UNIVERSITY OF MISSOURI
Extension

Insulating and Weatherizing Your Home

Published by MU Extension, University of Missouri - Columbia

Michael Goldschmidt, Housing and Environmental Design State Specialist
Department of Architectural Studies, College of Human Environmental Sciences

You can reduce your home's heating and cooling costs through proper insulation and weatherization (air sealing) techniques. These techniques will also make your home more comfortable. Any air sealing efforts will complement your insulation efforts, and vice versa.

Insulation

You need insulation in your home to provide resistance to heat flow. The more heat flow resistance your insulation provides, the lower your heating and cooling costs. Actual dollar savings will depend on present insulation levels and how much you add to them.

Heat flows naturally from a warmer to a cooler space. In the winter, this heat flow moves directly from all heated living spaces to adjacent unheated attics, garages, basements, and even to the outdoors. Heat flow can also move indirectly through interior ceilings, walls, and floors—wherever there is a difference in temperature. During the cooling season, heat flows from the outdoors to the interior of a house.

To maintain comfort, the heat lost in the winter must be replaced by your heating system and the heat gained in the summer must be removed by your cooling system. Properly insulating your home will decrease this heat flow by providing an effective resistance to the flow of heat.

For good energy efficiency, your home should be properly insulated from the roof down to its foundation. This includes the following areas:

- Attic spaces
    - Attic access doors to unfinished attics
    - Knee walls in finished attics
- Ducts in unconditioned spaces
- Cathedral ceilings
- Exterior walls
- Floors above unheated garages
- Foundations
    - Basements
    - Crawl spaces
    - Slab-on-grade floors

Several areas are often neglected when a home is insulated. Some of the more common ones are:

- Walls separating living area from the attached garage
- Walls and ceiling of basement garages
- Walls and ceilings of dormers
- Sloping ceiling areas in upstairs rooms where the ceiling has been "clipped" to accommodate the roof rafters
- Narrow cracks around window and door framing

R Value

Insulation's resistance to heat flow is measured or rated in terms of its thermal resistance or R value. The R value is additive: two inches of a given material will have twice the R value of one inch. Also, the individual R values for all materials in a section of a structure (roof, wall, crawl space, or floor) can be added together to obtain a total R value.

Several years ago, most insulation material was either mineral wool or fiberglass. These materials have similar insulating properties, and it was common practice to specify insulation in terms of inches of thickness. Today, many different insulation materials are on the market, and each has its own R value per inch of thickness. The only way to compare their insulating ability is to compare their R values.

Recommended R Values for Missouri Homes

For most Missouri Homes, the following are R value recommendations for various locations in a home:

- Ceilings / Attics: R – 49
- Walls: R – 18
- Floor over Crawl Space: R - 25
- Crawl Space Wall: R – 19
- Slab Edge: R – 8
- Basement Wall: R – 11

Types of Insulation

When insulating your home, you can choose from many types of insulation. To choose the best type of insulation, you should first determine where you want or need to install or add insulation and the recommended R values for areas you want to insulate. Table 1 below provides an overview of most of the common available insulation types, insulation materials, their installation methods, where they're applicable to install in a home, and their advantages.

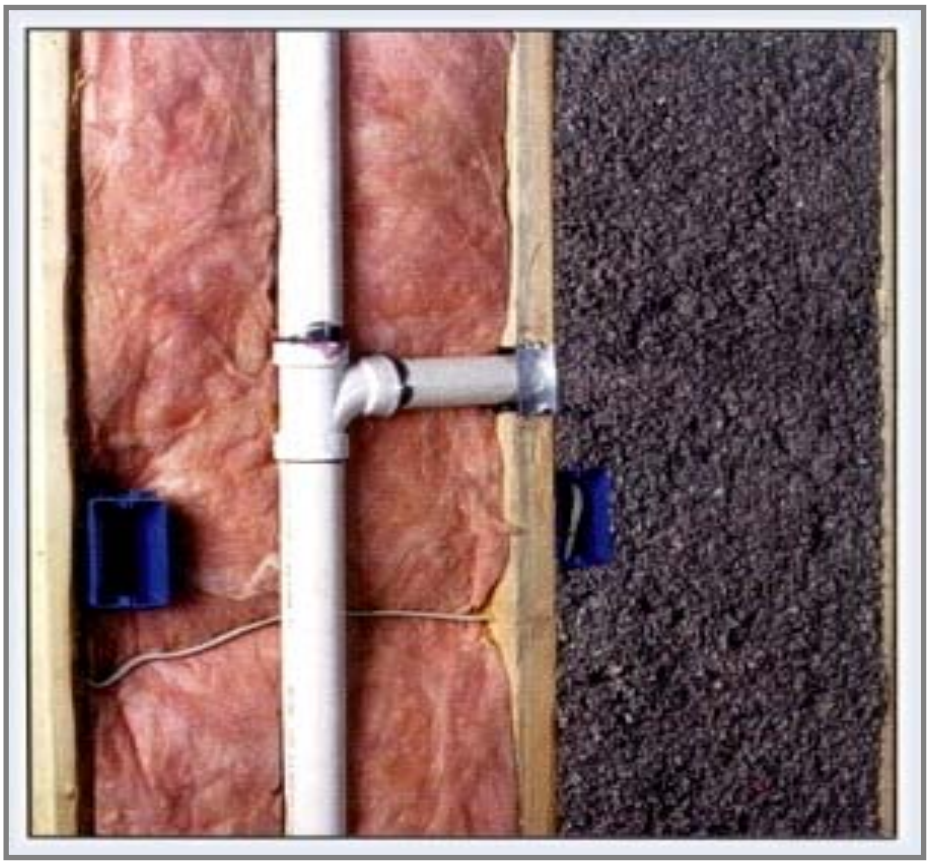
Table 1: Common Types of Home Insulation

Type	Insulation Materials	Location	Installation Method(s)
Loose-fill	Cellulose Fiberglass Mineral	Enclosed existing wall or open new wall cavities, unfinished attic floors, hard-to-reach places	Blown into place using special equipment
Blankets: batts and rolls	Fiberglass Mineral wool	Unfinished walls, foundation walls, floors, and ceilings	Fitted between studs, joists, and beams
Foam board or rigid foam	Polystyrene Polyisocyanurate Polyurethane	Unfinished walls, foundation walls, floors, ceilings, and unvented low-slope roofs	Must be covered with 1/2-inch gypsum board on interior side for fire safety and weatherproof facing on exterior side
Sprayed foam and foamed-in-place	Cementitious Phenolic Polyisocyanurate Polyurethane	Enclosed existing wall or open new wall cavities and unfinished attic floors	Applied using small spray containers or in larger quantities as a pressure sprayed (foamed-in-place) product

Table 2 below provides an overview of the range of R-values for most of the common available home insulation types.

Table 2: R Values (per inch thickness) for Common Types of Home Insulation

Insulation type	R value per inch thickness
Fiber glass blanket or batt	2.9 to 3.8
High performance fiberglass blanket or batt	3.7 to 4.3
Loose-fill fiber glass	2.3 to 2.7
Loose-fill rock wool	2.7 to 3.0
Loose-fill cellulose	3.4 to 3.7
Perlite or vermiculite	2.4 to 3.7
Expanded polystyrene board	3.6 to 4
Extruded polystyrene board	4.5 to 5
Polyisocyanurate board, unfaced	5.6 to 6.3
Polyisocyanurate board, foil-faced	7
Spray polyurethane foam	5.6 to 6.3



Wall Insulation Types

Left Side:
Fiberglass Batt

Right Side:
Blown-In Cellulose

Vapor Barriers (Vapor Diffusion Retarders)

One possible problem associated with adding insulation in the home is condensation (moisture). All air contains moisture. Warm air can hold more moisture than cold air. During winter months, air inside the house is warmer than outside air, and homeowners are adding moisture to it continually during normal household activities such as washing and cooking.

Water vapor in air behaves like heat; it moves from areas of high concentration (inside the house) to areas of low concentration (outside). If it encounters a cold surface during this migration, it will condense into free water. When condensation occurs inside an insulated wall, insulation becomes wet; building materials start to decay, finishes get stained, and paint peels off the walls or ceilings of the house. This can be prevented by using a vapor barrier (vapor diffusion retarder) material in conjunction with insulation.

A vapor barrier or vapor diffusion retarder (VDR) is a material that reduces the rate at which water vapor can move through a material. Effective moisture control throughout a home includes air sealing gaps in the home (see Weatherization below), not just the use of a vapor diffusion retarder. Vapor barriers are installed over the face of the studs or joists on the side closest to the inside surface of the home. The vapor barrier prevents moisture in the form of water vapor from getting to cold surfaces where it can condense.

Adding Insulation to an Existing Home

To determine whether you should add insulation, you first need to find out how much insulation you already have in your home and where. A qualified home energy auditor or home inspector will include an insulation check as a routine part of a whole-house energy audit. An energy audit will also help identify areas of your home that are in need of air sealing (see Weatherization below). If you don't want an energy audit, you need to find out the following:

- What type of insulation you have
- The R-value and the thickness or depth (inches) of the insulation you have.

If you live in a newer house, you can probably find out this information from the builder. If you live in an older house, you'll need to inspect the insulation yourself if you don't want an energy audit. Check the attic, walls and floors adjacent to an unheated space, like a garage or basement. The structural elements are usually exposed in these areas, which makes it easy to see what type of insulation you have and to measure its depth or thickness (inches).

As an alternative, you can inspect the insulation in exterior walls and ceilings using an electrical outlet or light fixture:

1. Turn off the power to the outlet or light fixture from your breaker panel or fuse box
2. Remove the outlet cover or light fixture and shine a flashlight into the crack around it. You should be able to see if there is insulation in the wall or ceiling and possibly how thick it is.
3. Pull out a small amount of insulation if needed to help determine the type of insulation.
4. Check outlets and light fixtures on the first and upper floors, if any, and in old and new parts of a house. Just because you find insulation in one area doesn't mean that it's everywhere in the house.

Inspect and measure the thickness (inches) of any insulation in unfinished basement ceilings and walls, or above crawl spaces. If the crawl space isn't ventilated, it may have insulation in the perimeter wall. If your house is relatively new, it may have been built with insulation outside the basement or foundation walls. If so, the insulation in these spaces won't be visible. The builder or the original homeowner might be able to tell you if exterior insulation was used.

Attic areas are easily accessible in most homes. This means labor costs for installing added insulation will be at a minimum. You may even be able to do it yourself. The ceiling is the often the biggest source of heat loss in most homes because it usually represents the largest area exposed to outside temperatures.

Un-insulated floors over unheated basements or crawl spaces lose about half as much heat as is lost through the ceiling area of the house. Pay special attention to water lines and other plumbing when installing floor insulation. Below-ground basements rarely freeze; however, crawl spaces and walk-out basements may be subjected occasionally to freezing temperatures if the floors above are insulated. You can prevent this by insulating pipes or by providing a minimum amount of heat to keep the area above freezing. In either case, the fact that your floor is insulated will result in a net savings in your energy bill. And your floors will be more comfortable.

Homes built on concrete slabs or homes with walk-out basements should have perimeter slab insulation. If no insulating barrier is between the concrete slab and the outside of the house, a considerable amount of heat is lost and will result in an uncomfortably cool floor near the edge of the slab.

Unless you are planning to do extensive remodeling, you will find adding insulation to an existing wall quite difficult. In fact, if you have any wall insulation at all, it's practically impossible to add to it without removing either the inside or outside wall covering material. Walls which have no insulation at all can have fill type insulating materials added to the spaces between the studs. This will have to be done professionally. It involves drilling holes in exterior walls between each stud and then blowing the entire space full of insulating material. The fill holes are then capped or plugged. In some cases it is possible to remove one or more strips of exterior siding before drilling holes. The siding can then be replaced, covering the holes.

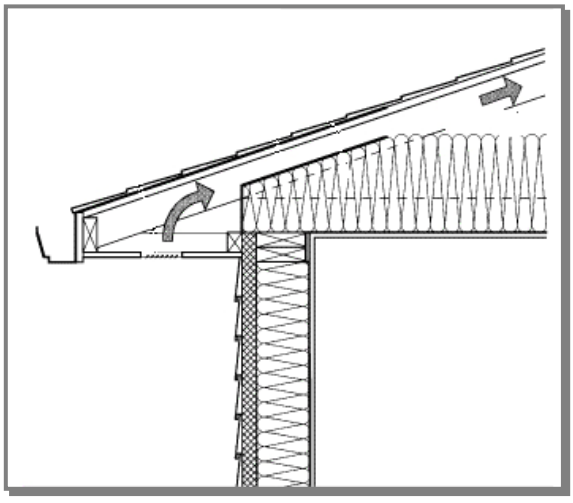
Piping and ducts should be on the interior wall, ceiling, or floor side of the insulation for maximum energy efficiency. If water pipes are on the exterior side of the insulation, they are more susceptible to freezing in the winter. If piping cannot be located on the interior side of the insulation, special pipe insulation should be installed to keep the pipes from freezing and to add additional energy efficiency. Pipe insulation is available in precut foam tubes sized for various pipe diameters and in fiberglass batts that can be wrapped around each pipe.

Ventilating the Attic and Crawl Space

Ventilation of the home attic and crawl space is important for two reasons. During the summer, excess heat that builds up in these spaces during the day results in high energy costs for cooling. Also, moisture produced within the home may move into these areas if vapor barriers are not used. If this moisture is not exhausted from the attic or crawl space it can condense and cause insulation and construction materials to deteriorate.

In Missouri homes, there should be one square foot of ventilation for every 300 square feet of attic or crawl space area.

Proper attic ventilation systems allow a continuous flow of outside air through the attic. It consists of a balance between air intake (at your eaves or soffits) and air exhaust (at or near your roof ridge). Soffit vents come in several sizes and styles, including small round discs and rectangular grilles. Perforated soffit material is also available which provides ventilation at the lowest part of a roof. Ventilated roof ridge shingles, ridge vents, gable end vents, static vents, or roof turbines can provide adequate ventilation at the highest part of the roof. In many roofs, special baffles are installed to keep the attic insulation from blocking the eave or soffit vents.



Cross Section of Roof and Wall Showing Insulation and Attic Ventilation

For crawl spaces, these vents are usually square or rectangular and are specifically designed for concrete or masonry foundation walls. They should be spaced equally along the crawl space wall perimeter. Make sure that the floor above the crawl space is well insulated, otherwise venting the crawl space will actually increase your energy use and could cause pipes to freeze.

Fan-driven attic or crawl space ventilators are powered by electricity and usually controlled by a thermostat in the attic or crawl space. They are very effective, but since they are motor-driven, the extra cost of running them partially offsets the energy they conserve.

Weatherization

Air leakage, or infiltration, occurs when outside air enters a house uncontrollably through cracks and openings. Properly air sealing such cracks and openings in your home can significantly reduce heating and cooling costs, improve building durability, and create a healthier indoor environment. The average house, even when well-insulated, contains cracks and gaps between building materials that add up to a hole about 14 inches square. In the winter, those gaps may make the house drafty and chilly. All year long, a leaky house not only wastes energy but can lead to water damage and provide a path for insects. Air infiltration also can contribute to problems with moisture control. Moldy and dusty air can enter a leaky house through such areas as attics or foundations. This air in the house could cause health problems.

The recommended strategy in both new and old homes is to reduce air leakage as much as possible. Weatherization includes sealing all exterior penetrations and cracks with sealant (caulking) and installing weatherstripping to all operable windows and doors.

Detecting Air Leaks

You may already know where some air leakage occurs in your home, such as drafts or cold spots, but you'll need to find the less obvious gaps to properly air seal your home. For a thorough and accurate measurement of air leakage in your home, you should complete an energy audit (UM Extension Guidesheet *GH 5983 – Energy Management Checklist for the Home* or *GH 5982 Audit Your Home for Energy Waste*) or hire a qualified energy auditor or technician to conduct one for you. In most areas of Missouri, these audits are free and are provided by utility companies, state agencies, or a University of Missouri Extension office. A complete energy audit can also help determine areas in your home that need more insulation.

In some cases, the energy auditor or technician can locate hard-to-find air gaps and areas of energy loss through the use of a blower door test or a thermographic scan. Thermographic scanning uses an infrared camera to detect air and heat leakage in the exterior surfaces of your house.

Without a blower door test or thermographic scan, there are ways to find some air leaks yourself. First, look at areas where different materials meet, such as between brick and wood siding, between foundation and walls, and between the chimney and siding. Also inspect around the following areas for any cracks and gaps that could cause air leaks:

- Door and window frames
- Mail chutes
- Electrical and gas service entrances
- Cable TV and phone lines
- Outdoor water faucets
- Where dryer vents pass through walls
- Bricks, siding, stucco, and foundation
- Air conditioners
- Vents and fans.

Other air-leak detection methods include the following:

- Shining flashlight at night over all potential gaps while a partner observes the house from outside. Large cracks will show up as rays of light.
- Shutting a door or window on a piece of paper. If you can pull the paper out without tearing it, you're losing energy.

Sealing and Caulking

Sealant and Caulk form flexible seals for cracks, gaps, or joints less than 1/4 of an inch wide. You can use a sealant or caulking compound to seal air leaks in a variety of places throughout your home, including around windows and door frames. Caulk and seal air leaks where plumbing, ducting, or electrical wiring penetrates through exterior walls, floors, ceilings, and soffits over cabinets. In addition to sealing air leaks, caulking can also prevent water damage inside and outside of the home when applied.

Most caulking compounds come in disposable cartridges that fit in half-barrel caulking guns (if possible, purchase one with an automatic release). Some pressurized cartridges do not require caulking guns. When deciding how much caulking to purchase, consider that you'll probably need a half-cartridge per window or door and four cartridges for the foundation sill. Caulking compounds can also be found in aerosol cans, squeeze tubes, and ropes (sometimes called rope caulk) for small jobs or special applications.

Caulking compounds vary in strength, properties, and prices. Water-based caulk can be cleaned with water, while solvent-based compounds require a solvent for cleanup. Table 3 below summarizes the various options for sealants and caulks

Installing sealants and caulking can be tricky and messy. Read and follow the instructions on the compound cartridge. Save yourself some trouble by remembering a few important tips:

- For good adhesion, clean all areas to be caulked. Remove any old caulk and paint, using a putty knife or a large screwdriver. Make sure the area is dry so you won't seal in moisture
- Hold the gun at a consistent angle. Forty-five degrees is best for getting deep into the crack. You know you've got the right angle when the caulk is immediately forced into the crack as it comes out of the tube.
- Caulk in one straight continuous stream, if possible. Avoid stops and starts.
- Send caulk to the bottom of an opening to avoid bubbles.
- Make sure the caulk sticks to both sides of a crack or seam.
- Release the trigger before pulling the gun away to avoid applying too much caulking compound. A caulking gun with an automatic release makes this so much easier.
- If caulk oozes out of a crack, use a putty knife to push it back in.
- Don't skimp. If the caulk shrinks, reapply it to form a smooth bead that will seal the crack completely.

Before applying new caulk, remove old caulk or paint residue remaining using a putty knife, stiff brush, or special solvent. After old caulk is removed, new caulk can then be applied to all joints in the window frame and the joint between the frame and the wall.

The best time to apply caulk is during dry weather when the outdoor temperature is above 45 degrees F. Low humidity is important during application to prevent cracks from swelling with moisture. Warm temperatures are also necessary so the caulk will set properly and adhere to the surface.

Rope Caulk

Foam Tape

Caulking / Sealant Tube and Gun

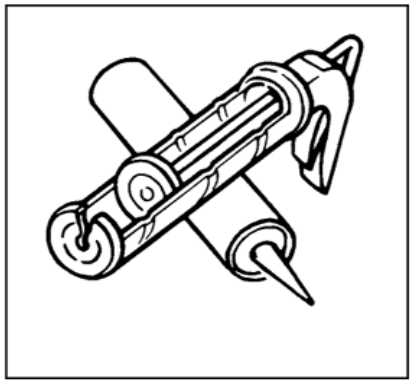


Table 3: Sealant and Caulking Types

Compound	Cleanup	Shrinkage	Adhesion	Cost	Comments
Silicone	Dry cloth if immediate or mineral spirits	Little or none	Good to excellent	High	Permits joints to stretch or compress. Will stick to painted surfaces, but paint will not adhere to most cured silicones
Polyurethane expandable spray foam	Solvent such as lacquer thinner, if immediate	None; expands quite a bit	Good to excellent	Moderate to high	Spray-foam quickly expands to fit larger, irregular-shaped gaps. Flexible. Can be applied at variable temperatures. Must be painted for exterior use to protect from ultraviolet radiation
Water-based foam sealant	Water	None; expands only 25%	Good to excellent	High	Takes 24 hours to cure. Cures to soft consistency. Water-based foam production does not produce greenhouse gases. Will not over-expand to bend windows (new construction). Must be exposed to air to dry. Not useful for larger gaps, as curing becomes difficult
Butyl rubber	Mineral spirits	From 5% to 30%	Good	Moderate to high	Durable 10 or more years; resilient, not brittle. Can be painted after one week curing. Variable shrinkage; may require two applications. Does not adhere well to painted surfaces. Toxic; follow label precautions
Latex	Water	From 5% to 10%	Good to excellent	Moderate	Easy to use. Seams can be trimmed or smoothed with moist finger or tool. Water resistant when dry. Can be sanded and painted. Less elastic than above materials. Varied durability, 2–10 years. Will not adhere to metal. Little flexibility once cured. Needs to be painted when used on exteriors
Oil or resin-based	Mineral spirits	From 10% to 20%	Good	Low	Readily available. Least expensive of the four types. Rope and tube form available. Oils dry out and cause material to harden and fall out. Low durability, 1–4 years. Poor adhesion to porous surfaces like masonry. Should be painted. Can be toxic (check label). Limited temperature range
Polyurethane	Dry cloth if immediate or mineral spirits	Little or none	Good to excellent	High	Permits joints to stretch or compress. Will stick to painted surfaces and paint will usually adhere to most cured urethanes

Weatherstripping Doors and Windows

Weatherstripping around windows and doors is essential to stopping air infiltration. Doors and windows in new homes generally come with factory-installed weatherstripping, however, doors and windows in homes that are ten years or older may not have any weatherstripping at all.

There are four main categories of weatherstripping, including:

- Compression foam, gaskets, or bulbs- Compression weatherstripping is used to seal swinging doors and window sashes. It consists of a molded strip (it may be wood, aluminum or rigid vinyl) with a flexible vinyl or rubber bulb along one side. As a rule, compression weatherstripping is the most durable type available. It is available as either a self-adhesive or nail-on product.

- V-Type Strips and Tape - V-shaped weatherstripping is fitted against the side of the door or window jamb so it presses against the edge of the door or sash and forms a seal. V-stripping may be vinyl, plastic, or metal (usually bronze). It is available as either a self-adhesive or nail-on product.

- Foam and Foam Tape - Foam weatherstripping is used to seal either swinging or sliding doors or windows. It comes in various sizes, with an adhesive backing on one side. It is usually a self-adhesive product fastened to the edge of a door or window stop or to the bottom of a sliding window sash. In some cases, it can also be used to seal other air gaps in walls and floors where caulking and sealant is typically used.

- Thresholds and Door Bottoms - A threshold fills the gap between the floor and the bottom of a door. It may have a built-in vinyl bulb. It should be paired with a door bottom or sweep mounted on the lower edge of the door. These products are usually installed with small nails or screws (usually included with the purchase of the weatherstripping).

When using any form of pressure-sensitive or stick-on weatherstripping, cleaning the door and window surfaces are required. A cleansing rag dampened with fast drying lacquer thinner or alcohol will take off this film. Many of the self-adhesive weatherstripping can be cut to the correct size using a carpet knife or heavy scissors. Some kits are also available in pre-cut sizes for common standard door and window dimensions.

Installation of nail-on weatherstripping requires the use of a hammer, small finishing nails, and a small saw or tin-snips to cut the product to fit the door or window. Some nail-on products are also available in pre-cut sizes for common standard door and window dimensions.

Door bottom weatherstripping is available in several materials. While easy to apply, these products can interfere with door swing and require a reasonably level threshold beneath the door. Simple hand tools are all that are required to install any of these door bottoms. After cutting it to size with a hacksaw or tin snips, the door bottom is surface mounted to the inside of the door using wood screws normally provided by the manufacturer. A fairly new innovation in weatherstripping is the mechanically operated, "automatic" door bottom. In this model, a vinyl seat (or bulb) is automatically lowered against the floor when the door is shut. The seal retracts when the door is opened.

Common thresholds are available in aluminum, bronze, or brass with a flexible vinyl or rubber bulb. When new, this threshold is effective, but under constant use, the bulb soon collapses leaving a sizable crack beneath the door. In many products, the bulb insert is replaceable. Though not the easiest to install by the do-it-yourself homeowner, the combination door bottom and threshold is long lasting and provides effective control against air infiltration. Since the vinyl is mounted in an aluminum extrusion fastened to the door, the aluminum threshold bears the brunt of wear.

Installing Door and Window Weatherstripping

To install weatherstripping to a door, first install the threshold. Measure the distance from the floor to the bottom edge of the door; thresholds come in a number of typical heights from 5/8 inch to 1 inch. Choose a threshold that allows about a 1/2 inch gap to leave room for the bulb.

The threshold should be placed so its highest point (or the center of the bulb if the threshold has a built-in bulb) is directly under the door. Measure the width of the opening and cut the threshold to length with a saw. The threshold will probably have to be notched on each end so it fits around the door stops.

Set the threshold in place and close the door to check the fit and position. Once the threshold is in place, mark the location on the floor, then open the door. Run a thin bead of caulking along the underside of the threshold on each side. Some thresholds have a C-shaped channel along the edges to accept caulking. Set the threshold in

place and screw it firmly to the floor.

To apply nail-on compression weatherstripping to a door or swinging (not sliding) window, first close the door or window. If the door has a deadbolt, lock it. Cut each strip to length with a saw or tin snips and stand it in place. Push the strip in toward the door or window sash so the bulb is partially compressed. Don't fit it too tightly or the door or window won't close properly. Nail the strip in place, starting from the center and working your way toward both ends. Check the door/window frequently to make sure it operates easily.

To apply self-adhesive foam weatherstripping, cut the foam strips to length with scissors. Peel back about 1 inch of the adhesive cover strip and press the foam into place at the top of the door or window stop. Work your way down, peeling the cover strip away as you press the foam into place.

To apply V-type weatherstripping to a door or swinging window, cut the strips to length with scissors (for vinyl or plastic strips only), tin-snips, or a hacksaw. Place each strip on the jamb with the raised "V" facing away from the door or window sash, positioned so the door or window sash will be centered on the strip when closed. Fasten the strips in place.

To apply V-type weatherstripping to a double-hung window, first lower the sash. Cut the strip to length and slip it down along the side of the sash with the raised "V" facing outside. Position the strip in the center of the sash and fasten it in place as far as possible. Raise the sash and repeat the process along the lower half of the strip

Other Air Sealing Ideas

Many hardware stores and lumber yards carry special pre-cut foam or rubber inserts to seal the gaps and air leaks around electrical outlets and light switches on the interior side of exterior walls. These inserts are easier to install and less hassle than trying to use caulking or sealant.

When the fireplace is not in use, keep the flue damper tightly closed. A chimney is designed specifically for smoke to escape, so until you close it, air escapes 24 hours a day.

Window air conditioners are common locations where there is much air leakage. To eliminate infiltration around your unit, properly caulk and seal all exterior sash and window joints especially where the window unit is touching the air conditioner unit. When autumn arrives, wrap the unit with a prefabricated air conditioner cover, or make your own using 4 mil polyethylene plastic. Tape the plastic to the window casing around the entire perimeter of the unit. To slow air infiltration from the crack between the raised sash of a double-hung window and the air conditioner, use ordinary fiberglass insulation or urethane foam strips. Many hardware and home products stores have special kits for installation around window air conditioner units.

Additional Information and Acknowledgements

The following internet websites are good locations for additional information on insulating and weatherizing new and existing homes:

www.missourifamilies.org
www.energystar.gov
www.eere.energy.gov
www.doe.gov
www.nrel.gov
www.aceee.org

Information for this guidesheet includes current and earlier publications from State Housing Specialist Dr. Ronald Phillips, former Housing Specialists J. Robert Cusick, Atiya Mahmood and Wanda Eubanks, Agriculture Specialist Richard E. Phillips, and the US Department of Energy - Energy Efficiency and Renewable Energy website.