Air Sealing Basics

Look high and low to find and plug air leaks that cost you money and comfort

BY MIKE GUERTIN AND ROBERT SHERWOOD

While you might think that air leaks are a problem only with older houses, we've tested old homes that are pretty airtight and brand-new homes that leak lots of air. Air leaks occur wherever there is a joint, gap, or hole in the rigid building materials that enclose a house, such as wall sheathing, framing, and drywall.

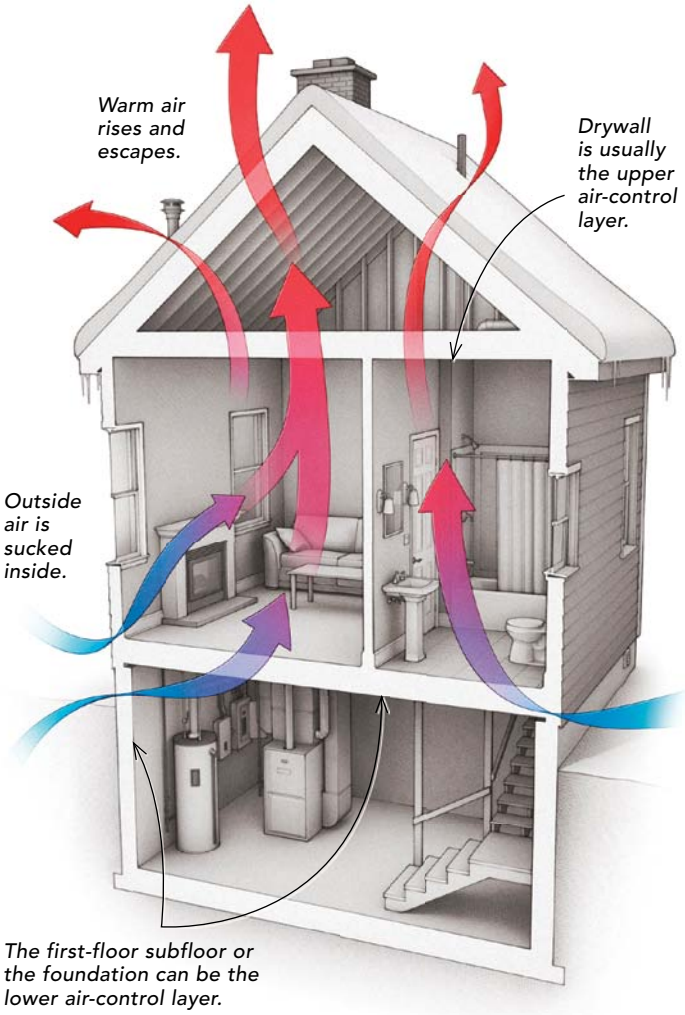
Making an existing house more airtight is pretty straightforward: Find the holes and seal them up. Many air leaks can be found just by looking for spaces between framing and chimneys, electric boxes and drywall, and the mudsill and foundation. The fixes are often simple and use common materials—rigid foam, caulk, acoustical sealant, and spray foam—which are selected based on

Bottom photo, facing page: Rodney Diaz. Drawing: Christopher Mills.

THE PATH TO A TIGHTER HOUSE

HOW HOUSES LEAK AIR

Warm air rises, creating a zone of higher pressure at the top of a house that forces air out of any hole it can find. This escaping air creates a zone of lower pressure at the bottom of the house that sucks in air through holes and cracks. This is the stack effect. Sealing leaks at the top and bottom of the house is the most effective approach for stopping it. The colder it is outside, the stronger the stack effect, so air-sealing can have a big impact in cold climates (zones 4 to 8) and a lesser one in mixed climates (zone 3). It is not as important in warm climates (zones 1 and 2).



TWO TOOLS FOR FINDING AIR LEAKS

SMOKE GENERATOR

The Wizard Stick works like an old Lionel locomotive, generating vapor by heating glycerin. It runs on 6 AA batteries and costs $25 from Amazon.com.

HOMEMADE BLOWER DOOR

Some scrap plywood and a $150 fan create a blower door that's adequate for finding air leaks.

THREE MATERIALS FOR STOPPING AIR LEAKS

RTV SILICONE

Sold for use as an automotive sealant, RTV is rated to 650°F. It's more flexible than so-called fire caulk, which tends to dry and fall out, so it can be a good choice for use around chimneys. Small quantities can be bought at auto-supply stores, but for caulk-gun tubes, Amazon.com is a good source.

ACOUSTICAL SEALANT

Meant for soundproofing, acoustical sealant never hardens, and it accommodates the normal movement of building materials without cracking. You might have to go to a commercial drywall supplier to find it.

SPRAY FOAM

Ranging in price from about $50 to over $100, foam guns make applying spray foam easy. Cans of foam for guns come in several varieties, from minimal-expanding for use around doors and windows to gap-filling for higher-volume applications. It's widely available online and at lumberyards and home centers.

SEAL THE BASEMENT WALLS OR THE

Whether to seal the foundation walls and slab or the subfloor above depends on factors unique to each house. When the basement is conditioned, the foundation walls and slab must be sealed because even though they are underground, air still can leak through the soil. If there are insulated foundation walls or ducts in the crawlspace or basement, use the wall and slab as the air barrier. If the subfloor consists of lumber planks, which leak a lot of air, it's probably easier to seal the foundation walls and slab. Bulkhead doors to the outside are big leaks, but it still might be easier to install a weatherstripped and insulated door at the bottom of the stairs than to seal the subfloor above.

CONCRETE PENETRATIONS

Apply spray foam around sump-pump pits as well as where utilities such as water lines, waste pipes, gas pipes, and oil fills enter the space.

RIM JOIST

The rim joist is prone to air leaks from the multiple gaps: mudsill to rim joist, rim joist to subfloor, and butt joints in the rim joist itself. Install rigid-foam insulation in each joist bay, and seal its perimeter with spray foam.

MUDSILL TO FOUNDATION

Even mudsills set on foam gaskets have gaps. Seal the perimeter with caulk from either the inside or the outside.

BASEMENT WINDOWS

Basement windows are often loose-fit sashes in cast-in-place frames. Use foam gaskets and foam rod to block air leaks.

SLAB TO FOUNDATION

Seal this gap, as well as any cracks in the walls or floors, with masonry sealant.

CHIMNEY CLEANOUT

Seal the perimeter of the door to the frame with high-temperature silicone caulk. The sealant can be cut away and then replaced when the door is opened for cleaning.

BASEMENT CEILING

Use the first-floor subfloor as the air barrier if it's plywood or OSB, if the joist cavities are uninsulated, and if there are few ducts in the basement or crawlspace. If the basement or crawlspace is damp, has dirt floors, or has walls built of unmortared stone, air-sealing the subfloor helps control moisture. In houses with those issues and leaky board subflooring, seal the subfloor with several inches of spray foam. You may also need to dry out the foundation. In all cases, the door to the first floor requires weatherstripping.

TUB OR SHOWER DRAIN

Piece in rigid foam around the pipes, gluing it to the subfloor with caulk or sealant. Fill the gaps with expanding foam.

PIPE AND WIRE HOLES

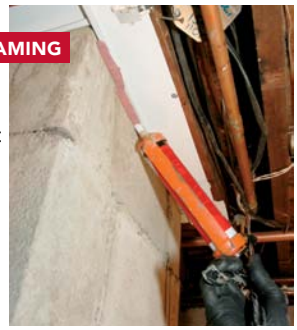
Seal the space between the framing and the wire or pipe with foam or acoustical sealant.

DUCT BOOTS

Seal to the floor with foam or acoustical sealant.

CHIMNEY TO FRAMING

Bridge the space with metal. Fasten it to the framing, and seal it to the chimney with high-temperature sealant or fireblock caulk.



SUBFLOOR GAPS

Apply acoustical sealant or a flexible caulk to the joints.

the hole size and surrounding materials. The energy savings usually pay for the cost of air-sealing within a few years—almost immediately, in fact, if you do the work yourself.

Air-sealing keeps conditioned air inside the house, but it also improves the performance of insulation such as fiberglass, cellulose, and mineral wool by stopping air from moving through it. In addition, because moisture vapor piggybacks on leaking air, air-sealing reduces the possibility of condensation developing in building cavities, which can lead to mold and decay. It's also a first step to adding fibrous insulation to an attic in a cold climate. This type of insulation alone does not prevent warm, moist air from escaping the living space. Finally, air-sealing can block gasoline or CO fumes from an attached garage, or moldy air from a crawlspace. Air-sealing does make it more important to vent bathroom exhaust fans and clothes dryers to the outside.

Air moves in and out of houses due to pressure differences between the inside and the outside. The three main forces driving pressure differences are the stack effect, wind, and mechanical fans. Although wind and fans may be important drivers in warmer climates, the stack effect is often the dominant cause of air leaks in heating climates. The stack effect happens when warm air rises and escapes through holes high in the house, much like how a chimney works. Although it's a weak force, it operates constantly, so it can account for a lot of air movement and energy loss.

Determine your air barrier

Air-sealing starts with deciding which building planes to use as air barriers. A building plane can be the exterior sheathing, subfloor, or drywall. One way to visualize the air barrier is to look at a section drawing of the house and find a continuous line that encloses the living quarters. The insulation should directly contact the air barrier. Generally that means the air barrier is the drywall or sheathing along the exterior walls, the top-floor ceiling or roofline, and either the foundation wall and slab or the first-floor sheathing. Once you've identified the air barrier, look for leaks in it and seal them up, starting with the biggest ones in the attic and the crawlspace or basement.

Finding the holes

Although a visual inspection can find plenty of leaks, it's easier to pinpoint them by pres-

surizing or depressurizing the house and feeling for drafts with your hand or using a handheld smoke puffer. The smoke moves toward a hole if the house is being pressurized, or away from a hole if the house is being depressurized. It's better to pressurize the house when you are using smoke inside to find leaks, and to depressurize the house when you are using smoke outside the living space. Professionals use a blower door for this, a tool that combines a high-capacity fan with a fabric-covered frame that fits in an exterior doorway. A manometer attached to the fan measures the air-leakage rate of the house to predict its performance or to determine rates of air leakage and assess the progress of air-sealing work.

Blower doors cost about $2600, though, and they aren't commonly available to rent. You can sometimes depressurize a house enough to find air leaks by turning on the exhaust fans, central vacuum, and clothes dryer all at once. But in very leaky houses, that may not create a noticeable pressure difference. Another option is a powerful (5000 to 10,000 cfm) drum fan. One can be had for under $150 (I have a 24-in. shop fan from Harbor Freight) and can be fit into a piece of plywood that mounts to a door or window, creating a low-tech, homemade blower door.

Close all windows, doors, chimney dampers, and attic hatches to maximize the pressure difference. Exhausting air from a house may suck air down chimneys, so turn off combustion appliances such as gas ranges, furnaces, boilers, water heaters, or clothes dryers. Make sure that fireplaces or woodstoves have been out for 24 hours. Clean the ashes out of the firebox to avoid sucking them into the house, and wash potentially lead-contaminated dust from around windows in pre-1978 houses. If you have vermiculite insulation in the walls or attic or otherwise think there may be asbestos in the house, consult an asbestos-abatement specialist before doing any air-sealing. Remember to turn the appliances back on and to relight pilot flames when the work is done. □

Editorial adviser Mike Guertin is a contractor in East Greenwich, R.I. Rob Sherwood is a senior project manager with Conservation Services Group in Westborough, Mass. Photos by Andy Engel, except where noted.

SEAL THE ATTIC

In most homes, the drywall ceiling dividing the living space from the attic is the best air barrier at the top of the house. Seal leaks from above, and cover attic accesses such as stairs or scuttles with a foam box such as the Battic Door or ones available at home centers. We sometimes encounter ceilings covered with tongue-and-groove planks or acoustical tiles and no drywall behind them. These ceilings are nearly impossible to air-seal, so it's easier to seal these houses at the rafter plane by spraying a layer of foam against the underside of the roof and sealing off any attic ventilation. When there is no attic, such as with many sloped ceilings, the drywall still can be used as the air-control layer, but air leaks have to be sealed from inside the living space.

DUCT BOOT

Holes in the ceiling for duct penetrations are usually oversize and can leak significant amounts of air. Seal around them with spray foam or acoustical sealant.

RECESSED LIGHTS

These are notorious for leaking air. The first option is to replace a recessed can with an airtight model or a ceiling-mounted fixture, but you also can build an airtight box around lights that have thermal cutoffs as long as you observe the manufacturer-required clearances.

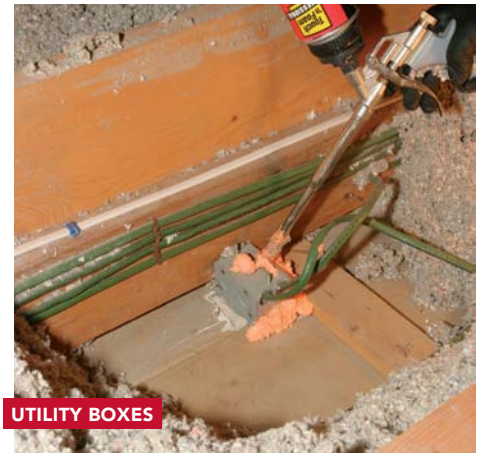
FRAMING AROUND CHIMNEYS

Insulate the space between the chimney and the framing with mineral wool, then bridge the space by bedding sheet metal in acoustical sealant and screwing it to the framing. Seal the metal to the chimney with RTV silicone or fireblock caulk.

Top-right photos, this page and facing page: Mike Guertin

Added up, the gaps between the wall and ceiling drywall and the top plates can amount to a large open area. Seal gaps up to ¼ in. with acoustical sealant and larger gaps with spray foam.

Often found on gable walls, open stud bays conduct air from inside the house into the attic even when they are filled with fibrous insulation. Block the bays with wood or rigid foam sealed to the framing.



Foam or caulk the gap between drywall and electrical boxes, duct boots, and bath fans. Seal holes in electrical boxes, or encase smaller boxes with expanding foam.

Fill holes in the plates and gaps around wires and pipes with spray foam or acoustical sealant.

Large breaks in the ceiling drywall often occur at utility chases, at corbeled chimneys, and above soffits. Block these holes with rigid materials (foam, plywood, OSB, drywall), and seal them to the surrounding framing and drywall.

Dedicated combustion air. *In tight houses, boilers and similar appliances should be supplied with air through a duct leading directly to the outside.*

Can you make a house too tight?

After air-sealing, have a knowledgeable HVAC technician or energy specialist make sure that your house has enough fresh air for your combustion appliances. Air-sealing can tighten a house to the point where combustion appliances don't receive enough make-up air to perform well. Atmospheric combustion appliances can be a health hazard in a tight house. The exhaust gases from a fireplace, woodstove, furnace, or water heater can be sucked down the flue by exhaust fans. Combustion appliances, or the area they operate in, should be outfitted with air intakes ducted from the outside. Broan makes a motorized damper that can be wired to open when the boiler or furnace fires, providing combustion air when needed while otherwise keeping outside air where it belongs. Intake ducts can connect directly to the burner on some models.

Tight houses can suffer from poor indoor-air quality if water vapor, VOCs, CO_2, and odors build up. You may need mechanical ventilation to bring in fresh air and exhaust stale air. In a balanced ventilation system, fans draw in and exhaust air at the same rate. An improvement to a basic balanced ventilation system is to use an energy-recovery ventilator (ERV) or a heat-recovery ventilator (HRV), both of which transfer a large percentage of the energy from the air being exhausted to the incoming fresh air.