Practical Air-Sealing

Getting to 3 ACH50 isn't hard if you focus on these locations

By Steve Easley

In my work as a building-science consultant, I meet with builders around the country. Many of these are production builders, and I often work with their crews to teach them about quality assurance—issues that can lead to either inspection red tags or costly callbacks. In the past few years, as more states and municipalities have adopted the 2012 and 2015 International Energy Conservation Code (IECC) into local building codes, I have spent an increasing amount of time educating crews about cost-effective approaches to air-sealing. The new energy code mandates blower-door verification for homes, with a maximum 3 ACH50 in climate zones 3 to 8. That's a tough mark for some builders to get to from the previous requirement of 7 ACH. The new requirement means that builders now have to be very deliberate in their air-sealing efforts.

With diligent effort, we can do a lot better than 3 ACH50. A good example is Jake Bruton's work featured in "Air-Sealing That Works" (Apr/18). But in this article, I'm not going to look at how close to the cutting edge of airtightness we can bring conventional practice. Rather, I'm going to target some of the low-hanging fruit, so to speak—the places a building crew can focus on to hit the 3 ACH50 that's required by code. That low bar begins with a discussion of what doesn't work.

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Fiberglass insulation (by far the most commonly used insulation in U.S. homes) does not stop air leakage. Two of the photos above show this clearly: The black areas are caused by dust and dirt getting pulled through the insulation. Insulation works as a filter but not as an air barrier. I'm constantly surprised how builders loosely think that if we are dealing with insulation, we must be dealing with the energy code. Maybe the limitation here is a lack of understanding that there's much more to the energy code than just saving money on air-conditioning bills.

Many of the builders I work with initially see air-sealing only as an energy issue. A few also appreciate the comfort and indoor-health issues. But one of the most important, and often under-appreciated, reasons for air-sealing is durability: By controlling air leakage, we help control moisture.

The photo above of fungus growing on the sheathing and wall framing is of an exterior wall; it's inside a wall cavity where a plumbing stack is running. Leaks at the plumbing stack and the sheathing allowed moisture laden air from the interior to leak into the stud bay. The moisture condensed as the air made its way out through sheathing joints, leading to water soaking the wood and providing the right conditions for mold and rot. The lesson here is that air-sealing is about so much more than just about reducing energy bills.

Why Accurate Measurements?

Air-sealing, or rather providing a "continuous air barrier," has been a code requirement for a long time. The big change with the 2012 version, in addition to lowering the maximum air leakage rate, was the new requirement to verify the air leakage rate for a home using a blower door. While the testing requirement is new to many builders, it may be a blessing in disguise. If you don't measure, you don't know how leaky or tight your building is. Many of the air leaks in a building cannot be visually identified. With a blower-door test, you have an accurate approximation of the total air leakage in the building.

Researcher David Wolf, working with Owens-Corning in 2013, performed a study that dove deeply into quantifying home air leaks. Using typical blower-door depressurization conditions, Wolf designed a battery of tests to measure, and rank, the impact of air leaks in different locations of a home to determine which air leaks make the biggest difference in the total air leakage (see "An Air-Sealing Priority List

," Aug/13).

Wolf's work has been especially useful in quantifying all those seemingly small, inconsequential leaks to show how big an impact these can have on total house air leakage. His work mirrors my field experience and is a good guide for builders and their crews on where to focus their air-sealing efforts.

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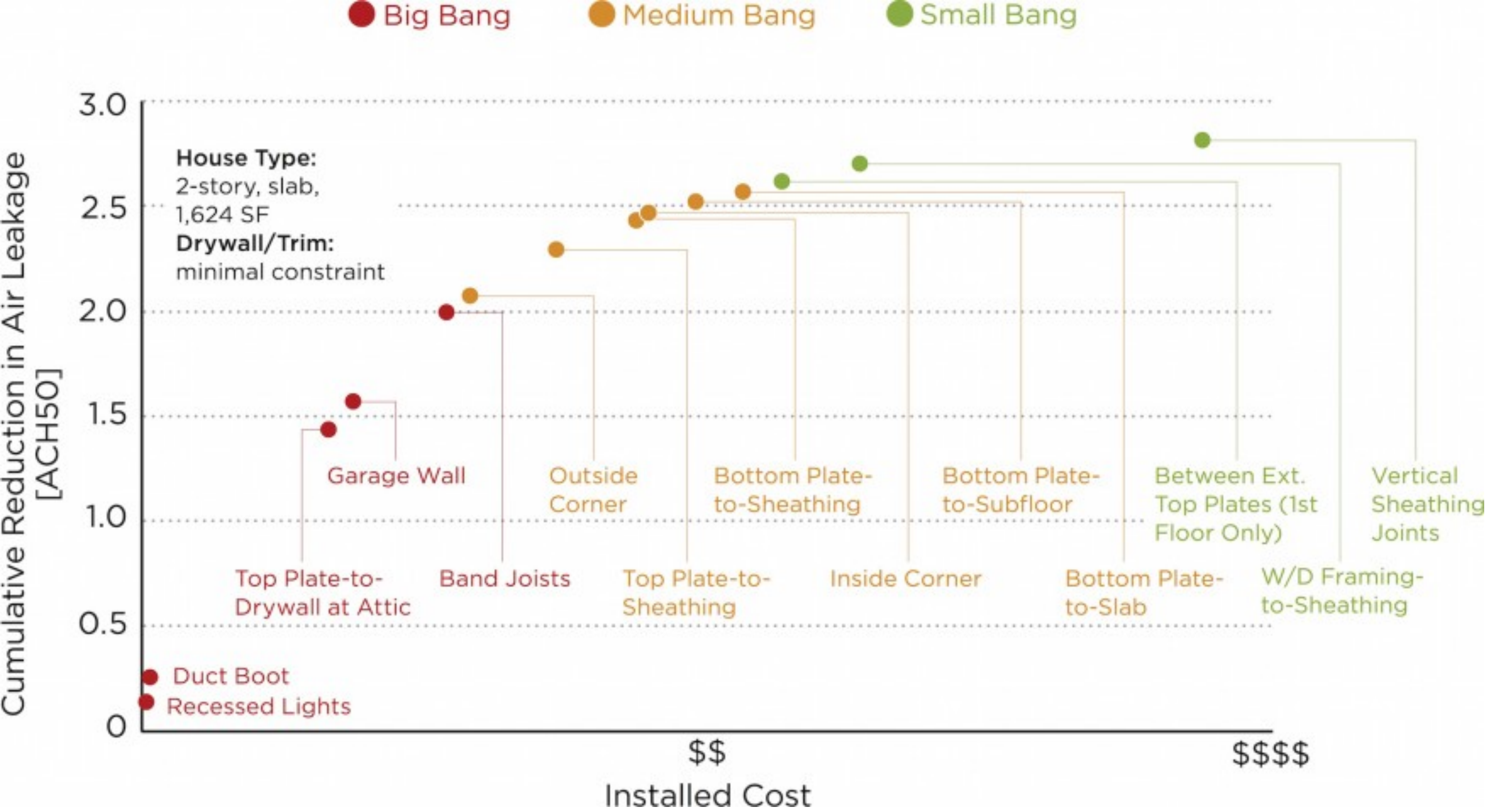

In studies conducted by David Wolf for Owens-Corning, air leaks are ranked on the basis of CFM50 reduction for the amount of effort required, and the amount of material needed, to complete each air-sealing task. Wolf grouped the results in three categories: those that provide a "big bang for a builder's air-sealing buck" (red); those that provide a "medium bang" (orange); and, as the return tapers off, those that provide only a "small bang" (green). Certain leaks — like vertical sheathing joints and the sheathing joints around windows and doors — require a lot of sealant for only a modest reduction in airflow, which is why they are "small bang" leaks.

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But there are other factors besides just the amount of leakage. How much effort is involved plays a big role, and that effort often varies by how a builder works, how many trades are involved, and how the scheduling of different trades unfolds during a project.

Attic First

For an air leak to occur you have to have a hole and a pressure difference. Pressure differences are caused by wind, stack pressure and mechanical equipment. Fewer holes mean less leakage. Attics are particularly prone to losses from stack effect, which effectively turns a house into a drafting chimney (hence "chimney effect" is a synonym for "stack effect"). Air leaks at the top tend to be the most numerous and the easiest to remedy, making the attic the single most important place to focus on.

I recently air-sealed a house built in 1978. Because the house had a family of bats in the attic, all the attic insulation had to be removed. This was a perfect opportunity to air-seal. By sealing only the attic leaks, we cut the air leakage rate from 4,460 cfm to 2,180 cfm—more than half the total air leakage.

If builders would conscientiously air-seal the attic ceiling after the drywall is hung—before insulation—getting to 3 ACH50 would be much easier. It wouldn't have to interrupt the sequence of the job, and it could be done with minimal cost. More production builders need to take this step.

Wall plates in attics. Partition and exterior walls are typically framed with truss chords fastened to the top plates. Once the ceilings are hung with drywall, you generally end up with hundreds of feet of cracks on either side of the top plates open to the attic.

Each stud bay in the partition effectively becomes a little chimney. Stack effect draws in air at the bottom of the wall plates and pushes it out the cracks into attics. Holes for electrical wiring and plumbing vents compound the leakage.

Top plates of partition walls in attics are huge sources of air leaks, made worse by all the electrical penetrations.

They can be sealed effectively with canned or boxed foam sealant, but with foam sealant, installers have to be extra careful to not miss spots along each side of the plates.

In Wolf's study, drywall-to-top-plates are one the biggest "joints," accounting for around 0.5 CFM50, or 1.3 to 1.6 ACH50, per linear foot of joint. This can add up fast in attics.

One way to shut down top-plate leakage on partition walls is to drywall the lid before standing partition walls. Jake Bruton employed this method on the build he covered in the April 2018 issue. It does require a full-scale sequencing change, which I have not been able to sell to many big builders, especially in this labor market. Even if you don't like this approach, its still easier to air seal the attic before insulation is installed. I can't stress enough that if builders take this step of addressing air-sealing in the attic, they will be able to achieve 3 ACH50 relatively easily.

Arn Mcintyre

Having an insulation contractor hit the entire top plate with closed-cell foam often works better. (Note: Be sure not to bury junction boxes in foam. And insulation-rated light fixtures may still need to be covered before applying foam to prevent foam from oozing inside the fixtures. Consult the manufacturer for recommendations.)

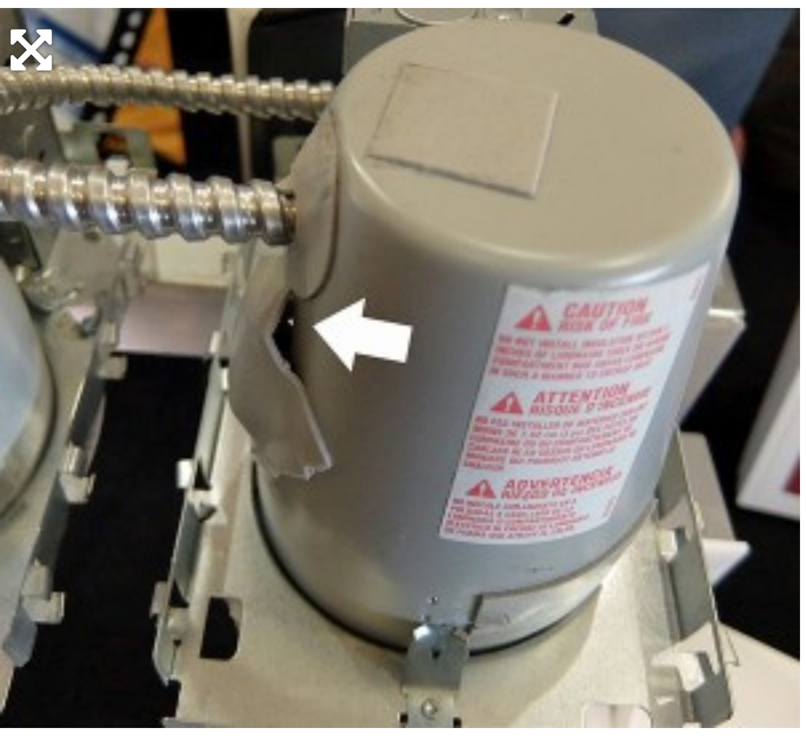
Foam sealant sprayed along all the plate joints certainly can work, but it's easy for installers to skip spaces along the joint, creating an incomplete air-seal. Some builders find it's easier to send in a spray-foam-insulation installer. One reduced-cost method is to foam-over plate areas of the attic floor, including the perimeter wall plates. Or, you can foam over the entire attic floor, though this can get expensive.

Can lights. Of all the openings in a house, one of the biggest from an air-leakage perspective is around recessed light fixtures. In Wolf's study, can lights accounted for an average of 9.1 CFM50, or about 0.15 to 0.31 ACH50, per fixture. One way to think about this amount of air leakage is that for every four to five can lights you seal, you can gain about 1 ACH50.

Conventional recessed cans are extremely leaky. You can see right through them.

Recessed lights are a common source of air leakage, as shown by the light shining around this conventional can light viewed from the attic.

Surprisingly, many so-called “airtight, IC-rated” fixtures (which is what the energy code requires) are not much better.



This fixture reportedly meets the code requirement for “airtight, IC rated,” but in fact you can see light through one gasket (white arrow).

Better from an air-sealing perspective (and arguably from a lighting perspective, as well) are a range of new LED “can-less” fixtures that either have a low-profile housing or are surface mounted. Both types have simple plug-and-play-type wire connections that not only simplify the installation but result in almost no penetrations. (Consult the LED manufacturer for specific recommendations regarding insulation contact.)

A variety of LED fixtures available these days provide better options where recessed lights are demanded. The fixtures shown in the foreground have plastic housings that are virtually free of air leaks, and provide a simple plug-and-play connection that is completely separate from the lamp housing; the electrical connection won't penetrate a ceiling air barrier.

Duct boots at the end of HVAC supply runs through the attic are another big ceiling penetration from an air-sealing perspective. Wolf measured the average leakage at 7.7 CFM50, or 0.13 to 0.26 ACH50, per boot. Foam sealant carefully applied to the perimeter of the boot and the drywall tends to be the easiest way to seal these leaks.

Duct boots are best sealed with foam sealant.

Knee-wall areas and the floor and roof sections outside attic trusses are protected from weather, but otherwise “open” to outside. The best way to deal with these enormous leaks is with rigid foam or heavy cardboard sheathing. It is picky work to piece-in these sheet goods and foam or tape the edges. But if not done, the impact on performance can lead to costly warranty issues. (For more on this, see “Fixing the Bonus Room,” Mar/17.)

Because this is an attic truss, there is no bottom wall plate at the edge of the floor deck. Additional blocking between the trusses is needed to provide a surface to seal to.

Attics often have other huge openings that many builders don't see as air leaks. A common one occurs in the ceilings of single-story attached garages where they bump up and connect to a larger attic space over the main house, or to a two-story wall. The best way to shut these huge leaks off is to sheathe over them at the framing stage. Otherwise, you will need to go in later and cut pieces of rigid foam to block off the areas between the truss chords, and then seal the edges with foam sealant.

Huge hidden leaks above this garage ceiling will be inaccessible once the ceiling is hung. These areas should have been sheathed before the attic trusses were installed.

Dropped ceilings above cabinets are often left open to the attic floor. The exterior wall gets insulated, and often the insulation contractor will lay a batt over the opening in the attic floor, but underneath that insulation is just one big hole to the unconditioned attic, which is effectively outside.

Cabinet soffits are huge leaks to the attic.

Drywall on the lid is the best way to shut these down.

The most effective way to seal these is by installing the ceiling drywall before framing out the soffits. A continuous drywall lid over the area effectively shuts down the airflow, whereas the drywall that gets pieced on the sides and bottom of the soffits doesn't. There are too many cracks at the soffit corners that corner bead and drywall mud don't seal.

Not every builder can get the drywall contractor on board to hang the whole ceiling early in the schedule, but you may be able to get the pick-up framing crew to install a few selective sheets of drywall over the soffit area. It's not much drywall compared with the entire ceiling. Having the pick-up crew install these few sheets may not be as disruptive as you expect.

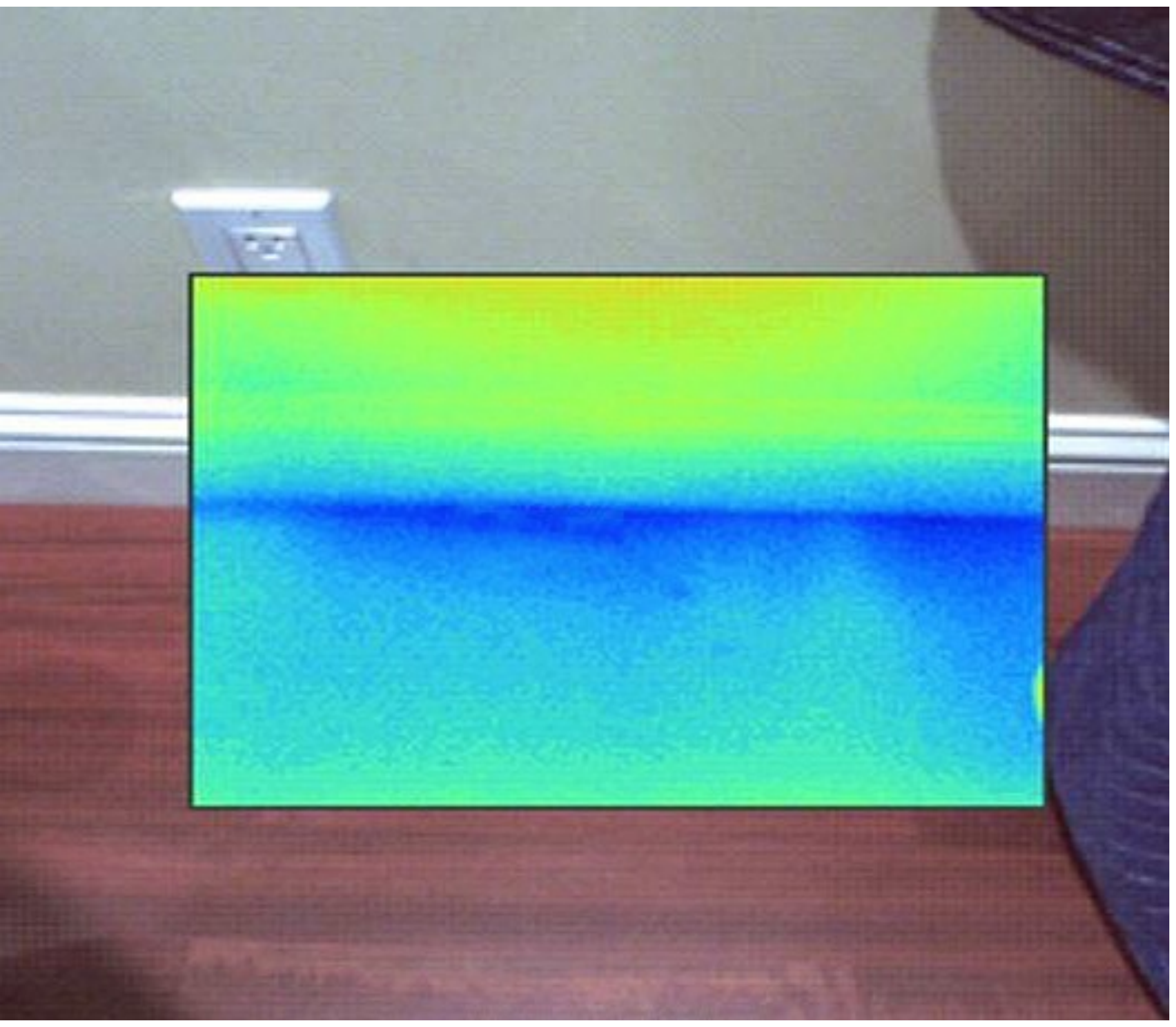
Bottom Plates and Band Joists

Beyond the attic, there remains a host of wall air leaks on which builders can focus attention to produce a significant reduction in total leakage area.

One of the most significant is the bottom plate connection to the foundation, and especially at the garage separation wall, where plate leaks measured in at 0.6 CFM50 or an average of 0.2 ACH50, per foot of joint.

All exterior wall plates can leak, and the garage separation wall should be considered an exterior wall.

At the bottom of the house, stack effect is a strong driver of air leakage, concentrating high pressure at the top and bottom of the building. This makes all sill plates prime leakage areas.



An infrared image shows air getting pulled from under the baseboard during a blower-door depressurization test.

Band joists for second floors fall closer to the neutral pressure plane—the middle section of a building's height—and therefore, they do not tend to be as affected by stack pressures. Nevertheless, they are still extremely leaky owing to the number of cracks formed by all the pieces joining in this area. In fact, Wolf measured these as the leakiest joints in a house at 0.86 CFM50, or about 0.4 ACH50, per foot.

Some builders continue to believe that stuffing the rim with fiberglass is sufficient. Batts may work to insulate this area, but you first need to air-seal with caulk in the corners at the top and the bottom of the rim joists (the corner between the sill or wall plate and the top-side decking), as well as along the joists or floor trusses crossing the sill plate. This is awkward work, to say the least. Getting between the floor joists and the decking is difficult. Some framing crews have gotten skilled at handling a caulk gun as they frame, sealing the plates before installing floor decking, and then coming back to apply one bead to seal the top of the rim to the deck. This is not the way every framing crew likes to work, however.

Band joists are among the leakiest areas in a house. Insulation stuffed between joists is not an air-seal.

Closed-cell foam applied here provides a good air-seal. Even if you don't insulate the walls with it (as shown here), hitting the rim-joist area only with foam can be a cost-effective way to air-seal this difficult area.

A much easier and still very effective way to address the rim joist is to seal the entire area with closed-cell spray foam (13). It can be cost-effectively foamed to a 1-inch thickness (or in colder areas to 2 inches), and insulated with batts (flash-and-batt), or insulated to a great depth to satisfy the entire code-required wall R-value. Even if you're not insulating the wall cavities with foam, insulating the rim joist entirely with closed-cell spray foam is turning out to be a go-to solution for an increasing number of builders.

HVAC Penetrations

Vents and ducts passing through framing can lead to some large, significant leaks through the building shell. (That is, leaks that impact the blower-door test—not to be confused with a duct-tightness test. Duct testing is a separate concern between the builder and the HVAC installers.) Many HVAC ducts and vents run through boxed-out framing chases and connect an equipment room at slab level, or a basement or crawlspace, with the attic. Once again, with many of these leaks, stack pressure is the principal driver. Plumbing vents, which run either in boxed out chases or through a stud bay, also fall into this category of leaks that connect the bottom of walls to the attic. (And we'll get to plumbing drains in a moment, which deserve their own kind of special attention at the floor level).

Ducts need to be sealed at the locations where they run from an attic or crawlspace into conditioned space.

But just going through the motions is not enough; attention with spray foam is required.

What makes HVAC vents, including chimney vents, special is that the air-sealing solution often includes an all-important accommodation for avoiding the risk of fire. Boxed-out vent chases should be capped with OSB or plywood, and this combustible material needs to be cut back from the vent and the gap bridged with sheet metal and fire-rated caulk.

Vents for combustion appliances must not touch combustible materials.

Sheet metal and fire-rated caulk will work for air-sealing the gap.

Fireplaces are an important subset of this. Too often, these are installed in boxed-out framing areas. The fireplace insert itself is often housed in an area that has walls that are open to the exterior walls and a lid that opens, with a vent running out through the roof. It's critical that builders follow the vent, which sometimes passes from the conditioned space into the attic through a very large framing opening.

Fireplace inserts are often boxed into framing. (In this case it's a "box-out.") The exterior wall behind the fireplace will be left open to the exterior from an air-sealing perspective after the finish drywall is installed.

One way to do it is with a "box-in," which results in a sealed chamber for the fireplace insert. The boxed-in chamber will be hidden once drywall is hung on the walls.

The best way to handle the insert is to house it in its own chamber, seal it off with drywall and sheathing before final drywall, and use the appropriate vent, sealed with fire-rated caulk. When the walls of this home are drywalled, only the face of the fireplace will be visible (in other words, it will look like a fireplace, not a woodstove).

Combustion Safety

Here is an important addendum related to combustion appliances and fireplaces: If you are working with a home-performance contractor for your blower-door testing, you are likely in good hands and will be guided on accommodating any natural-draft combustion appliances. (Note: For a good reference on home performance contracting, see Measured Home Performance. This site is published in California but applies broadly to all states. In particular, the videos and PDF of the book by Rick Chitwood and Lew Harriman are invaluable resources.) Best practice by far in any home is to install direct-vent, sealed combustion appliances. However, if you're making a budget choice not to use sealed-combustion equipment, and you're not working with a home-performance contractor, beware: A combustion appliance that is starved for air can backdraft, drawing carbon monoxide down the chimney. This is one of those no-joke matters; it can end in the death of an occupant, and no builder wants to face that.

Until recently, energy codes have not done a good job addressing the life-safety issue of combustion-appliance backdrafting. The IECC rectifies this in the 2015 version with an entirely new section addressing fuel-burning appliances. It requires the combustion appliance, such as a furnace or a water heater, to be isolated from the building envelope by locating the equipment room either outside the envelope—in the garage or crawlspace, for example—or in a separate room supplied by open air ducts. This room must be insulated and sealed off from the rest of the conditioned space, so that like a garage or the crawlspace, it exists effectively outside the building envelope. Again, the safest, simplest and most cost-effective solution is to use sealed combustion equipment.

Plumbing

There are two serious leaks that get missed time and time again.

Tub area. Plumbers often cut out a section of the subfloor to install traps, leaving a massive hole under the tub. Rigid foam (or another easy to cut and handle panle stock), and foam sealant at the edges, can remedy this.

The open area in a first-floor slab that is formed-out to accommodate the drain trap also needs to be sealed. Foam sealant, laboriously installed, can work, but spray-foam insulation might be more efficient to install.

One is the bathtub drain over crawlspaces. It's not uncommon for plumbers to overcut the floor sheathing to make ample room to glue up the drain trap. This happens not only in wood-framed floors but also in slabs where the slab is often formed to fit the trap and this gets left as a wide-open hole under the tub.

Behind tubs, framing is often left open.

The exterior wall behind a tub or tub platform should be sealed with drywall or sheathing. (Heavy cardboard sheathing, such as Thermoply, works well for this.)

The other place that gets missed is the wall behind the tub. Unlike most of the wall in the bathroom, which gets air-sealed with drywall or backerboard, the area behind the tub, or tub platform, is often left open.

The solution is simple: Before the tub surround is framed in or the tub installed hard to the framing, the wall needs to be covered with a panel stock. This is required by code.

P*hotos by Steve Easley except where noted.*

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Steve Easley is principal of Steve Easley Associates, a company based in Danville, Calif., that provides building-science training and quality assurance for builders nationwide.

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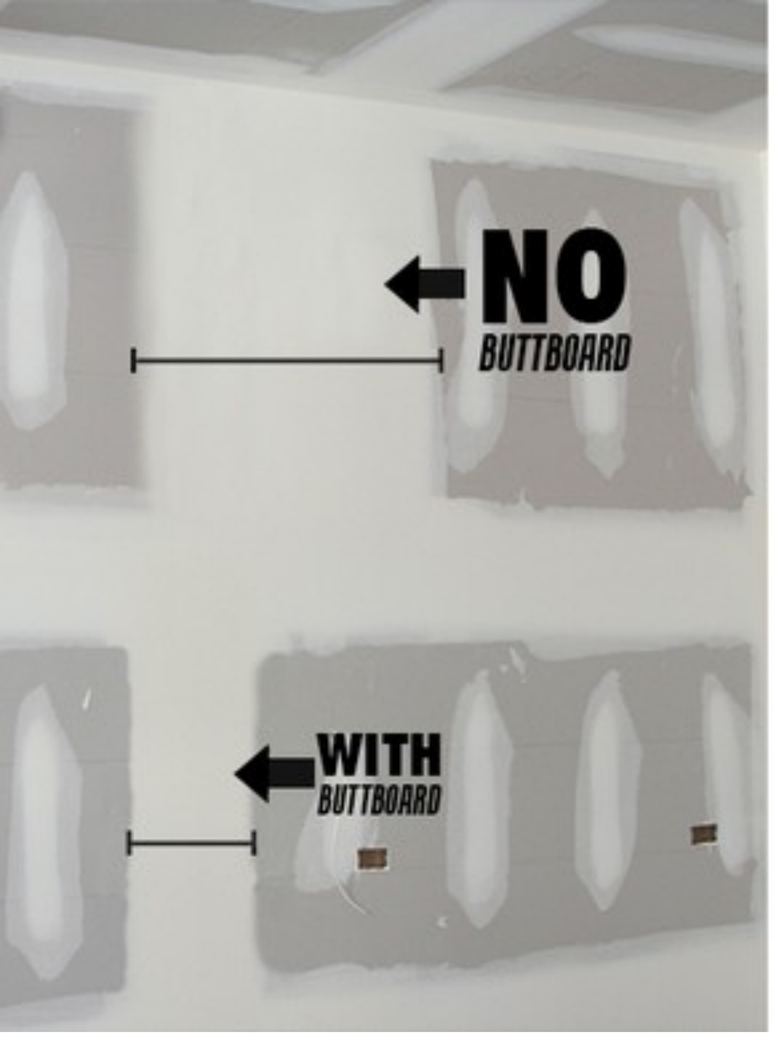

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