HOW TO MEET AND E
AIR-SEALING R

The 2021 International Residential Code has several provisions aimed at curbing energy consumption in homes. It's imperative to educate those in the field on both the code and industry best practices, using the right products in the right way to achieve a project's performance goals. To help builders and remodelers, we'll give a condensed view of the air-barrier, air-sealing, and insulation installation details outlined in Table N1102.4.1.1. The requirements there address insulating rim joists so that insulation is in permanent contact with the exterior rim board, that shaft and penetrations to the exterior are air-sealed and insulated, and that narrow cavities be filled with insulation—among other important details. In addition to the code itself, we've included articles that demonstrate and explain how to accomplish these commonly required air-sealing and insulation details.


XCEED
EQUIREMENTS

How Good Is Your Air Barrier?

If your goal is extremely low air leakage, choose your materials carefully

BY SCOTT GIBSON

Pointing to benefits ranging from lower energy costs to healthier indoor air, building scientists have long recommended that houses be constructed so they are essentially airtight. Model building codes have followed suit by gradually requiring tighter as well as better-insulated dwellings.

The 2021 International Residential Code (IRC) sets specific airtightness standards for new houses, verified with a blower-door test. Maximum permitted air leakage—described as air changes per hour at a pressure difference of 50 pascals, or ACH50—varies by climate zone and whether the builder follows a prescriptive or performance path to code compliance.

As a result, even builders skeptical about airtight construction should be meeting these minimum standards. Builders and designers who work on high-performance houses left these code minimums in their rear-view mirrors years ago. At the far end of this spectrum are buildings certified by the Passive House Institute, whose benchmark is 0.6 ACH50—very tight indeed.

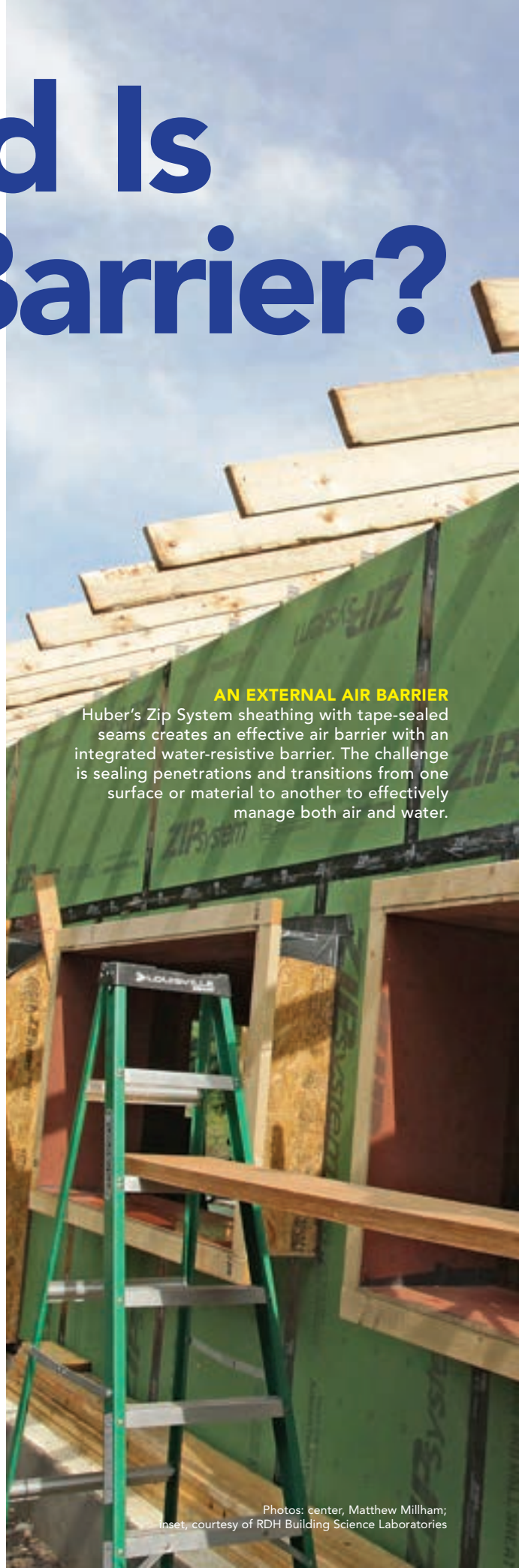
Creating airtight houses requires a range of techniques and materials. An air barrier is not a single material but a combination of materials that together form a continuous air-impermeable layer that should be readily identifiable on construction drawings. Various flashing tapes, sealants, and gaskets are essential parts of the puzzle, but a lot of the heavy lifting is done with materials that cover big areas—sheathing, drywall, housewrap, and peel-and-stick membranes.

How airtight each of these materials is has an impact on the overall airtightness of the building. The more rigorous the airtightness standard, the more important the physical characteristics of the material. The time to ensure airtightness is while the house is being put together. Revisiting the problem later and trying to correct air leaks is expensive and time consuming.

As Laverne Dalgleish, executive director of the trade group Air Barrier Association of America (ABAA), says, "You've got one chance to do this without costing you a phenomenal amount of money to do a retrofit."

First, what is an air barrier?

An air barrier is just one of the four control layers that need to be managed to maintain healthy, comfortable, and energy-efficient spaces. Water, vapor, and thermal (temperature) are the other three, and while many of the materials chosen to build the envelope of a home can operate as more than one control layer, this article will focus just on air barriers. An ideal air barrier should



AN EXTERNAL AIR BARRIER
Huber's Zip System sheathing with tape-sealed seams creates an effective air barrier with an integrated water-resistive barrier. The challenge is sealing penetrations and transitions from one surface or material to another to effectively manage both air and water.

Photos: center, Matthew Millham; inset, courtesy of RDH Building Science Laboratories

MEASURING AIRTIGHTNESS

A standard ASTM test measures how much air passes through a material at a given pressure. Results can be reported in one of two ways (and not all manufacturers report both values). Materials meeting the minimum standard can be considered air barriers. The list below includes a mix of self-adhered, liquid-applied, and sheet products.

Product	*L/s/m² @75 pa (standard is 0.02)	**cfm/ft.² @1.57 lb./ft.² (standard is 0.004)
Tyvek CommercialWrap	0.0023	0.00046
Tyvek HomeWrap	0.01	<0.004
ZIP System sheathing	0.0016	
Henry Air-Bloc 16MR	0.0013	0.00026
Prosoco R Guard Spray	0.0024	0.00048
Tremco ExoAir 130	0.0005	0.00001
Drywall	0.02	0.004
Intello Plus	0.0025	0.00005
SIGA Majvest 500 SA	0.0003	0.00006
Henry Blueskin SA	0.0002	0.00004

* Liters per second per square meter at a pressure of 75 pascals

** Cubic feet per minute per square foot at a pressure of 1.57 lb. per square foot

FLUID-APPLIED BARRIERS Air barriers come in many forms. While self-adhered or mechanically fastened and taped membranes are common, fluid-applied membranes are another option. This spray-applied product, Tremco's Enviro-Dri, forms a waterproof skin over the sheathing that greatly reduces air leakage and requires very little additional air-sealing.

be strong, durable, continuous around the entire building enclosure, and, of course, air impermeable. "Air barriers keep outside and inside air out of the building enclosure," Joseph Lstiburek wrote in a paper published by the Building Science Corporation. "Air barriers can be located anywhere in the building enclosure—at the exterior surface, the interior surface, or at any location in between."

In other words, the air barrier can be in the form of exterior sheathing or a combination of sheathing and a membrane, it can fall in the middle of the wall as a layer of spray polyurethane foam or another impervious material, or it can be on the inside of the building, as a layer of gypsum drywall or specialized building paper.

One air barrier is essential. Some builders and researchers think there should be more than one air barrier in a building—one on the inside and one on the outside.

Air impermeability is key, but what exactly does that mean? In technical terms, it means that air leakage is limited to a certain volume of air at a certain air pressure. The industry standard for a specific material like drywall, housewrap, or sheathing is 0.02 L/s/m^2 (liters per second per square meter) at a pressure of 75 pascals.

Materials leakier than this don't qualify as an air barrier, and builders looking to meet rigorous airtightness standards should think twice about using them.

What material testing reveals

Some materials are assumed to be effective air barriers. They include structural panels such as plywood and oriented strand board, or OSB (at least ⅜ in. thick); concrete, flexible water-resistant barriers; and gypsum board.

A number of these materials have been tested, either by their manufacturers or by independent third parties such as the ABAA, using a standardized test—ASTM E2178. Test results can sometimes be found in the fine print from a manufacturer, although you may have to dig a bit to find them. At its website, ABAA posts results of its own testing of a variety of materials used as air barriers. There are 10 self-adhered sheet membranes on the list of tested products, including Siga's Majvest 500 SA, used by Maine builder Dan Kolbert on a double-stud wall last year. That product showed an air-leakage rate of 0.0003 L/s/m^2, many times better than the air-barrier standard. When tested as part of an assembly (using a different ASTM test method), air leakage was 0.004 L/s/m^2. These results show that the material is a good choice for an air barrier. The same list includes products from the Henry Company, Polyguard, Demilec, and Dörken, among others.

Results also are posted for fluid-applied membranes, medium-density spray polyurethane foam, mechanically fastened commercial building wrap, some rigid board insulation such as Styrofoam, and factory-bonded membranes to sheathing, like Georgia Pacific's DensElement Barrier System. Some of these products show up routinely on commercial jobs but not so much on residential job sites.

According to Dalgleish, the nonprofit ABAA will test materials submitted by association members, who pay a $5000 fee to join. There are no results at the website for plywood or OSB, Dalgleish says, because no one has submitted them for testing. Likewise, the Oak Ridge National Laboratory, a well-known research facility, says it has the means to test material and assemblies that would be used as air barriers but has not been asked to do so. So there is no data to be mined there.

Don't bank on OSB alone

Although OSB is assumed to be a reliable air barrier, a round of private testing by RDH Building Science in Waterloo, Ont., found otherwise. The company was approached by Huber Engineered Woods, which manufactures Zip System sheathing, and was asked to test Zip System, plywood, and OSB for airtightness.

Testing was very limited, involving just one sample of plywood and three samples of OSB, along with three Zip System panels. (The

Photos: this page, Patrick McCombe; facing page top, Travis Brungardt; bottom, Scott Gibson

manufacturers of the OSB and the plywood were not identified.) Zip System sheathing is souped-up OSB, coated with a resin-impregnated kraft paper for water and air resistance. Huber executives no doubt felt pretty good about the RDH experiment; it showed extremely low rates of air leakage for 7/16-in. Zip sheathing.

Commodity OSB didn't do as well. None of the samples met the air-barrier standard, and one showed five times the air leakage that would be permitted. After the samples had been put through a wetting and drying routine to simulate job-site conditions, the results were even worse.

Jonathan Smegal, the lead researcher on the project for RDH, was careful to point out that OSB manufacturers are not making claims about the material's airtightness. OSB is marketed as structural sheathing, not an air barrier. But given the fact that many builders have been using it for that purpose, the test results were not encouraging.

Dalgleish is not surprised. "Not at all," he says. "That's one of the beefs we have with the code. The code has listed a bunch of materials that you don't have to test. My personal position, and the ABAA's position, is the same: If you don't test it, you don't know."

He adds that manufacturers working in a very price-competitive market are watching for ways to reduce costs and may change manufacturing techniques or product ingredients when the opportunity presents itself. Such changes may not affect a product's structural properties, but they could change its air permeability. "Something manufactured five years ago that was fantastic may not be the same material today," Smegal said.

A MEASURE OF SUCCESS
A blower-door test is the standard for finding out how airtight the building enclosure actually is. Some performance standards, such as Passive House, require extremely low levels of air leakage.

Air barriers as part of an assembly

Performance of the material itself is one consideration, but materials become part of assemblies. In the RDH tests, plywood was tested alone, then tested again after wetting and drying, and again after it was covered with a layer of taped Tyvek housewrap. At this last stage, Smegal's group nailed on sections of vinyl siding to see how that affected airtightness. Predictably, leakage went up as the Tyvek-plywood assembly was peppered with nail holes.

Smegal predicted that a house using a similar assembly as its air barrier should easily be able to pass code-required blower-door testing, but probably would not be able to achieve Passive House tightness. It might be hard, he said, to get the house down to a range of 1 to 1.5 ACH50.

Whole-house results also depend heavily on other parts of the air barrier—components such as windows and doors, seals around plumbing or electrical service entrances, gaskets or sealants under bottom plates on exterior walls, and the many other parts and pieces of the assembled whole. As Smegal pointed out, just because one part of the assembly does not meet the material definition of an air barrier, that does not necessarily mean the building can't be reasonably tight when complete.

Kohta Ueno, a senior researcher for Building Science Corporation, adds that it's often the edges and margins of an assembly where air leaks occur, not through a material itself. "We all know that details and connections are where air barriers fail," Ueno says. "I have done plenty of forensic investigations where they've done a beautiful job on the wall, and a fantastic job on the roof, and basically where they came together

DETAILS COUNT
High-quality tape is often a vital part of a continuous air barrier that connects a number of building components. Here, 3M tape is used to seal an OSB air barrier at the ceiling.

something happens and you have a ⅛-inch gap going hundreds of feet around the building. That adds up to a massive air leak."

Proper installation may be one of the most important details of all. "Everything comes down to the workmanship," says Carl Seville, a Georgia building consultant and green-building certifier. "Well-installed housewrap is better than badly installed Zip."

In the case of housewrap, the material may qualify as an air barrier, but unless it's installed carefully it will be leaky. If the housewrap is being used solely to shed water, a simple weather lap will be fine. But that won't be good enough if the housewrap is supposed to be detailed as the air barrier. "Can you detail a mechanically fastened housewrap as an air barrier?" Ueno asks. "You can, but I seldom see that done very effectively."

When materials are easy to install, it often improves their performance as an air barrier, which helps explain why Huber's Zip System sheathing is so popular. Nail it up, seal seams with Zip tape, and you're essentially done (although walls must still be connected to the rest of the air barrier to make it continuous).

Some prefer interior air barriers

Ueno is among those who think that exterior air barriers—in the form of taped sheathing or either liquid-applied or self-adhering membranes—are the best approach. Some builders take the opposite view. One of them is Ben Southworth of Garland Mill in Lancaster, N.H., a high-performance builder with Passive House training.

On the outside of the building, Southworth applies a combination of pressure-treated plywood and Zip System sheathing and tape, but his principal air barrier is on the inside of the house. He uses a vapor-open European membrane such as Intello over the studs. After blowing insulation into the cavities, he carefully tapes the seams. He then adds 2x3 strapping to create a service cavity before installing the interior finish. This approach protects the air barrier from damage, and wiring and plumbing lines are routed through the service cavity, meaning fewer penetrations through the air barrier.

Southworth can easily hit the Passive House airtightness standard, and he thinks an interior barrier makes the most sense. "That's how they taught us," Southworth says of his Passive House instructors.

SMART BARRIER DOES DOUBLE DUTY
Intello Plus is one of several vapor-variable smart membranes that provide both air and vapor control. It acts as a continuous interior airtight membrane as well as a vapor retarder that changes its vapor permeability in response to the relative humidity of the surrounding air.

CLOSING THE GAP
Spray foam can be part of an air-sealing arsenal, along with tapes, gaskets, and other products made specifically for application at edges and penetrations.

"We're really trying to keep all air, particularly moist air, off the exterior sheathing, that condensing surface," he continues. "It makes more sense to me to have our line of defense be that interior paper rather than the sheathing."

The interior mechanical chase makes the building more resilient, and it allows plumbing or electrical lines to be added later without disturbing the air barrier. With sheathing on the exterior sealed at the edges and seams, Southworth is, in effect, using two air barriers, and he routinely gets very low blower-door test results. "It's not the only way," he says, "but it's how we do it."

Spray polyurethane foam is an air barrier

Spray polyurethane foam is used chiefly as a thermal control layer, but it also can act as an air barrier provided that it's applied in a thick-enough layer. Open- and closed-cell foams have different densities. An open-cell foam must be applied in a thicker layer than a closed-cell foam in order to qualify as an air barrier. Air permeability varies by manufacturer, but air barriers are commonly created with 3 in. of open-cell and as little as 1 in. of closed-cell insulation.

A foam's air permeability is reported in a document called an Evaluation Service Report published by the International Code Council Evaluation Service (ICC-ES). These reports are available online. Once you know the type of foam the installer will use, you can look up the report and know exactly how thick the foam should be applied in order to be considered an air barrier.

When it comes to spray foam, there are a couple of things to keep in mind. First, spray foam is manufactured at the job site by mixing two chemicals together. However unlikely, it is possible that it will be mixed or applied incorrectly. Second, spray foam doesn't always make it to areas where leaks occur, such as the seam between a double top plate on an exterior wall.

Photos: left, Brian McAward; center, Daniel Morrison; right, courtesy of AeroBarrier

"Spray foam is a fantastic air barrier where it is," Ueno says. "It does nothing where it's not. So any time you have a wood-to-wood joint where it's not covered up by the spray foam, all of those are potential air-leakage locations."

AeroBarrier seals from the inside

Another option is a product called AeroBarrier, a liquid sealant that is atomized and forced into gaps and holes in the building enclosure when the building is pressurized. AeroBarrier is a substitute for caulks, tapes, and other air-sealing materials. Airtightness can be verified in real time by technicians, and the company says just about any level of airtightness is attainable. Costs average about $1.50 per sq. ft. of floor area.

One adherent to the AeroBarrier method is Pioneer Builders, a spec builder in Port Orchard, Wash., which typically has four or five houses underway at any one time. According to company vice president Bryan Uhler, Pioneer often aims for an airtightness level of 3 ACH50, sometimes lower, and has found AeroBarrier to be the most cost-effective way to get there. Crews don't have to take any special air-sealing steps during construction—that's a big time saver. And AeroBarrier comes in near the end and seals up the building envelope in a matter of a few hours. He likes the system because it saves time and makes job sites safer by eliminating some ladder work.

Costs cover a wide range

Most builders are looking to minimize costs. Some materials used as air barriers are available at just about any lumberyard or big-box store. They include OSB, Zip System sheathing, plywood, and housewrap. Sealing tapes, such as those from Zip or 3M, also are easy to find. Lumber and sheathing prices spiked during the pandemic but have subsided somewhat in recent months. OSB at 7⁄16 in. thick was available for $0.55 per sq. ft. in October in Portland, Maine, while 15⁄32-in. plywood was $0.75 per sq. ft. and 7⁄16 in. Zip sheathing was about $1 per sq. ft. Housewrap cost $0.16 per sq. ft.

Other materials—particularly specialty European membranes—are a little harder to find and are typically more expensive. The Siga Majvest 500 self-adhering membrane that Dan Kolbert uses was $1.12 per sq. ft. from Performance Building Supply in Portland, Maine. Intello Plus (an interior vapor-variable membrane) was $0.45 per sq. ft. at 475 High Performance Building Supply in New York City. Intello X, an exterior version, was $0.48 per sq. ft. The same company also sells a liquid-applied air barrier called Visconn that can be brushed, rolled on, or sprayed. A 2½-gal. container costs about $200, which boils down to between $1.18 and $1.60 per sq. ft. depending on how it's applied. More-complicated applications, such as self-adhering membranes or liquid-applied membranes, also require more labor than taped plywood or Zip sheathing. That's another cost factor.

Think about the airtightness goal

Builders seeking simple code compliance—3 or 5 ACH50—have more room for error in both technique and material selection than someone looking for Passive House levels. Ueno likens air-sealing strategies to having a budget: The tighter the house needs to be, the smaller the budget of total holes in the building enclosure. In a Passive House, covering large expanses of the exterior with commodity OSB as the primary air barrier may use up a disproportionate amount of your total budget of air leaks, leaving little room for error on closing up all the small potential leaks elsewhere. But if the aim is 3 or 5 ACH50 to meet local code requirements, the choice of a particular type of sheathing or self-adhered membrane may not matter as much.

As Ueno puts it, "The goal you have for your project definitely will start to dictate which approach you will take for air barriers." In in his view, that means an exterior air barrier is the best choice, Ben Southworth's success with interior air barriers notwithstanding. "If you're pursuing ultrahigh performance, an exterior air barrier just basically works better," he says. "That's how you end up with these fantastically airtight houses. You can see it, you can inspect it, you can ensure continuity." □

Scott Gibson is a retired contributing writer for *Fine Homebuilding* and Green Building Advisor.

THE MIST THAT SEALS
AeroBarrier is a unique approach to air-sealing a building enclosure. An atomized sealant is forced into cracks in the building envelope under pressure, doing the work of caulks, tapes and other conventional sealants quickly and effectively.

Upgrade Your Attic

Want to keep heating costs from going through the roof? It's easy: Keep your heat from going through the roof.

BY MIKE GUERTIN

Saving money on heating fuel is a lot simpler than negotiating with OPEC or your local utility. Here's how: On a recent upgrade in the attic of a 1950s-era house (one of two projects featured here), I air-sealed and then spread a 12-in.-deep layer of cellulose throughout 1500 sq. ft. of space in about a day. As a result of this and other energy-saving improvements made to the home, the heating and cooling costs were reduced by half compared to the previous year, even in the face of higher electricity and heating-fuel costs.

I typically focus my efforts to improve the energy efficiency of an attic in two areas: sealing air leaks in the ceiling and increasing the amount of insulation in the attic itself.

The payback period for tightening a leaky ceiling can be one heating season. Adding insulation might take a few heating or cooling seasons to pay off, but the wait is relatively brief. The payback in energy savings for air-sealing and upgrading attic insulation on these two homes was less than three years, although the savings vary with every project.

On these projects, I installed a radiant reflective membrane. Besides reducing radiant-heat gain from the roof, the membrane makes the attic more attractive and dust-free for storage use, and it keeps the blown-in insulation I use from blocking the rafter bays. While radiant barriers can reduce peak attic temperatures by 10°F to 30°F, they haven't proved to be cost-effective in all geographic regions or in attics that are adequately insulated, that are air-sealed, and that have well-insulated, wrapped air-handling equipment and ductwork. In these cases, you may be better off spending the money on more insulation and air-sealing than on a radiant barrier.

Stop the air leaks, stop losing heat

Air leaks can account for 30% of a home's energy loss, so it pays to seek out and seal every penetration between the living (conditioned) space and the attic (unconditioned) space before adding insulation. Don't leave any batt unturned when hunting down air leaks. Dust deposits in leaking air stain insulation brown or black, so you can start by

Attic work safety

Working with insulation is about balancing safety and comfort. Although official health warnings are ambiguous at best, it's a good idea to err on the side of caution, especially with fiberglass. You might see photos of me without a long-sleeved shirt or, occasionally, gloves; when it's 100°F in an attic, I'll endure some itching to stay cooler. You won't see me without a mask, though.

- **A respirator** and safety glasses are necessary in any situation.
- **When handling fiberglass**, it's a good idea to wear long pants and a long-sleeved shirt, or a one-piece work suit. If your hands are sensitive, wear gloves.

Drawings: Don Mannes

Insulation

POTENTIAL AIR LEAKS IN THE ATTIC

If air leaks aren't sealed, conditioned air from inside the house can pass through fiberous insulation placed between the ceiling joists. These leaks can range in size from a pinhole to the gap surrounding the typical 3-ft. by 4-ft. access hatch. For the contractor or homeowner who wants to create a tighter building envelope, the hardest part of the task is finding the air leaks; sealing them is relatively easy. Below is a checklist.

One word of caution: Air-sealing a house can lead to backdrafting of natural-draft-combustion appliances like water heaters, furnaces, or boilers, so have a combustion-safety assessment done before and after tightening a house. Add fresh-air intakes to the combustion appliance area(s) as needed based on the results of the assessment.

1. Recessed lights and electrical boxes
2. Holes for wires or pipes in drywall and framing
3. Attic hatchway
4. Spaces between the framing and the chimney
5. Plumbing or electrical chases
6. Framed soffits that are open to the attic
7. Drywall joints between ceiling and wall plates
8. Leaky joints in ductwork

• **Step only on ceiling joists**, never on the ceiling. Use kneeboards that span between ceiling joists for more freedom and stability.

GREAT STUFF PRO™ Gaps & Cracks Polyurethane Foam Sealant
greatstuff.dupont.com

Choose the right air sealant for the job

When I'm air-sealing an attic, I use four or five different types of sealants. I use caulk when I need precision: sealing a recessed-light can to the ceiling drywall, for instance, or sealing some pieces of rigid foam to framing. I use expanding foam to fill large holes around pipes and wires and gaps larger than ¼ in. At locations where fireblocking is required according to the International Residential Code section R302.11 Fireblocking, I use a sealing caulking or foam that is acceptable to the local building or fire official. See **7 Common Fireblocking Locations** (FHB #296) for more information.

Fireblock caulk
3m.com

Big Stretch
sashco.com

THE SPACE AROUND **THE CHIMNEY**

There's usually a 2-in.-wide gap, required by code, between framing and masonry chimneys. To close the gap, first stuff it with stone or slag wool (**1**), then apply a bead of adhesive caulk to the framing (**2**). Next, screw down wide strips of metal (recycled drip edge) along the perimeter (**3**). Seal the metal to the chimney with fire-rated intumescent caulk (**4**). For continuity, you need to seal the ceil-ing joists to the drywall below and at inside/outside corners of the rough opening with caulking.

looking for discoloration in the insulation.

I treat the drywall ceiling as the air barrier and seal all penetrations, joints, and holes. The open framing for soffits and chases is a highway for air leaks from wall cavities into the attic. Another gaping hole is the attic-stair bulkhead (sidebar p. 12).

I install an insulated and gasketed cover for the attic access panel or pull-down stairway. You can buy a ready-made access cover or make your own. The cover can be fit within the riser or on top of it. When the cover sits on top of the riser, apply the gasket material (usually adhesive-backed foam tape) to the cover (not the floor) so that it's not damaged when someone accesses the attic.

Next, I seal recessed-light cans and ceiling-mounted light-fixture boxes. Both are often overlooked, but when combined are one of the biggest sources of air leaks. The holes and the perimeter of ceiling-mounted electrical boxes should be sealed to the drywall with a fire-resistant sealant or foam (sidebar left). Gaps around ducts, wires, and pipes that penetrate into the attic must be located and closed, too. Most inexpensive and old bathroom exhaust-fan

IC-rated light
Airtight insulation-contact-rated recessed light

REPLACE, SEAL, OR ENCLOSE **RECESSED LIGHTS**

Recessed lights are one of the most overlooked sources of air leaks into attics. The best choice is to change old can bodies (**1**) for airtight insulation-contact-rated (IC-rated) models (inset photo) and then seal the rim to the drywall with foam or caulk. IC-rated lights that aren't airtight can be sealed by covering the fixture with an airtight box made from rigid-foam insulation (**2** and **3**), metal, or drywall, or by sealing

Photos left: Krysta S. Doerfler

NEEDS A FIRE-RESISTANT SEAL

boxes have open seams and holes that should be covered with mastic or duct-sealing tape. The fan-box perimeter should be sealed to the drywall with caulk or foam.

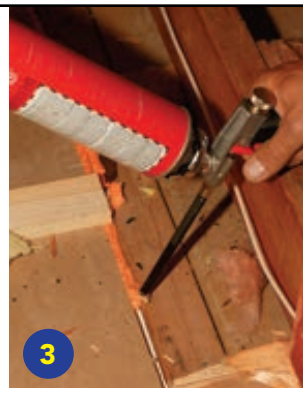
Another typical area to block off and seal is the 2-in.-wide space between framing and masonry chimneys. Combustible materials aren't allowed to contact the masonry, so it's best to use sheet metal to block the space.

I also seal the joint between the drywall and the wall plates. The thin joints between the ceiling drywall and the wall top plates might seem insignificant, but they add up when you figure the linear footage of walls. Expanding foam or sealing caulk easily fills the gaps.

Address wiring issues

Because old knob-and-tube wiring can't be buried under new insulation, have an

SMALL LEAKS ADD UP, SO SEAL THEM ALL



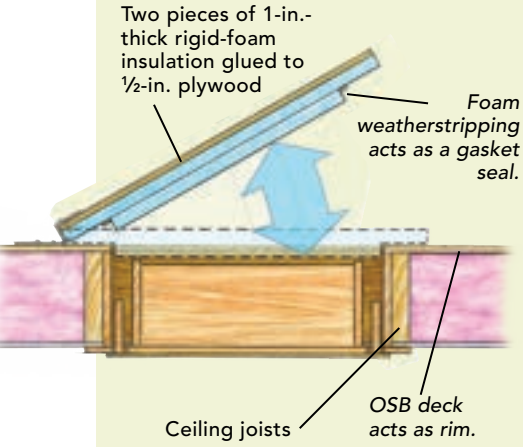
Usually, the greatest number of leaks come from small perforations in the ceiling: metal electrical boxes, drywall seams, and any place a wire or pipe comes through from below. Use expanding foam to seal large gaps around pipes (**1**) and wires. Use caulk to seal small holes in electric boxes and the gap between the box and drywall (**2**) and seal drywall to wall-plate gaps 1/4 in. or wider with foam or caulking for narrower gaps (**3**). If any of the sealing comes under local regulations for fireblocking or draftstopping, then use fire- or smoke-rated foam or caulk.

holes in the can body with spray foam or caulking (**4**).

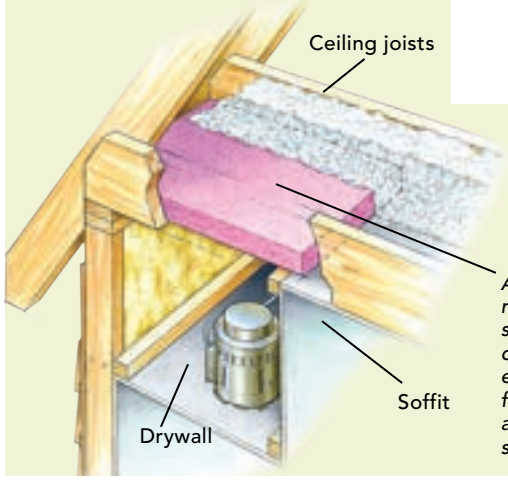
Non-IC rated cans cannot be covered with insulation and need an airspace around them. It can also be dangerous to install an air-sealed box over them. Ideally, non-IC rated cans should be replaced with IC-rated models.

Block the biggest offenders

The attic access is a big leak that can be fixed quickly: Build or buy an insulated cover for the access bulkhead. The key is to provide a rim to connect to the sealing cover. The rim can be made from strips of sheathing, framing lumber, or rigid foam; then the cover sits on top or fits around the rim. Here, the author added a deck of leftover ½-in. plywood and OSB after the insulation was added.



Interior soffits that are framed before the drywall is hung can leak huge quantities of air. Fill in the openings between the ceiling joists above the soffits with solid materials like rigid-foam panels, drywall pieces, or sheathing scraps, then seal the edges with expanding foam or caulk.



electrician replace any old wires in the attic before adding insulation. Ideally, all junction boxes should be raised above the level of the insulation. When elevating the junction boxes isn't a option, you should install clearly marked permanent tags that can be seen above the insulation level.

While I am working in the attic, I like to install two electrical conduits (one line voltage and one telecom/low voltage) between the attic and the basement or the crawlspace to make any future wiring upgrades easier to accomplish.

Tune up existing insulation

The two types of insulation that are often found in older attics are fiberglass batts and loose-fill cellulose. For batt insulation to perform at its rated level, it must be installed snug to the ceiling surface and to the edges of the framing. Any gaps or voids reduce the insulation's effectiveness. If the existing insulation is in good condition, it can be reused.

I tune up the insulation by tightening end joints, making sure batts are tight to the ceiling drywall, and filling in any voids with new pieces of insulation.

If I've decided to increase the amount of insulation with more batts, I like to add insulation on top of the old batts flush with the top of the ceiling joists and then install a new layer of unfaced batts running perpendicular to the joists. Placed above the joists, the cross-layered batts can be tight together to minimize heat loss through the joists and to maximize performance.

If I'm upgrading with loose-fill insulation, I keep it from falling into eave soffits and maintain channels for roof ventilation by installing a layer of blocking made from rigid insulation in the rafter (or truss) bays over the exterior-wall plates. I notch the rigid insulation around the rafters so that I get a tight fit in the bay.

Blowing insulation is a two-person operation

Blown-in loose-fill cellulose or fiberglass isn't as common as batt insulation, but both are installed quickly and cover the attic floor completely. Loose fill can be blown in over any existing insulation that's been tuned up first. Cellulose (R-3.2 to R-3.8) has a higher R-value per inch than fiberglass (R-2.7 to R-3). Both of the materials are installed with the same basic techniques. A two-person crew is the absolute minimum. The machines used to blow in insulation vary in power and features, but rental machines are typically the most basic.

Pick a blower location as close to the attic access as possible. Cellulose and blowing fiberglass are messy to handle, so the loading area will be covered quickly. I prefer to set up outside, but a garage is an ideal place to stage the bales and blower when the weather doesn't cooperate. I lay down a large, clean tarp and place the machine in the middle with the bales close by. Insulation that falls onto the tarp is easy to gather up and reload. Don't let any debris get mixed into fallen insulation. Nails and sticks can jam the blower or plug the hose.

The insulation fluffs as it races through the corrugated hose, so use the recommended hose length for the blower and type of insulation you are installing to ensure the proper loft. Route the hose up to the attic with gentle bends. Tight bends can reduce airflow and lead to a plugged hose

Blowing machines have agitators that break up the insulatioin bales and a blower

Joist bays should be sealed with rigid blocks to keep insulation where it belongs. Cut rigid foam into strips the width of the joist bays, and slip them out over the top wall plate. The panels block the loose-fill insulation that's to be installed from clogging the soffit-to-ridge air channel and add a higher R-value to the short space over the plate.

that drives air through a hose. The person feeding a cellulose machine breaks up the bales and drops them through a protective grate on top of a hopper.

Fiberglass blowers are a little different. Compacted fiberglass bales slide into the machine's loading port, and the machine breaks them open. The person loading the machine doesn't have to open or break up the bales.

The insulation installer handles the hose and works from the far ends of the attic toward the access hole. Good lighting is a must. If hard-wired attic lighting isn't enough, run a string of work lights or wear a high-powered headlamp. Discharge the hose at a slight angle upward, and let the insulation fall into place. This helps it to spread more evenly. Shooting the hose directly at the ceiling causes the insulation to mound up. If high spots occur, use a long stick or a broom to even them off. Although high spots aren't really a problem, low spots don't perform as well.

Once insulation covers the ceiling joists, there's little way to know the depth of the insulation. Insulation distributors sell paper gauges marked in inches that you staple to rafters or ceiling joists. I make gauges by cutting 1½-in.-wide cardboard strips about 1 in. to 2 in. longer than the target depth; I draw a line across each strip at the final insulation grade. Expecting the insulation to settle 1 in. or 2 in. over time, I mark the strips at 14 in. and staple them to the sides of ceiling joists every 6 ft. □

Editorial adviser Mike Guertin is a builder and remodeling contractor in East Greenwich, R.I. Photos by Charles Bickford, except where noted.

BLOWING INSULATION IS A TEAM EFFORT

A division of labor keeps insulation flowing. One person handles the hose, and the other feeds the blowing machine. The most critical job is at the machine (inset photos left and bottom right), where the steady rate of insulation flow is controlled by the operator. At the other end of the hose, it's best to start at the farthest point and work back to the attic access. A slight upward hose angle helps to spread the insulation more evenly.

Fiberglass made easier

Owens Corning's (owenscorning.com) AttiCat machine breaks up bails and blows loose-fill fiberglass. The packaging is stripped as the bale is pushed into the hopper. Then the machine agitates the fiberglass and blows it out through the hose. The blowing fiberglass is not as dusty as cellulose.

The Best Way to Insulate a

Stop energy losses with a spray-foam kit

BY ISAAC SAVAGE

As a building-performance consultant, my main goals are to improve the comfort, efficiency, durability, and healthfulness of buildings. To achieve these goals, it's necessary to control the movement of heat, air, and moisture within and through a building envelope. Attention to insulation and air-sealing details throughout a house is critical.

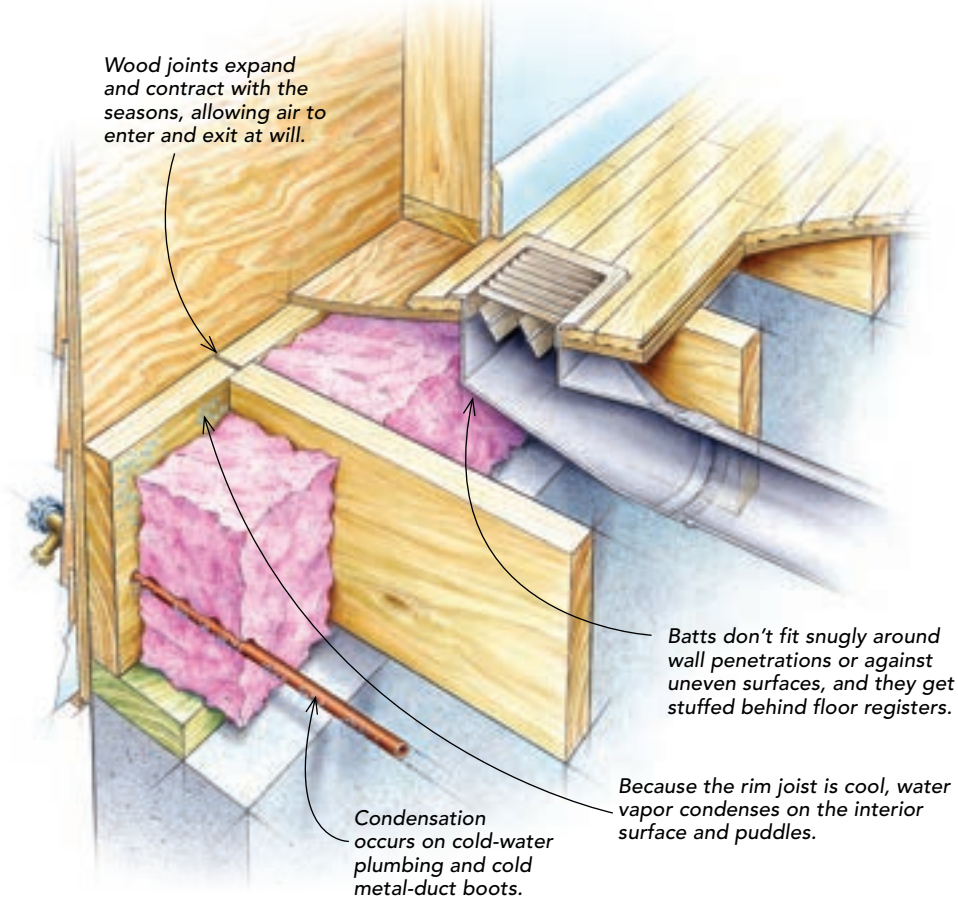
The areas most susceptible to energy loss and moisture damage are often the ones you no longer see after a home is built. The rim joist, also known as a band joist, is a perfect example. It should be insulated to achieve the same R-value as the exterior walls. All joints around the rim joist are susceptible to expansion and contraction, making them especially vulnerable to air and moisture movement. Once the drywall is installed, the rim joist is rarely thought about again. But improper insulating and sealing in this area can lead to comfort complaints, high energy bills, air-quality issues, and moisture damage.

In the past, few options have been available for insulating rim joists, but with the increased awareness of building science, manufacturers are developing innovative solutions to insulate this area properly. Two-component spray-foam kits offer a quick, effective solution to tricky insulating problems. The kits consist of two liquid chemicals that mix together in the tip of a gun, then expand once they hit the surface. The foam is highly adhesive, so it sticks and stays in place as it expands to fill gaps. Once cured, the foam provides an effective air seal as well as insulation. □

Isaac Savage is president of Home Energy Partners, a building-performance consulting and insulating contractor in Asheville, N.C. Photos by Chris Ermides, except where noted.

FIBERGLASS DOESN'T STOP AIRFLOW

Stuffing fiberglass batts between floor joists is a common method of insulating the rim joist in many homes, but it's a severely flawed technique. Fiberglass works best in an enclosed space where it can trap air (between drywall and the exterior sheathing of a stud wall, for example). When used as shown in the drawing below, the insulation cannot perform at its full-rated R-value because air and moisture can move freely in and out of the building through wall penetrations and wood joints, eventually making their way into conditioned space through areas like floor registers. Not only does air move freely around the batts, but because the insulation is not enclosed, it moves freely through the fiberglass as well.



FOAM-KIT SOURCES

Spray-foam kits (about $360 for a 200-bd.-ft. kit) are available in either open- or closed-cell foam. Open-cell foam is R-4 per inch and allows vapor to pass through it, which lets the building dry to the inside. Closed-cell foam is R-6 to R-7 per inch and does not allow vapor to transfer as quickly. Either type is suitable for the rim joist. Kits and yield calculators are available through manufacturers' Web sites and their distributors.

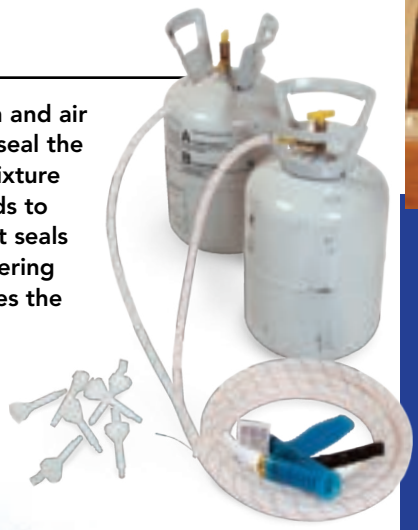
Versi-Foam
RHH Foam Systems
rhhfoamsystems.com

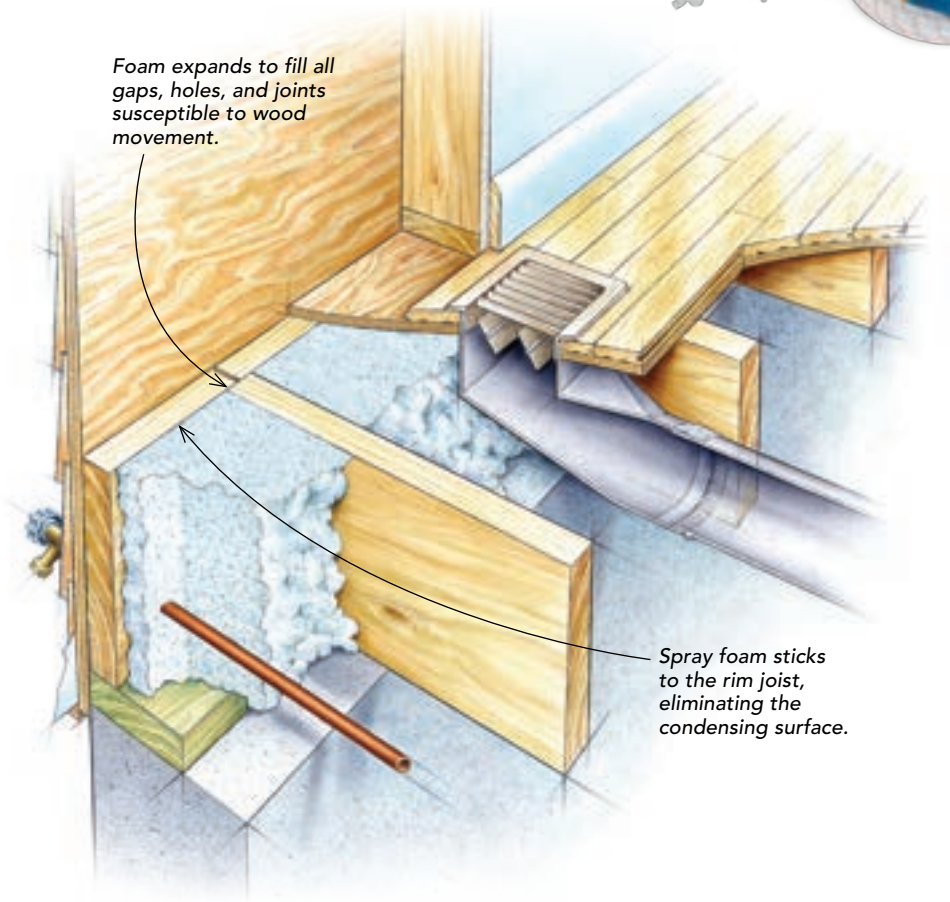
Drawings: Don Mannes. Photo left, facing page: Krysta S. Doerfler.

Rim Joist

SPRAY FOAM DOES

A two-component spray-foam kit (right) is insulation and air barrier, making it the fastest, most efficient way to seal the rim joist. When sprayed between floor joists, the mixture sticks to the surrounding surfaces. The foam expands to fill holes made by wall and floor penetrations, and it seals wood joints, stopping air and water vapor from entering or escaping. Once the foam expands fully, it insulates the cavity as well. Because the foam doesn't allow air to move through it (which diminishes R-value), it always performs at its full-rated R-value.





Handi-foam
ICP Building Solutions
handifoam.com

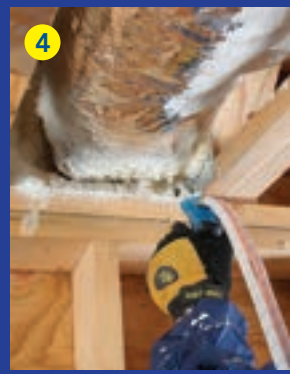
Touch 'n Seal
DAP Products Inc.
touch-n-seal.com

Tiger Foam
Commercial Thermal Solutions, Inc.
tigerfoam.com

FOAM STICKS TO EVERYTHING

When applying expandable foam, protect anything you don't want covered in foam. **(1)** Wear protective clothing; I recommend using a Tyvek suit with a hood. Wear gloves, goggles, and a high-quality respirator.

Applying foam is fairly simple. Don't stop spraying for more than 30 seconds, or the foam will dry in the gun and ruin the kit. Before you start, shake the canisters well to mix the liquid inside; then open the valves. Coat the gun end of tips with petroleum jelly before you start spraying so that they're ready when you need them. **(2)** Replace a tip when you notice a decrease in spray volume, and spread more petroleum jelly around the connection between tip and gun. **(3, 4)** The gun reacts much like a garden-hose spray nozzle, so keep steady pressure on the trigger. Spray the cavity perimeter first, then cross back and forth to fill the space. Adjust the speed of your strokes to get the thickness you're looking for.



BY MARTIN HOLLADAY

How to seal 4 hidden air leaks

A ⅛-in. crack doesn't seem like much to worry about, but a ⅛-in. crack that runs the length of your house amounts to a square hole 8 in. on a side—a big-enough hole to toss a cat through. Because it is a crack, you can seal it with caulk, but not all holes in the building envelope are cracks that can be sealed with a tube of caulk. Some of them really are big enough to toss a cat through, and they need to be sealed with sheet goods such as drywall, rigid foam, or plywood.

Some common gaps and holes are listed in the Energy Star thermal-bypass checklist. Among the most common holes found in poorly sealed houses are holes near soffits, chases, and bathtubs. Green Building Advisor has a collection of 56 detail drawings that pertain to the Energy Star checklist. These drawings come from that collection.

Chases and soffits are raceways for air leaks

Older houses often have several big holes in the attic floor. Many are around open chases for ducts, electrical cables, or flues, often running unimpeded from the basement to the attic. When installing plumbing chases in new houses, install air-barrier sheathing first, and seal the gaps between intersecting walls with caulk. As the framing shrinks, these gaps become large. The top of an open plumbing chase in an existing house can be sealed with a variety of sheathing materials as long as seams and edges are sealed with caulk or tape.

If any chases for plumbing pipes, ducts, or flues originate in the basement, be sure to seal the chases at the bottom with the same techniques you used to seal the chases in the attic.

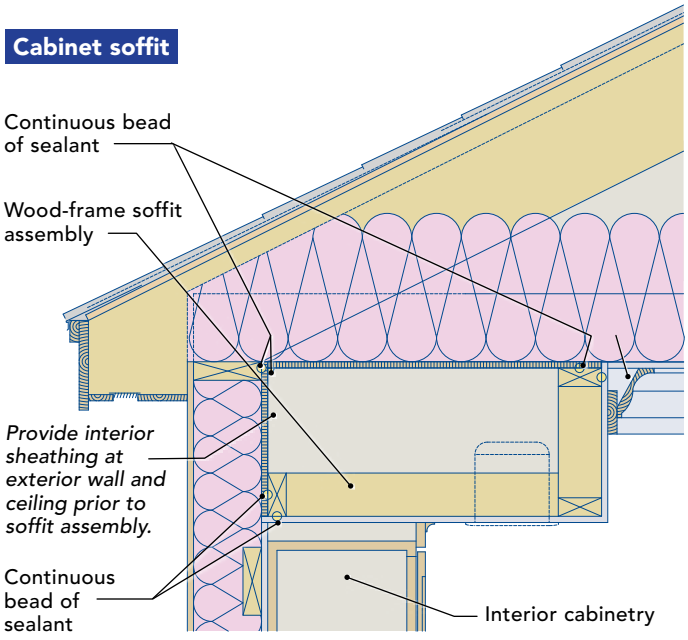
While you're in the attic, check for any unsealed kitchen soffits. Such soffits are often built above a row of wall cabinets. In new construction, the ceiling drywall should be installed and taped before the soffit is framed. The first clue to a leaky soffit is often a piece of discolored fiberglass insulation. The discoloration is caused by escaping air that has carried dust upward, often for years.

In many existing houses, the sides and top of kitchen soffits are open to the framing cavities. In this case, you can install the necessary pieces of air-barrier sheathing from above. Don't forget to seal

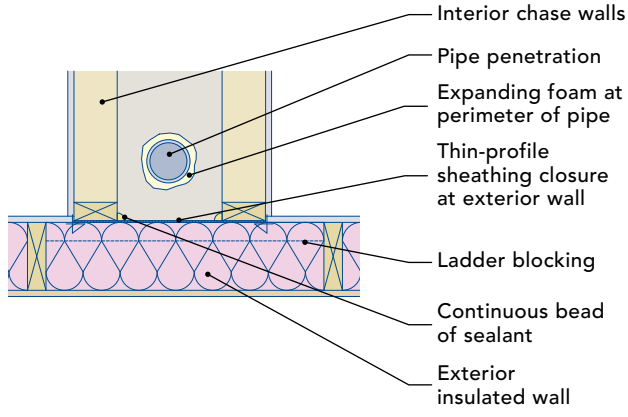
4 ASSEMBLIES TO GET RIGHT FROM THE START

While a chase or soffit in an existing home can be air-sealed, sleuthing around in attics and crawlspaces is no fun. When it comes to tub assemblies and prefab metal fireplace surrounds, retrofitting an airtight assembly can require major demolition and repair. In all of these cases, you can boost energy efficiency dramatically by installing air-barrier sheathing at the framing stage.

Cabinet soffit



Chase walls (plan view)



Drawings: Steve Baczek, Architect

in your house

the perimeter of the sheathing and any seams with durable tape, caulk, or spray foam. Once the soffit is airtight, don't forget to replace the insulation

.

Tubs hide big holes in floors and walls

When you're installing a fiberglass tub/shower unit against an exterior wall, it's essential to insulate and air-seal the wall before installing the tub. On new-construction jobs, remember to install a durable air-barrier material (for example, Thermo-ply sheathing) to cover the insulation.

In an existing house where builders omitted the insulation and the air barrier behind the tub, repairs are difficult. One solution (not the cheapest) is to remove some of the siding and sheathing so that spray-foam insulation can be installed from the outside. A better bang for the buck may be to address the problem as part of a larger bathroom remodel. If you're contemplating a bathroom upgrade, it may be cheaper to demolish the tub/shower unit and seal the wall properly from the interior.

If your house has an unconditioned basement—in other words, if the basement ceiling is insulated—be sure to pull that insulation aside and check for air leaks under any first-floor bathtubs or showers. Plumbers typically cut out a big piece of the subfloor to accommodate drain lines and traps, but rarely repair the ruptured air barrier. If these cutouts are not sealed, your floor has a huge hole.

Keep fireplace heat inside

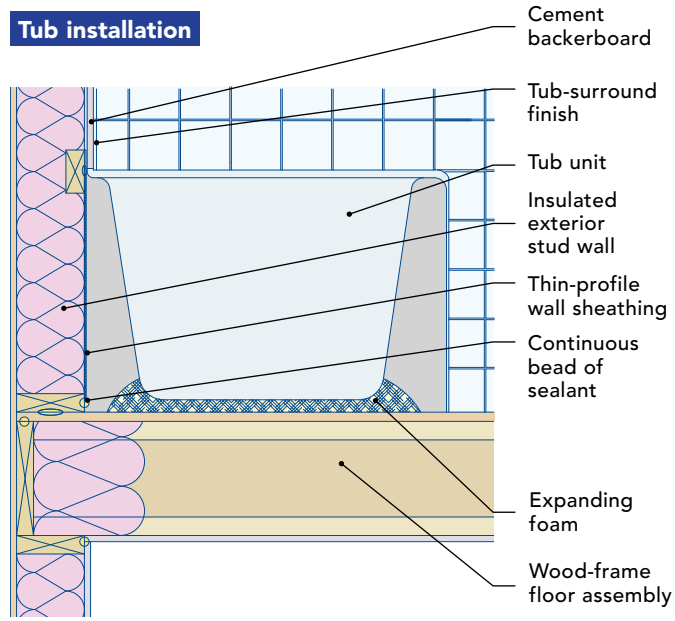
Prefabricated metal fireplaces, whether wood-burning or gas-burning, are usually installed in a niche framed into an exterior wall. Unfortunately, many of these fireplace niches are poorly sealed against air leaks.

The best opportunity to prevent such leaks is before the fireplace is installed. After the niche is carefully insulated, the insulation should be covered with a durable, rigid air-barrier material, such as Thermo-ply sheathing, drywall, sheet metal, or OSB. All gaps and seams should be sealed with caulk, spray foam, or contractors' tape. Where the chimney penetrates the niche ceiling, seal gaps with metal flashing and high-temperature silicone caulk.

To repair air-barrier defects behind an existing metal fireplace, it may be necessary to remove sections of siding and sheathing to provide access for the installation of spray polyurethane foam. □

Martin Holladay is a retired editor who lives in Vermont.

Tub installation



Prefab fireplace niche

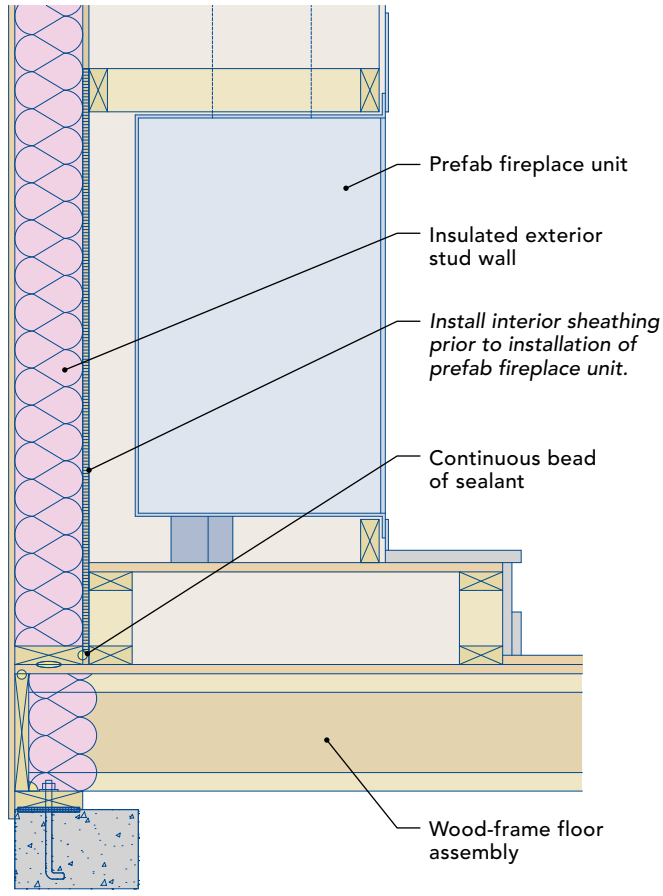


TABLE N1102.4.1.1 (R402.4.1.1) AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope.The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop-down stairs, or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
Walls	The junction of the foundation and sill plate shall be sealed.The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of not less than R-3 per inch. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and in continuous alignment with the air barrier.
Windows, skylights, and doors	The space between framing and skylights, and the jambs of windows and doors, shall be sealed.	n/a
Rim joists	Rim joists shall include the air barrier.	Rim joists shall be insulated.
Floors, including cantilevered floors and floors above garages	The air barrier shall be installed at any exposed edge of insulation.	Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking. Alternatively, floor framing cavity insulation shall be in contact with the top side of sheathing or continuous insulation installed on the underside of floor framing; and extending from the bottom to the top of all perimeter floor framing members.
Crawl space walls	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.	Crawl space insulation, where provided instead of floor insulation, shall be permanently attached to the walls.
Shafts and penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.	n/a
Narrow cavities	n/a	Batts to be installed in narrow cavities shall be cut to fit or narrow cavities shall be filled with insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	n/a
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be sealed to the finished surface.	Recessed light fixtures installed in the building thermal envelope shall be air tight and IC rated.
Plumbing and wiring	n/a	In exterior walls, batt insulation shall be cut neatly to fit around wiring and plumbing or insulation that on installation, readily conforms to available space, shall extend behind piping and wiring.
Shower/tub on exterior walls	The air barrier installed at exterior walls adjacent to showers and tubs shall separate the wall from the shower or tub.	Exterior walls adjacent to showers and tubs shall be insulated.
Electrical boxes and phone boxes on exterior walls	The air barrier shall be installed behind electrical and communication boxes. Alternatively, air-sealed boxes shall be installed.	n/a
HVAC register boots	HVAC supply and return register boots that penetrate building thermal envelope shall be sealed to the subfloor,wall covering or ceiling penetrated by the boot.	n/a
Concealed sprinklers	Where required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.	n/a