Building codes require that air spaces between chimneys and floor or ceiling assemblies through which they pass be sealed with a non-combustible fire stop (see Figure 5-3 and Figure 5-4).
- Along the edge of shared walls. There is often a gap between the party wall (i.e. the shared wall between units in duplexes, triplexes and row houses) and the edge of the attic floor. Ensure that this gap is well sealed. If you suspect that air is leaking up and out of a party wall made of concrete blocks, hire a contractor to seal the blocks.

**Figure 5-8** Sealing a light fixture on the ceiling





### 5.1.4 Ventilation

Attic ventilation serves a number of purposes. It reduces summer heat buildup, prolonging the life of roofing and reduces air conditioner loads. After air sealing, attic ventilation is your second line of defence against the water vapour that may have found its way into the attic. It ensures a colder, well-ventilated attic space less prone to the formation of ice dams at the eaves.

Houses with peaked roofs and accessible attics are the easiest to vent by using the ratio of 1 to 300 (see below). This ratio refers to unobstructed vent area, so it must be increased if vents are covered with screening (to keep out insects, etc.) and with baffles (to keep out rain and snow), which reduce their clear area. Ideally, locate vents to allow for good cross ventilation from end to end and from top to bottom. However, although important, vents will not prevent condensation and will not solve the problems created by air leakage.

Make sure that existing attic vents are working properly and not blocked by insulation, debris or other materials. You may have to locate roof or soffit vents from outside if they are not clearly visible from inside the attic.

Although an airtight ceiling will significantly reduce the likelihood of moisture in the attic, building codes still require minimum attic ventilation. The ratio of vent area to ceiling area should be approximately 1 to 300.

Do not automatically increase ventilation. Also, do not use electric exhaust fans for attic ventilation as these can draw more air than can be supplied through the soffit vents. This will actually pull house air into the attic, resulting in greater heat loss and moisture accumulation. They are also prone to failure, noise production and increased energy use. Wind-driven, revolving roof vents do not create suction and are no more effective than other types of capped vents.

The location of vents is as important as their number and type. Often, a mixture of types and locations will work best. The following sections detail the best approach depending on your attic type.

## 5.2 EASILY ACCESSIBLE ATTICS

After you have inspected the attic and carried out any remedial work, focus first on air and moisture control.

### 5.2.1 Air and moisture control

There are five options for installing an air barrier system in an unfinished attic:

- concentrate on air sealing
- install polyethylene over top of the joists
- install polyethylene between the joists
- spray foam between the joists (hire a contractor)
- spray foam under the roof to create a conditioned attic (hire a contractor)

The first option is the most practical, since installing a polyethylene air and vapour barrier in an existing attic is fraught with obstructions and requires painstaking attention to detail. On the other hand, spray foam offers air sealing and an initial layer of high quality insulation that can be topped up to the desired RSI (R) level.

If the attic retrofit is being completed in conjunction with interior renovations, the easiest approach is to install a new, single air and vapour barrier on the underside of the ceiling joists.

### 5.2.2 Concentrate on air sealing

It is a good idea to paint the room side of the ceiling with two coats of oil-based paint or apply a single coat of latex vapour barrier paint to inhibit vapour movement. Ordinary latex paint is not a suitable vapour barrier.

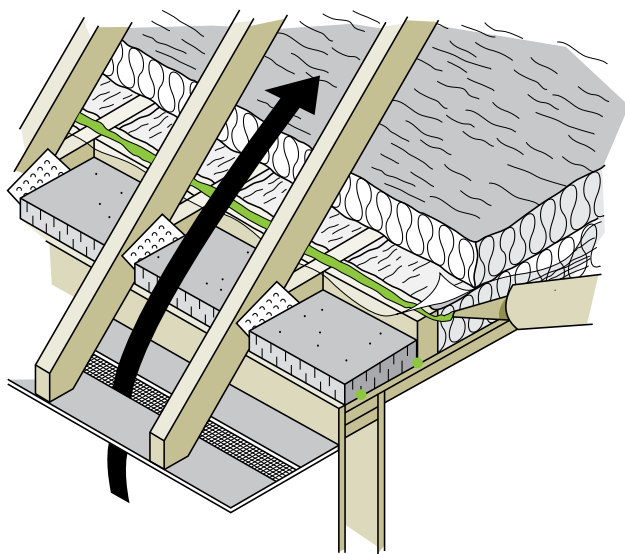
See Chapter 4, “Comprehensive air leakage control,” for detailed information on sealing all air leaks into the attic.

### ***Install polyethylene over top of the joists***

If the attic is relatively unobstructed with chimneys, plumbing stacks or structural members, consider installing polyethylene directly over the ceiling joists. This method involves the least number of seams and requires less caulking and stapling than other methods. It also leaves existing insulation in place. However, seal all obvious air leakage paths before laying down the polyethylene.

To avoid trapping moisture between the plastic and the ceiling, which might lead to possible wood rot or other moisture-related problems, install a minimum of twice the insulating value over top of the air vapour barrier (i.e. applying the one-third, two-thirds rule). For example, if the joist height is 89 mm (3 1/2 in.) and contains RSI 2.1 (R-12), install at least RSI 4.2 (R-24) over top of the polyethylene.

**Figure 5-9** Installation of polyethylene sheets over attic joists



Rigid foam board at the eaves to maintain ventilation space

The main difficulty with this technique involves sealing the barrier to the wall top plate, especially at the eaves where there is little room to manoeuvre. This area must be well sealed. Spray foam or rigid board insulation can help bridge the gap in this area. Cut rigid board to fit between the ceiling joists and to extend from the exterior wall top plate toward the attic. A second piece of rigid insulation, installed vertically, joins the polyethylene to the horizontal rigid board. Carefully caulk any joints or seams between materials. Expanding two-part spray foam kits (or the service of a spray foam company) are also very good for sealing areas around joists and boards.

### ***Install polyethylene between the joists***

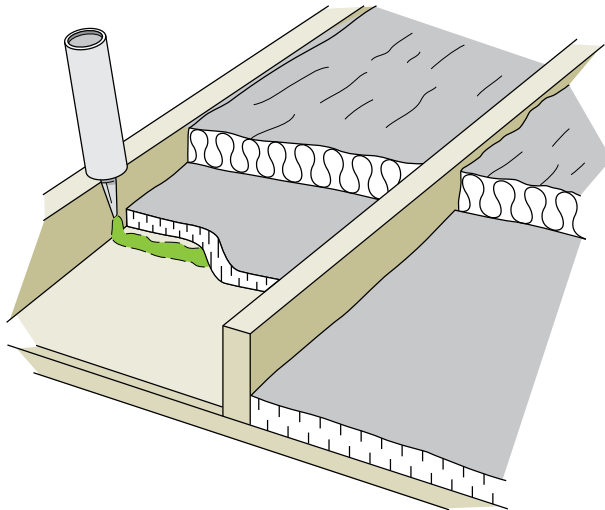
Where obstructions, such as a truss roof, make the previous method too difficult, install a polyethylene air barrier or low-permeable foam insulation board between the joists. However, note that this is a lengthy and painstaking process.

Remove existing insulation from the area you are working on and set it to one side. Cut foam boards to fit snugly between the trusses. Caulk all edges, gaps and joints. Obstructions, such as electrical wires, will require cuts in the barrier; seal these carefully to make the barrier continuous. Another option is to cut the polyethylene strips about 200 mm (8 in.) wider than the joist spacing. Lay a bead of caulking on the side of the joists along their length and install the polyethylene using staples, installed through the caulk every 75 mm (3 in.) See Figure 5-10.

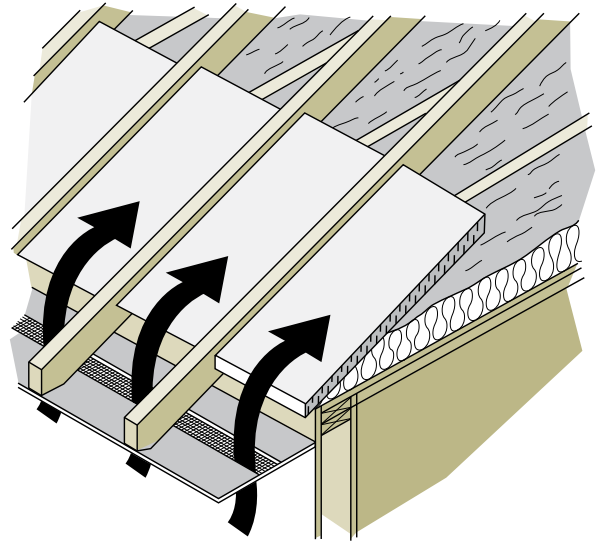
### ***Spray foam between the joists***

Spray foam contractors can install closed-cell foam between the joists to air seal and add insulation at the same time to the ceiling. All existing insulation and dust must be removed first to allow for a good bond. A minimum of 50 mm (2 in.) is needed; top up with other insulation afterwards.

**Figure 5-10** Foam board laid between the joists and caulked as an air and vapour barrier



**Figure 5-11** Baffles can be used to maintain airflow through the soffit vents



### *Spray foam under the roof*

This approach involves installing closed-cell spray foam directly under the roof surface, right down to the junction of the ceiling and exterior walls. This eliminates roof venting and creates what is called a hot roof, where the attic space becomes part of the conditioned (heated and cooled) house space. This process may be suitable for some attics, but do not proceed without approval from your building inspector, and then only use a certified spray foam contractor who is familiar with the process.

### **5.2.3 Installing insulation**

Common materials for use in accessible attics are batt or blanket types or loose-fill insulation. If there are obstructions above the joists, such as with a truss roof, it may be easiest to put batt insulation into the joist spaces and then use loose-fill insulation to create a complete blanket of insulation above the joists and around all obstructions. Loose-fill insulation is also good by itself, especially in irregular or obstructed spaces.

### *Batt or blanket insulation*

Fit batt insulation into place between the ceiling joists snugly, without compression. If the joist space is not the standard 16 or 24 in. (400 or 600 mm), cut the batts to fit the space or use loose-fill insulation.

Additional installation tips:

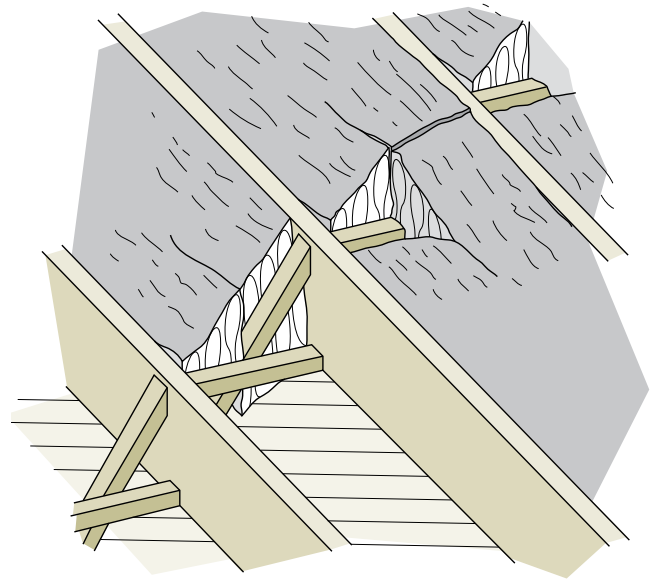
- Butt batt ends together as snugly as possible.
- Batt should cover the top plate of the exterior wall but not block the venting. To maintain airflow, leave a space of 38 to 50 mm (1½ to 2 in.) between the top of the insulation and the underside of the roof sheathing. Use baffles between each rafter space to prevent it from being blocked (see Figure 5-11).
- Insulate above and below cross bracing, splitting or cutting the batt to accommodate the cross bracing as illustrated in Figure 5-12. Alternatively, cut one batt into a series of wedges and then fit a wedge under each brace. In either approach, do not compress the insulation.

- The first layer of batts should be thick enough to completely fill to the top of the joist space. The second layer can then run perpendicular across the joists to block any heat flow through and around the joists (see Figure 5-13). Ensure that there are no gaps between the two layers of insulation.
- Fill any awkward spaces or gaps with pieces of batt or with loose fill.
- Apply blanket insulation in the same way as batts. It may be pre-cut with a knife or cut on the spot. Start at one end of the attic and unroll the blanket.

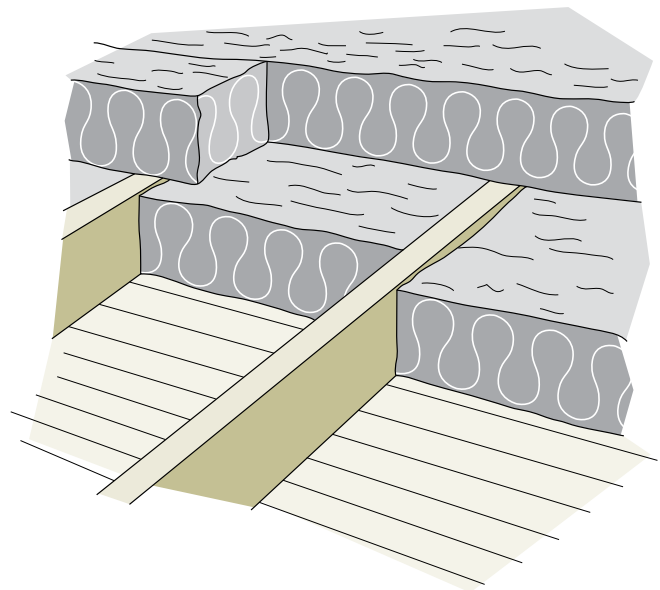
### ***Loose-fill insulation***

- Loose-fill insulation can be poured by hand or blown in on top of the air and vapour barrier to a depth greater than the height of the joists. This task can be done by the homeowner using rented equipment or by a qualified contractor.
- Before adding insulation, nail enough depth indicators (e.g. a piece of wood nailed perpendicular to the joist) or mark highly visible lines on truss members so you can easily see and gauge the depth of the insulation. Maintain an even depth throughout the attic by levelling the insulation with a board or garden rake (see Figure 5-14).
- Fill all nooks and crannies.
- At the eaves, do not block the ventilation. Prevent insulation from disappearing into the eave space by installing a piece of rigid board insulation or a wood baffle before the work begins. Building-supply stores sell cardboard or foam plastic baffles that can be stapled between the rafters (see Figure 5-11). Be sure that the insulation extends out far enough to cover the top of the exterior wall.
- If the loose fill is deeper than the joists, build insulation framework (a crib) around the attic hatch so that it can be filled to the edge (see Figure 4-7).

**Figure 5-12** Fitting insulation around cross bracing



**Figure 5-13** The top layer of insulation runs perpendicular to the bottom layer



**Figure 5-14** Installing loose-fill insulation



Note the markers that indicate the final depth of the insulation.

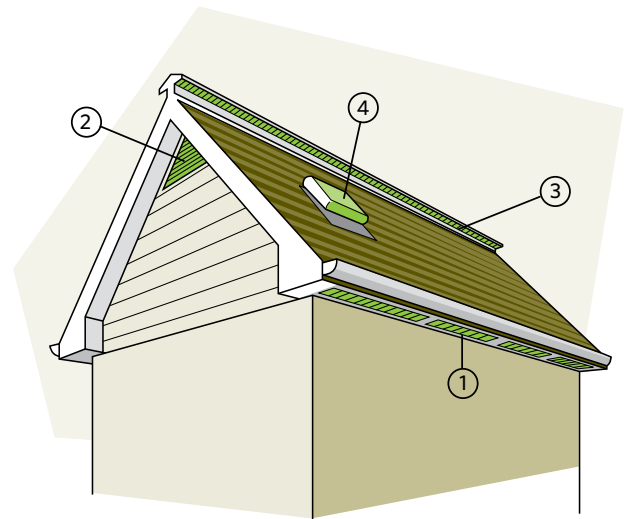
- The bags of insulation material will list how many square metres (or square feet) each bag should cover to provide the required RSI value. Calculate the attic area to help determine the number of bags needed.
- If you are having a contractor do the work, calculate the RSI value that you want and check the bags of insulation to be used. They should indicate the area that one bag will cover at the selected insulating value. You and the contractor should then agree on the total number of bags to be used, the expected insulating value and the minimum settled depth of insulation throughout the attic, based on a specific density.
- Remember to seal the attic hatch (see Figure 4-7).

- Seal and insulate up to party walls in attached housing (see Section 5.1, General considerations for all attics).
- Do not cover recessed light fixtures unless they are installed in approved covers.

### 5.2.4 Ventilation

Ideally, 50 percent of the attic ventilation openings should be continuous soffit vents, and the other 50 percent gable, ridge or roof vents. Figure 5-15 shows various types of vents. Any of them are adequate when used in conjunction with soffit vents. Ridge vents are preferable where practical, but must be equipped with baffles to deflect wind blowing up the roof and to prevent the penetration of water and snow. Occasionally, a house will only have soffit vents. In this case, install gable end, ridge or roof vents to take advantage of cross ventilation.

**Figure 5-15** Roof venting



Different types of ventilation

- |                   |               |
|-------------------|---------------|
| 1. Soffit vents   | 3. Ridge vent |
| 2. Gable end vent | 4. Roof vent  |

## 5.3 HOUSES WITH HALF STOREYS

Houses with 1 ½ or 2 ½ storeys have attics with several small sections that may make access, air sealing and insulating very difficult. If you cannot get into these spaces, you may have to hire a contractor. If the space is accessible, the following section gives some guidelines on how to do the work yourself.

### 5.3.1 Air and vapour control

Where you have access to the attic space, follow the directions for the control of air and vapour flows as outlined in Section 5.2, Easily accessible attics.

Houses with half storeys have one major source of air leakage that must not be overlooked: through the ceiling joists immediately beneath the knee walls

(see Figure 5-17). This critical air leakage area must be sealed flush with the back of the knee wall finish. This can be done by cutting and fitting foam board that will fill that ceiling joist opening and seal it into place with caulking or spray foam.

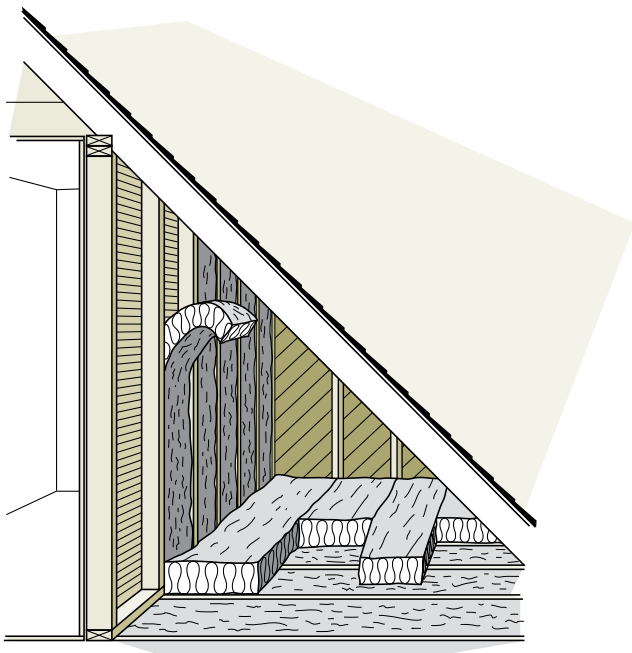
Another option may be to dense-pack loose-fill insulation between the floorboards and the ceiling below while ensuring that an air barrier is installed.

### 5.3.2 Ventilation

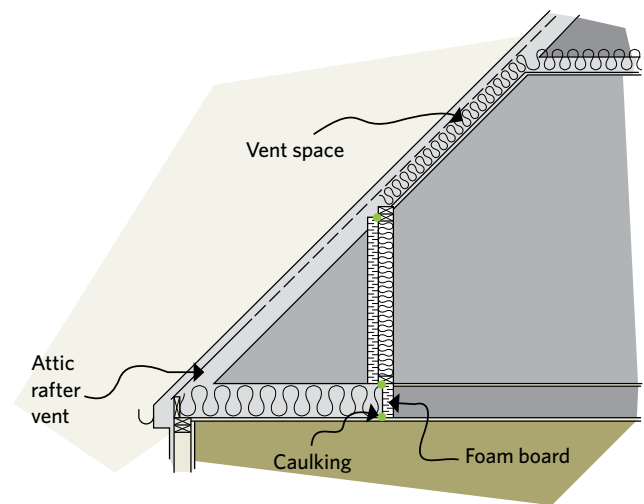
Ventilate the attic spaces above and beside the top storey separately by using gable vents. Position the vents to prevent wind from blowing through the insulation.

A second option is to use gable vents in the area above the attic ceiling and eave vents in the side areas. This is a good option if the house already has working eaves vents (see Figure 5-19). A ventilation space in the rafter section will permit airflow between the insulated areas.

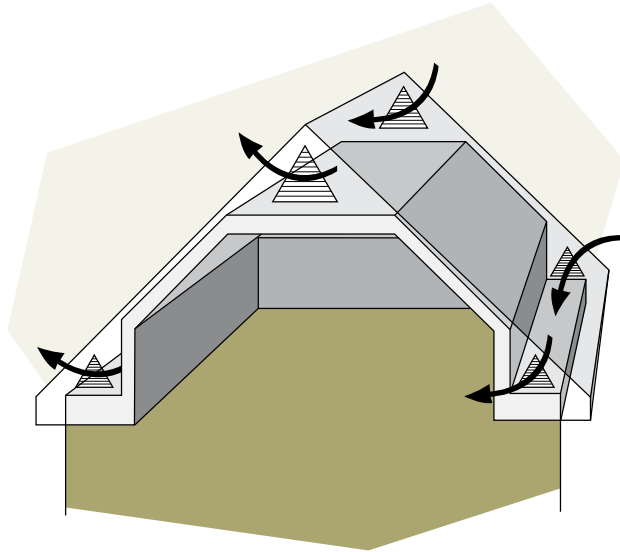
**Figure 5-16** The wall and floor sections of a half storey should be insulated



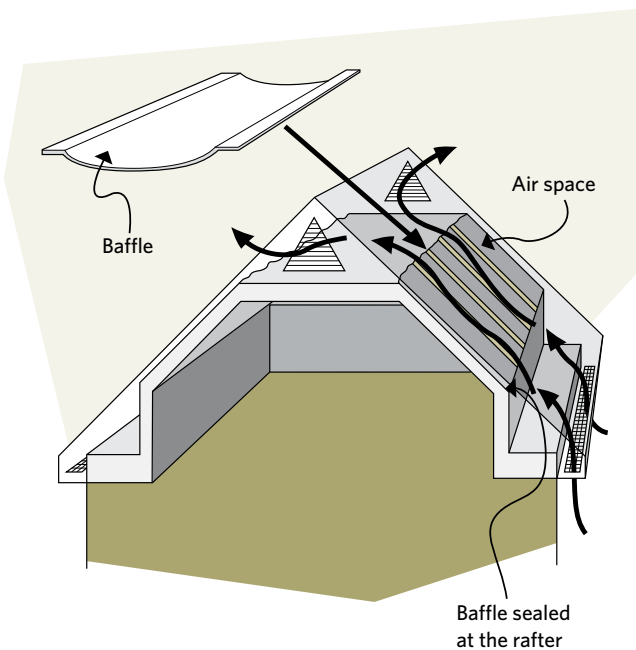
**Figure 5-17** Rigid insulation can be nailed over the studs of the knee-wall section



**Figure 5-18** Each section has its own cross ventilation



**Figure 5-19** Ventilation occurs between sections through attic rafter vents installed in the rafter section



Otherwise, you will have to install rafter vents in the section along the rafters to ensure adequate ventilation (see Figure 5-18 and Figure 5-19). These vents must be on the cold side of the space, while the warm side can be filled with insulation that can be added to the sloping ceiling portion unless other arrangements are made in the renovation process.

### 5.3.3 Insulation

Spray foam and rigid foam insulation can be used, but batts are less expensive and easier to handle in confined spaces. If there are any electrical outlets (use care to avoid shocks – and also take this opportunity to upgrade wiring in this area) or pipes in the knee wall, keep them on the warm side of the air and vapour barrier and insulation, and seal the air and vapour barrier around them.

- Treat the attic floor behind the knee wall and the attic space above the half storey's ceiling (see Figure 5-17) exactly as described previously for a standard, unfinished attic; in addition, add air sealing under the knee wall.
- Treat end walls as described in Chapter 7, "Insulating walls." (End walls are the full-height walls that are exposed to the exterior.)
- The knee wall can be treated like an unfinished attic floor (see Figure 5-9), making allowances for the fact that it is vertical. Install a combination air and vapour barrier made from polyethylene strips sealed between each stud. Sealing all cracks and penetrations and painting a vapour barrier on the interior surface also can create the air barrier. Next, install the insulation and secure it in place with building paper, cardboard, olefin sheets or chicken wire. Better yet, nail 25 mm (1 in.) or more of rigid board insulation to the exterior side of the studs to hold the insulation. This will also increase the thermal resistance of the wall section and reduce thermal bridging. A wall in the attic that adjoins a heated space can also be insulated like a knee wall.
- The section between the rafters may be filled with insulation if all penetrations through the ceiling

are sealed and if this is permitted by local building codes or standards (see hot roof in Section 5.2.2, Concentrate on air sealing, subsection Spray foam under the roof). The hot roof could involve the slope ceiling and then the knee wall space. It is unlikely to be necessary in the small triangular top attic. Having an insulated roof slope allows the knee wall spaces to be used for storage (as they often are).

- Exposed foam in accessible areas must be fire protected.
- Due to limited space for insulation and venting on the sloping ceiling, consider adding rigid board directly to the ceiling, and then air seal and cover with drywall. This method will greatly increase comfort levels in summer and winter, though it may reduce headroom.
- Some contractors specialize in high density blown insulation that will help reduce airflow while improving thermal values.

### *Dormer windows*

Many 1 ½ or 2 ½ storey houses have dormer windows. The walls of the dormer may be insulated with batts, as described for the knee wall. Dormers typically include a lot of framing members that limit the amount of insulation that can be added. Besides air sealing, consider dense-pack blown-in insulation and also the addition of rigid board insulation and drywall to reduce thermal bridging.

### *Floorboards*

Some houses will have the attic floored over, even when it is not used as living space. You can insulate it by lifting the floorboards and treating it as you would an unfinished attic, though some or all of the boards may have to be replaced to maintain the ceiling stiffness.

Alternatively, a contractor can fill the subfloor space completely by blowing in dense-pack loose-fill insulation through access holes. Air leaks, such as around plumbing stacks and open eave spaces, should

be sealed first. With the contractor, ensure that the space is filled completely and at the right density.

**SAFETY WARNING:** Before insulating, check for wiring (replace damaged or frayed wiring), recessed light fixtures or other sources of heat that may be concealed beneath the floorboards. All heat sources must be protected from the insulation or removed entirely.

You will not likely be able to achieve the minimum manufacturer's recommended levels for attic insulation by filling this space alone. If possible, add some insulation on top of the floorboards to keep them warm and to reduce thermal bridging through the joists and floorboards.

## 5.4 CRAMPED ATTICS, CATHEDRAL CEILINGS AND FLAT ROOFS

This section discusses methods for insulating difficult areas.

### 5.4.1 Cramped attics

There are three options for insulating an attic that is too cramped to work in:

- Insulate on top of the existing roof (see Section 5.5, Ice dams).
- Add rigid board and drywall to the ceiling if there is adequate headroom.
- Have an experienced contractor blow in dense-pack loose-fill insulation.

The last two options can also be done together. The first and last methods may apply where there is inadequate headroom.



There will likely be no way of installing a new sheet-material air barrier. If one does not already exist, it should still be acceptable to install insulation if there is no evidence of moisture problems, if humidity levels in the house are reasonable and if any air leaks through the ceiling into the attic are sealed. You can achieve added protection by painting the ceiling below the attic with latex vapour barrier paint (ask paint suppliers or manufacturers) or two coats of oil-based paint.

Ensure that the contractor prevents insulation from entering the eaves and blocking the ventilation. If there are any recessed light fixtures, chimneys or other sources of heat in the attic, make sure precautions are taken to avoid creating a fire hazard.

Ventilating cramped attics can be difficult because of the difficulty of creating an adequate airflow. Where the roof extends past the exterior walls, it may be possible to use soffit vents in combination with roof vents or built-up ridge vents.

Many houses with cramped attic spaces lack eaves. In such cases, approach ventilation with caution. The best approach is to carefully seal the ceiling below the attic from inside the house and then insulate without installing additional vents.

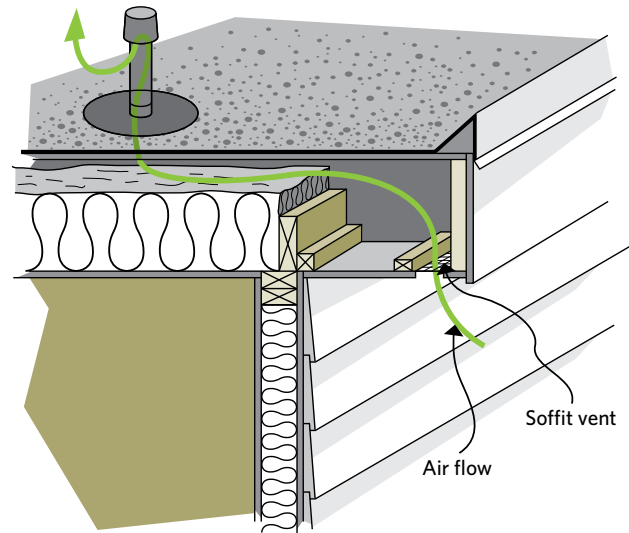
If possible, check the roof space for moisture problems during or just after a cold snap in mid-winter. Some frost is to be expected, but if the buildup is especially heavy, you will have to vent the space, thoroughly seal all air leaks and reduce humidity levels in the house. Check with local building authorities to determine which procedures are permitted in your area.

#### 5.4.2 Cathedral ceilings and flat roofs

A house (or any portion of a house) with a flat roof, cathedral ceiling or some other attic-less construction is difficult and will require the services of a qualified contractor.

The main problem with these roofs is the limited space for insulation and ventilation. If there is

**Figure 5-20** Flat roof



already some insulation in the joist space, trying to add more may not be beneficial. However, if you decide it is worth your while to increase insulation levels, there are a number of options. Each option involves some risk of either moisture problems or thermal bridges that can reduce the effectiveness of the insulation. A technique involving blown insulation is discussed below.

Section 5.6, Renovations and repair, discusses both interior and exterior retrofits, including the addition of a new roof. The existing space between the ceiling and roof can be dense-packed with cellulose or glass fibre loose-fill insulation by a contractor. Densities are typically between 56 to 72 kg/m<sup>3</sup> (3 ½ to 4 ½ lb./cu. ft.). The contractor should calculate and confirm the density for each roof cavity.

This approach eliminates roof ventilation, so it is generally not recommended (check with local building authorities first). However, the high density of the insulation, combined with comprehensive air sealing, should reduce airflow sufficiently to avoid condensation problems.

Take extra care to make sure that air leaks into the ceiling are sealed from below. This is difficult because wiring and plumbing usually puncture the ceiling in a number of places. Moreover, the partition walls may not be completely blocked off at the top, allowing large amounts of air to flow through the interior walls into the ceiling.

Where the interior walls are completely open to the ceiling, there is no easy solution unless you are prepared to have your interior walls blown full of insulation and sealed along all trim, outlets and other penetrations.

## 5.5 ICE DAMS

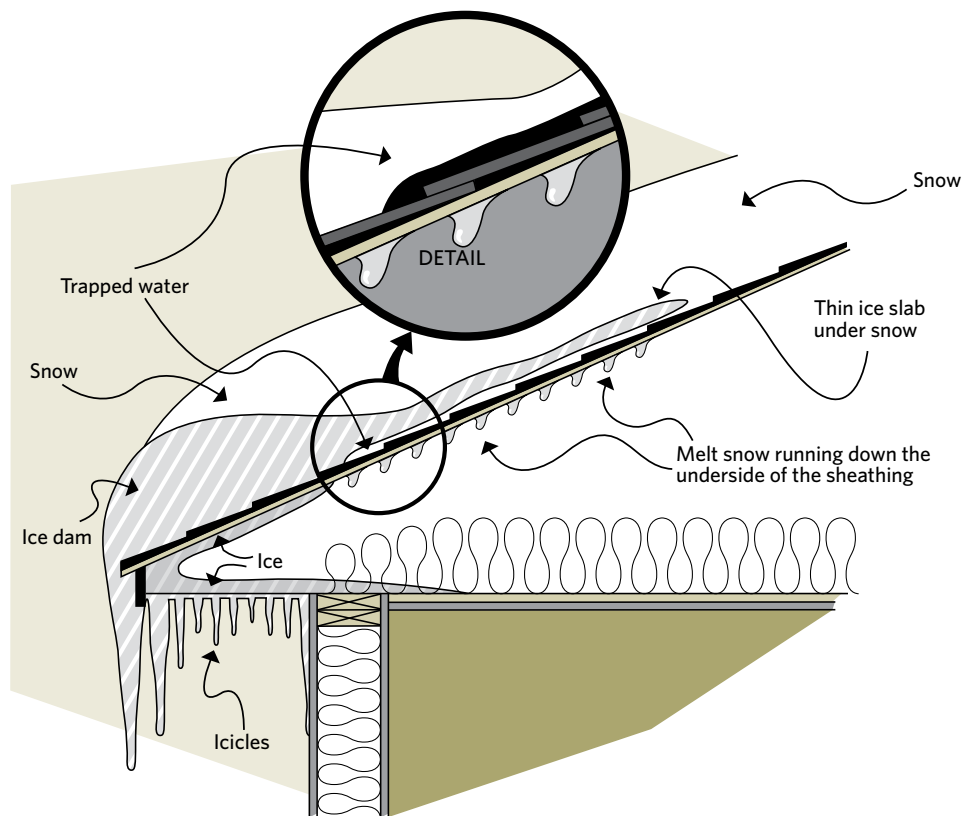
Ice dams are large masses of ice that collect typically on the lower edge of a roof and in the gutters. As

melting snow (or rain) runs down the roof, it meets this ice mass and backs up, sometimes under the shingles and then leaking into the attic.

Ice damming usually occurs when there is a significant amount of snow on the roof. The snow itself, especially when deep, can act as an insulator. If the attic temperature is above freezing, it warms the roof sheathing, which melts the layer of snow that is in direct contact with the roof. Melt water runs down the roof until it meets the overhang.

If the air and the overhang are below freezing, the water freezes on the roof and starts the ice dam. In addition, southerly exposed dark wall siding heated by the sun can cause warm convection currents to enter the eave and roof area above it, causing ice damming.

**Figure 5-21** Ice dams



### 5.5.1 Roof type and ice dams

Uninsulated attics usually do not have ice dams because the heat coming through the attic tends to melt snow as it lands and prevents much accumulation. A well-sealed and insulated attic results in a cool roof and generally will also not have ice dams. Ice dams are more frequent if many valleys and dormers complicate the roof or there is a large overhang. More complicated types of roofs hold more snow because they are more prone to have more thermal bridging and air leakage areas.

### 5.5.2 Locating areas prone to ice dams

One way to find areas prone to ice dams is to look at the roof after the first heavy frost in fall or light snow. Note where the snow melts first and find out what is under that spot. One common sight in such conditions is a horizontal melt line across the roof of a 1 ½ storey house, where the short knee wall meets the ceiling. Other places would be beneath a roof-ducted exhaust fan, plumbing vent, under a skylight and above a leaky attic access hatch. The best prevention for ice damming is to seal all attic air leaks and insulate thoroughly.

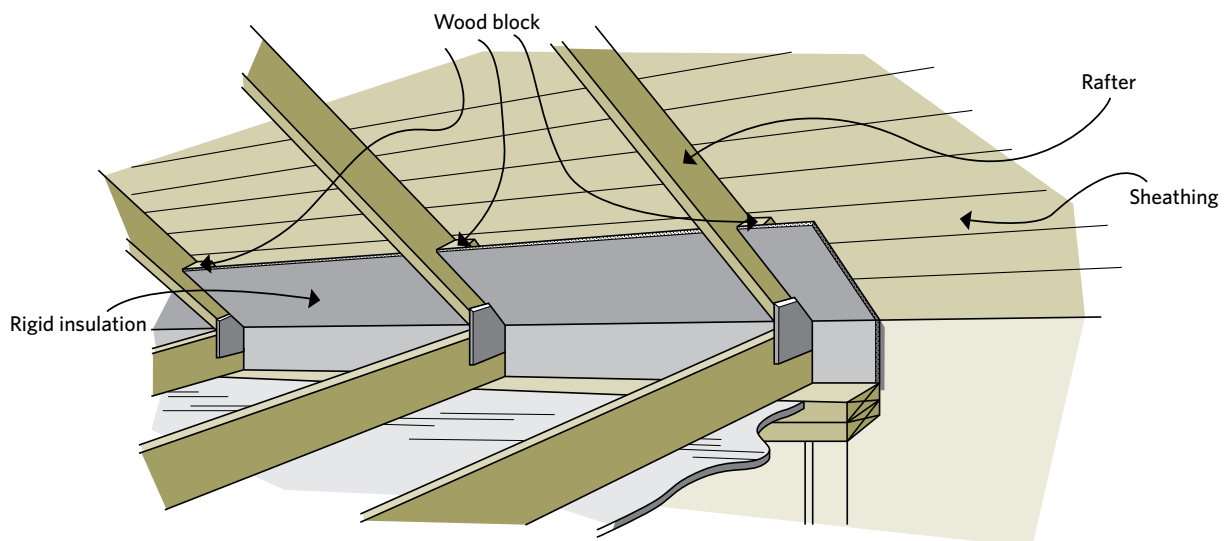
Dark wall finishes can absorb solar heat and cause warm convection wall currents that may be to blame for ice dams. Sealing the associated soffit vents may help reduce the problem. However, other venting may still be required to ensure that the roof space is properly vented.

### 5.5.3 Dealing with restricted attic space

Many attics, including those under low-sloped roofs, do not have enough space for adequate insulation at the edge of the attic floor. If soffit insulation requires a baffle to keep a ventilation opening against the sheathing, there may only be about 100 mm (4 in.) of space left for insulation. This restricted insulation level will allow the snow to melt just above the overhang and promote ice damming.

Try to put the best insulation possible at that edge to reduce heat loss. Spray foam is ideal as it air seals as well as insulates. Cut pieces of extruded polystyrene will help as well. Install a piece of extruded polystyrene 25 mm (1 in.) from the sheathing to maintain the ventilation air space and then fill between this foam board and the attic floor with insulation (see Figure 5-22).

**Figure 5-22** Creating ventilation space with rigid insulation



### 5.5.4 Cathedral ceilings

Ice dams on roofs with cathedral ceilings are more difficult to resolve as they are harder to access. The same principles apply to preventing ice dams – stopping house air leaks, upgrading insulation, possibly improving roof ventilation. Ice dam issues on cathedral-type roofs are usually best dealt with by contracting an insulator with dense-pack insulation experience or when re-roofing.

### 5.5.5 Installing a new roof

When re-roofing, remove the roof finish and the sheathing, air seal and fill the cavities with insulation and then install the new roofing materials, including an ice-shield membrane. A well-sealed roof will need little to no ventilation. If you are uncertain about whether or not the sealing can be done effectively, leave a ventilation channel under the sheathing from the soffit to the peak. Sometimes insulation can be added to the ceiling inside, although this approach will not stop the air leakage.

An alternative measure to prevent ice dams is to make the roof impermeable by using a self-sealing membrane under the shingles. Building codes require such membranes on the lower part of the roof in new houses. These membranes do not stop ice dams, but they prevent the water from leaking through the roof sheathing and into the house. Ice damming can still occur and possibly damage shingles and gutters.

### 5.5.6 Quick fixes and their limitations

There are many popular, quicker solutions but they have drawbacks:

- Attaching electric heating cables will melt channels in the ice, sometimes alleviating a problem, but they use a significant amount of electrical energy while being an eyesore on most roofs.
- Removing gutters will keep them from becoming ice traps, but gutters keep roof water away from the foundation.
- Attacking ice dams every winter with an axe or ice pick will damage the roof surface.
- Although removing snow from the roof will also help, removing ice dams and snow is not always easy or safe to do.
- For certain older houses with complicated roofs, it may be impossible to completely eliminate ice dams without resorting to several different techniques.

The preferred solution for most houses is to keep house heat out of the attic by air sealing and insulating.

## 5.6 RENOVATIONS AND REPAIR

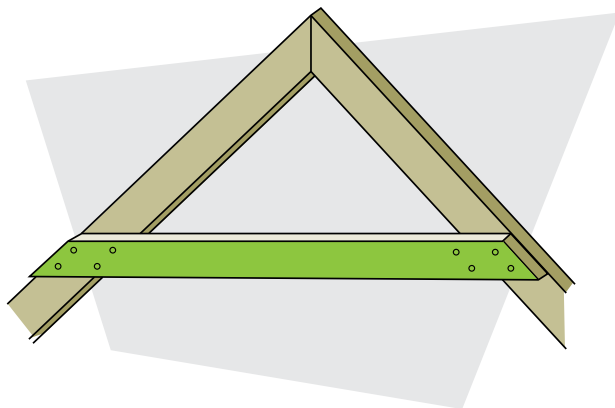
Renovations or repairs provide an opportunity to ensure a well-insulated attic ceiling and walls with an effective air and vapour barrier.

A popular renovation activity is to convert an existing unfinished attic into a new living space. Depending on the depth of the rafter space, it may be difficult to achieve the recommended high attic RSI values. If you choose to finish your attic, check for local code requirements and then consider the following steps:

- Install collar ties between every pair of rafters (see Figure 5-23). These ties will provide structural support for both the roof and the new ceiling.
- Ensure that the insulation installed in the rafter spaces fits snugly against the top of the walls to form a continuous thermal envelope. There must be no gaps around the perimeter of the attic floor, otherwise heat will escape and ice damming may occur near the eaves. In most cases, it should be possible to insulate each rafter space all the way down to the eaves and over the top of the exterior wall. Leave a clear space between the top of the insulation and the underside of the roof sheathing to allow for

- roof ventilation. Seal any roof vents into the parts of the attic that are not heated.
- Staple a continuous polyethylene air and vapour barrier to the rafters and end-wall studs; then carefully seal the edges and seams with acoustical sealant.
  - If your attic is not too cramped, consider adding strapping onto the rafter bottoms and wall studs to allow for more insulation (up to the recommended minimum level for attic insulation, if possible). After installing insulation in the existing cavities, nail or screw strapping (2 x 2 or 2 x 3 on-edge) perpendicular to the rafters and studs. Space the strapping to suit the width of the insulation you will use. However, the strapping should be no more than 610 mm (24 in.) apart – measured on centre – or you will have difficulty attaching the interior finish. Fit insulation snugly between the strapping, covering all the rafters and studs. Finally, staple a continuous, sealed polyethylene air and vapour barrier to the strapping. Alternatively, secure rigid board insulation 25 to 50 mm (1 to 2 in.) to the rafters and studs, seal or install a vapour barrier and then cover with an approved finish (e.g. drywall).

**Figure 5-23** Collar beams (collar ties) provide additional support



- Insulation between the collar ties is applied from below in much the same way, with a continuous polyethylene air and vapour barrier applied last. If the collar ties have already been insulated and if there is access to the upper portion, then more insulation may be added as in a normal attic.

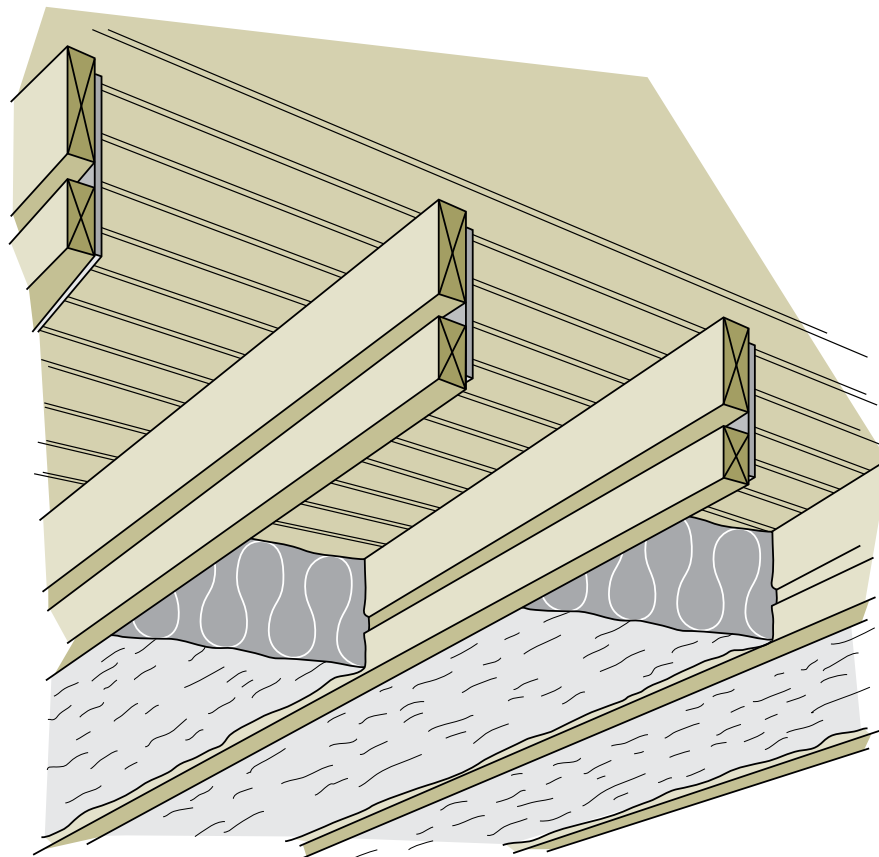
### 5.6.1 Dropped ceiling

Where headroom is sufficient, constructing a dropped ceiling to hold insulation is an excellent way of thermally upgrading a cathedral ceiling or flat roof, especially when planned as part of a renovation. The following are several options:

- Construct a new ceiling immediately below the existing ceiling. If the roof has exposed joists or beams (usually for decorative purposes), it may be possible to close the space, which creates a new ceiling. Install batts or rigid insulation in the space followed by a continuous air and vapour barrier and a new ceiling. In all cases, you must prevent warm air from getting into the new cavity space and bypassing the insulation. Seal the perimeter of the new ceiling and any possible air leakage paths through partition walls.
- With the ceiling removed, extend existing rafters or trusses to accommodate additional insulation. Cross strap the existing rafters or extend the rafter cavity with 2 x 4 lumber and plywood gussets (see Figure 5-24).

Although it is not necessary to remove the interior finish and expose the rafters and tops of the walls when constructing a new ceiling, it is a good idea. This will allow you to perform air sealing, check the state of the insulation and verify if there is a vapour barrier.

- Mechanically fasten rigid board insulation directly to the structure of an existing ceiling. Although this technique avoids the mess and time required to tear down the ceiling, it will make access to the space between the ceiling and the attic floor more difficult (e.g. to install

**Figure 5-24** Extending the rafters provides space for insulation and ventilation

recessed light fixtures). If rigid board insulation doubles as the air barrier, fit the boards tightly and seal the seams well. Extend electrical fixtures to accommodate the depth of the new ceiling.

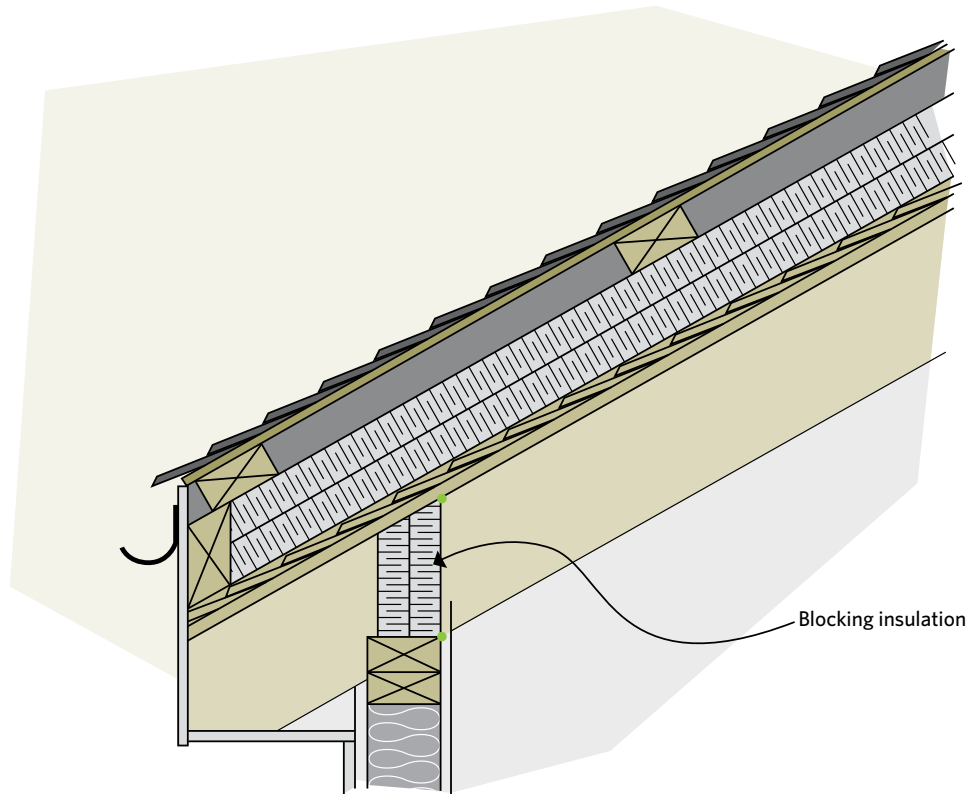
### 5.6.2 Adding a new roof

Insulation can also be added on top of an existing ceiling or roof. This option is most suitable for cathedral ceilings and flat roofs when major exterior alterations, such as a new roof, are required. Air sealing, installing new insulation, sheathing, roofing surface and replacing eavestroughs, soffits and fascia plus disposal will cost several thousand dollars. You will almost certainly need the services of a qualified contractor.

One method involves installing rigid board insulation on top of the existing roof (see Figure 5-25). The higher RSI value of rigid insulation means a smaller increase in the roof thickness, although several layers of insulation may be needed to meet the desired RSI level.

Sheet polyethylene is first placed on the existing roof to provide the air and vapour barrier, following the  $\frac{1}{3} - \frac{2}{3}$  rule. Alternatively, a layer of closed-cell spray foam or low-permeability rigid board can be installed with the joints taped to prevent air leakage. This step is not necessary if an air barrier is already in place.

**Figure 5-25** A new insulated roof can be built over the old roof



It is important to insulate (i.e. block) and air seal the spaces between the joists along the perimeter of the roof. This prevents heated air from escaping around the insulation. Line up the edges of the blocking material with the inside finish of the exterior wall and thoroughly caulk all seams. Another approach is to hire a spray foam contractor familiar with air sealing to block these critical areas.

Another method is to build up the existing roof or to frame a new roof and fill it with batt insulation or loose-fill insulation, which is blown in. Ensure that the air and vapour barrier is tightly sealed. The new space or roof frame may add to the structural loading of the entire assembly, so this must be done following local code requirements.

This approach is best done with new trusses or by installing cross members (called purlins) that span the length of the roof. Once the purlins are in place, the new rafters are installed, followed by the proper installation of the insulation to avoid air movement and thermal bridging. Leave enough clear space above the insulation and above the new roof rafter to allow for ventilation.