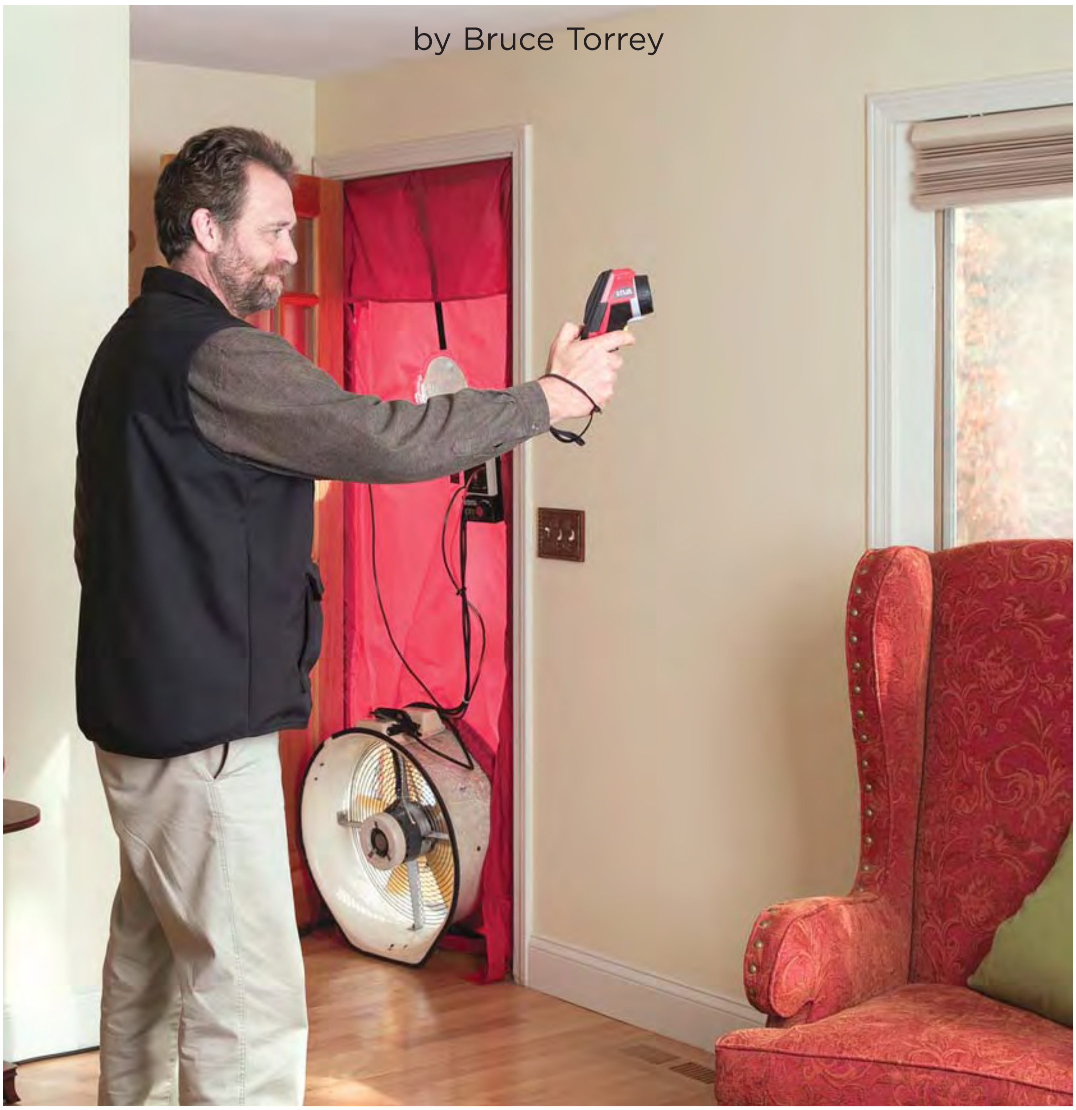
Air-Sealing Attics In Existing Homes

For best results, locate the heat loss with a blower door and an infrared camera

As a contractor during the1980s energy crisis, I directed my energies toward building the beta version of the super-insulated home. I experimented and struggled with my share of "cutting edge" strategies, with mixed results. It became quickly apparent that some of the experimentation — like site-built skylights — was less than successful. What was not so obvious at the time was that, in spite of beefing up the insulation levels in everything I built, I wasn't really getting the thermal performance I would have expected.

However, as more building diagnostic tools

by Bruce Torrey



became available, I was able to see the flaws in my previous insulation strategies. I also saw a business opportunity: troubleshooting the all-too-common efficiency and comfort problems in buildings.

Over the last couple of decades, energy prices have continued to rise and energy codes have gotten stricter, but many of the same flawed insulation strategies are still being used in the field. Meanwhile, the consumer's demand for increased comfort often goes unanswered. Many of the calls we get involve existing homes that have new replacement windows and are already insulated. So what else is left to do?

Fortunately, advances in building science are helping the industry take a fresh look at how buildings really perform and what types of improvements are most practical and effective. The critical first step is to understand how a building loses heat. This may sound obvious, but there are still many misconceptions.

Flawed Assumptions

Probably the biggest misconception involves *where* a house loses most of its heat and what types of details can stop these "hidden" drafts. In most building configurations, fiberglass batt insulation — or even loose cellulose blown into an attic — doesn't do a good job of controlling air movement. Many studies have shown that air moves through fiberglass batts and degrades their R-value. And while cellulose can stop air movement when it's blown into closed cavities at densities above 3.5 pounds per cubic foot, loose-fill cellulose blown in an attic will not stop air leaks.

Most of the homes I visit have attic insulation, but they also have many air leaks from inside the house into the attic — at mechanical penetrations and plumbing chases, along partition-wall top plates, at framing intersections like soffits or other changes in ceiling height, around chimneys, and so on. In a typical leaky attic, upward air pressure from

Typical Thermal Bypass

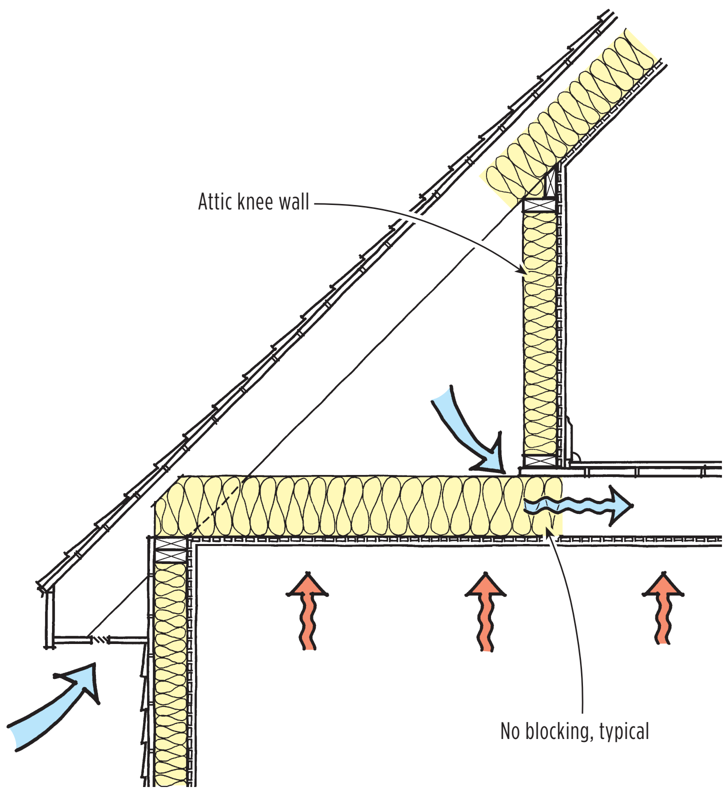


Figure 1. Even though they're often insulated, attic knee walls are a common thermal problem area. Because there is typically no blocking below the knee-wall bottom plate, cold air from the attic or outside air moving through the insulation at the eaves chills interior ceiling cavities, drawing heat away from the living space.

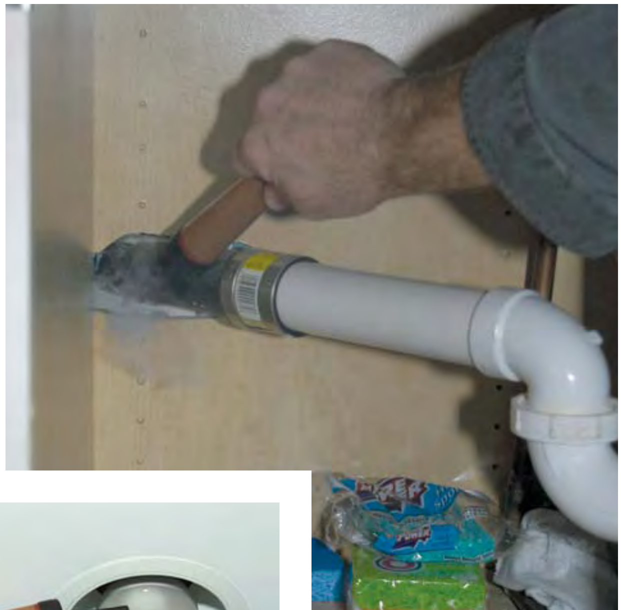


Figure 2. With the blower door running, the author uses a smoke pencil to detect leaks in the house's air boundary. The leaks shown here — at a window sill (above), at a plumbing penetration in a base cabinet (above right), and at one of several can lights (right) — were the result of a kitchen remodel that left the home feeling draftier than before.

the stack effect — the tendency of warm air to rise — can replace all of a home's heated inside air with cold outside air in just two or three hours.

Homes with knee walls or side attics have the further complication of horizontal heat loss and infiltration between heated floor cavities and the eaves (**see Figure 1, page 2**). In many cases attic ventilation only makes this worse, by connecting the interior to the outside and allowing wind to move far into the heated space.

New Tools, Better Results

These air leaks seldom get addressed during traditional home improvements because they're not visible from inside the conditioned space; they're concealed inside framed cavities, behind drywall or plaster. But with modern diagnostic tools, it's possible to find them and to complete an accurate, detailed heat-loss assessment of a home in just a few hours.

Using an infrared thermal camera in conjunction with a blower door, an energy auditor can identify leaks in the air envelope and insufficient or missing insulation in the thermal envelope.

On a typical job, I first set up the blower door and depressurize the house to 50 pascals, relative to the outside. This approximates the range of pressures a building would be subject to on a very windy night and helps establish a consistent benchmark for comparing the leakiness of one building with that of another.

The blower-door fan draws outside air in through penetrations in the shell and exhausts it through an entry door. The calibrated fan measures the cubic feet per minute of airflow required to maintain the 50-pascal pressure difference between inside and out. The draftier the shell, the higher the flow in cubic feet per minute. Simple math helps us convert the cfm reading to a whole-house air-exchange rate, stated in air changes per hour.

With the blower-door fan running, I make a visual inspection of the home, looking for any obvious leakage spots (**Figure 2**). A smoke pencil — a handheld device that emits a stream of

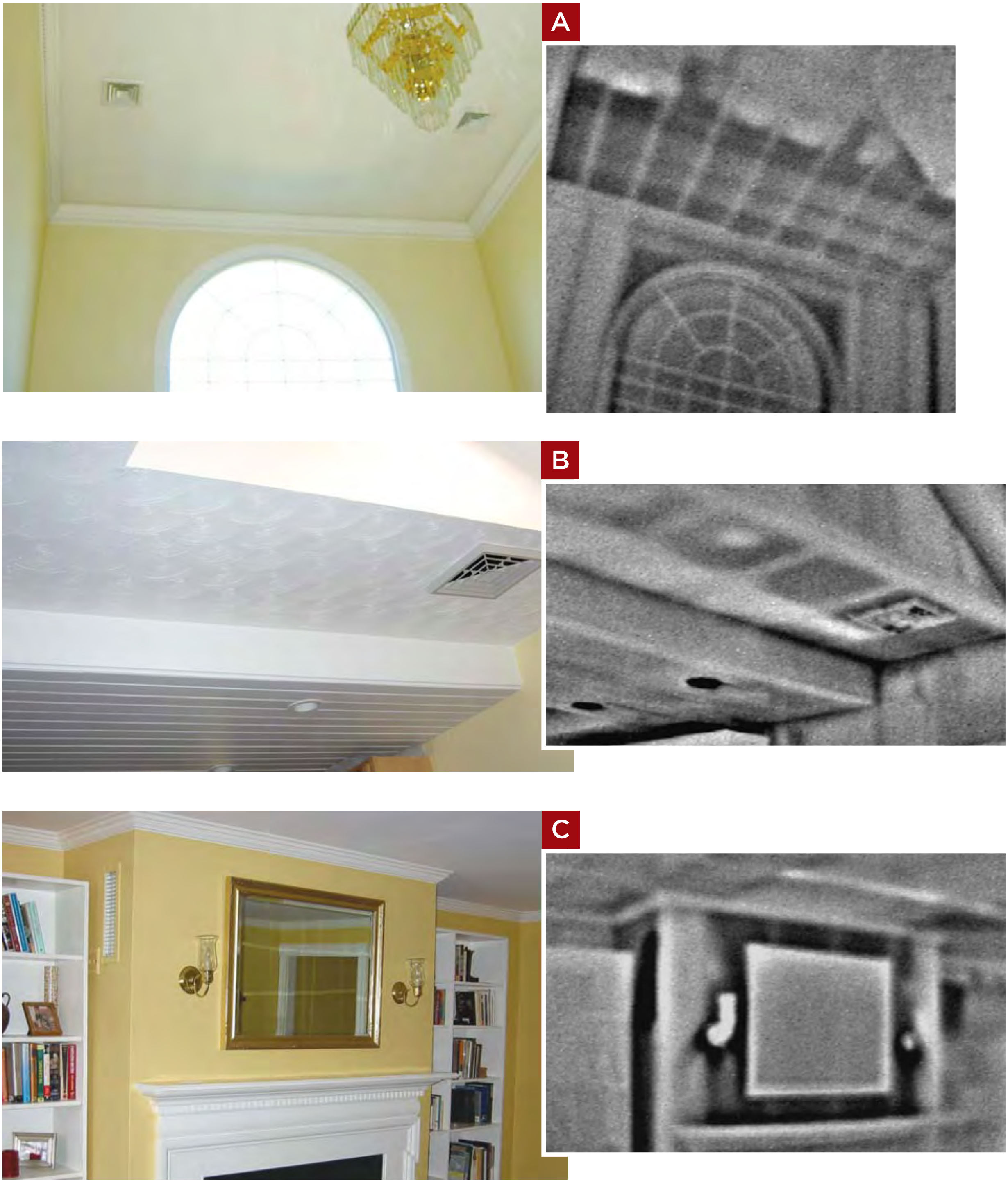


Figure 3. The darker spots in these thermographic images indicate the presence of cold in framing cavities behind the drywall surface — areas where cold air has infiltrated or heat has been lost through conduction. At top (A), the framing around a Palladian window lacks insulation, while the ceiling area above suffers from wind-washing at the eaves. An interior soffit (B) is cold because the batt insulation does not make good contact with the drywall; also, the gap around the ceiling register is drafty. The uninsulated wall around an interior fireplace (C) is chilled from cold attic air dropping down through the vertical chimney chase between the framing and the masonry.

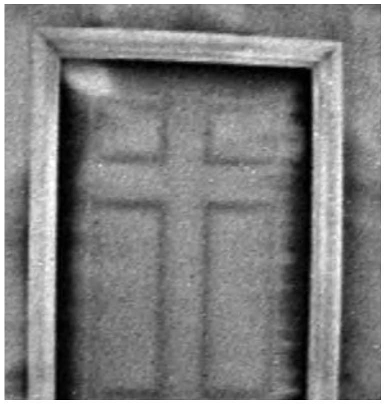


Figure 4. Wind-washing — air moving under and through the ceiling insulation at the eaves — degrades insulation performance, as is evident from the dark areas in the ceiling next to the exterior wall (above). Leaks in window framing (above right) and around an exterior door (right) show up in a typical plumelike pattern.

chemical smoke — helps in tracing drafts.

After the blower has been running for a while, drawing in cold outside air, I take another tour through the house, this time using the infrared camera to scan for hidden air leaks and thermal bypass problems. The thermal image viewed through the camera reveals the radiant temperatures of the surface scanned. Since the R-values — and therefore the resulting temperatures — of an insulated bay and the adjacent wood framing members are different, it's simple to identify the framing details as well as weak spots in the insulation (**Figure 3, page** 4). Thermal scans often reveal areas where the insulation has settled or is not dense enough, and wall and ceiling bays that were completely missed when the insulation was installed.

Because the blower door is drawing in cold air from the exterior or attic, the scan can identify and measure areas of air infiltration, recognizable by a plumelike thermal pattern (**Figure 4**).

The scans also show areas where the wall surface has become chilly, indicating that the cold air is moving through or beneath the insulation. These spots are common on ceilings near the eaves, due to the effects of wind-washing (outside air moving into the eaves and through the fibrous insulation), but they can also show up in interior locations where you might not expect to find them (**Figure 5, page 6**).

Sealing Strategies

Because framing details, air leakage paths, and insulation quality vary from home to home, there are no boilerplate solutions. Sealing air leaks into the attic is usually the most cost-effective improvement, but it can also be the most challenging. Fiberglass batts and loose-fill cellulose do not stop air leaks, so simply covering the leakage points with insulation doesn't work. Neither does sealing cracks in the attic floor above the insulation: Since the insulation is air permeable, you have to seal the leak below the insulation.

It's important to keep in mind that the drywall ceiling is discontinuous — it's interrupted by interior partitions and framed chases that enclose leaks. While those partitions and chases may appear airtight from inside the house, viewed from

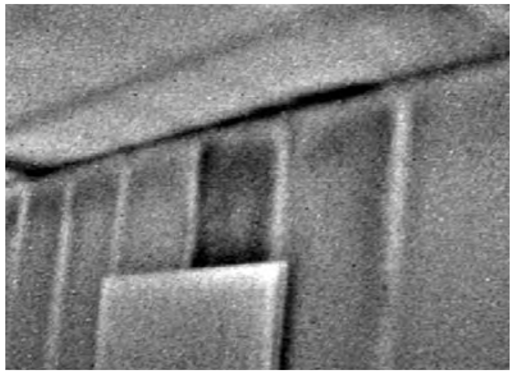




Figure 5. The infrared scan revealed an unexpected cold area in this interior partition wall, which was traced to air leaking into the attic along the top plate, shown here being sealed (right).

the attic they are full of penetrations for electrical, mechanical, and plumbing runs (**Figure 6, page 7**). Even the long intersections between the edges of the top plates and the cut ends of the ceiling board provide air paths into the attic.

The first step in the sealing process is to move the existing attic insulation to expose the air leaks. These include penetrations in the middle of a ceiling, like air supply registers and light fixtures, as well as the top plates of all partition walls.

Two-part foam. For sealing the leaks, most weatherization contractors use two-part polyurethane foam, which comes in cardboard containers in various sizes with an attached 30-foot hose and spray nozzle. The foam sticks well to dirty surfaces, and the high-pressure applicator makes it easy to spray in hard-to-reach places (**Figure 7, page 7**).

Small penetrations, like the gaps around light fixtures, fan boxes, and duct boots, can be sprayed directly. With larger bypasses — wet walls, unblocked balloon-framed cavities, the space under an attic knee wall — the opening can first be loosely stuffed with fiberglass, then sprayed. For extremely large openings like drop soffits and large chases, it's best to fit a piece of plywood or rigid insulation board over the hole, then seal it in place with foam and screws (**Figure 8, page 8**).

Fire-code sealant. One place where you can't use foam — due to fire codes — is around chimneys and flues. Because of code-required clearance to combustibles, it's not uncommon to find leakage areas of 3 square feet or more around a masonry chimney. Here it's best to seal the gap with sheet metal sealed with an ASTM 136 high-temperature caulk.

Adding Insulation

Once penetrations have been sealed, the attic is ready for an additional layer of blown insulation, which fills gaps in the fiberglass batts and also

Figure 6. Moving attic insulation uncovers a common cause of leaks: wire holes through partition-wall top plates (above). The double line of soot stains indicates upward air leaks between the drywall and a partition plate (top right). Fiberglass stuffed into a plumbing wall (center right) was no match for the air rising from below; note the spray foam at left in the photo — the solution. A double layer of fiberglass did not prevent air movement through an interior soffit into the attic (bottom right).

Figure 7. Because it sticks even to dirty surfaces, two-part urethane foam works well for sealing around attic penetrations (left). A worker seals beneath an attic ledger (above), after first chinking the gap underneath with fiberglass.

Figure 8. Rigid foam board is ideal for sealing large openings like this oversized framing chase. After cutting the board to fit, the worker beds it in wet spray foam (left), then seals the edges (above).

covers the tops of the ceiling joists, reducing conductive heat loss.

Knee walls. Field and lab testing has confirmed that batt insulation works best when it's enclosed in an airtight space. This is rarely the case with attic knee walls, which are typically open on the attic side. So I often recommend adding a layer of rigid foam to the back of knee walls and taping the joints. This prevents air movement into the wall cavity from the attic side, and cuts conduction through the studs. Another method is to add a second layer of fiberglass horizontally across the backs of the knee-wall studs and secure it with a layer of housewrap — again, to reduce infiltration and conductive loss through the studs.

If for some reason an attic wall has not been insulated, I recommend securing housewrap across the studs and blowing the cavities with loose-fill insulation.

Some knee walls contain ductwork or pipes that make them impossible to insulate effectively. In these cases, it makes sense to move the thermal and air barrier to the outside roof slope by adding a code-approved rigid board to the underside of the rafters and blowing in cellulose. Where the budget can handle it and for spaces with limited access, an approved spray foam also works well.

Don't forget exterior walls. Although this article focuses on attics, it's worth noting that we often recommend additional blown-in insulation in the exterior walls below. I say "additional" because many of the homes I visit already have some type of wall insulation, but the scans frequently show that it's settled or insufficient. Be sure to have the insulation contractor blow in dense-pack cellulose at such spots; otherwise, cold air in the walls will find its way along floor and ceiling cavities and make the house cold and drafty.

Looking Ahead

With energy costs increasing, the demand for weatherization is also on the rise. If you're a remodeler, this might be a good time to consider providing your clients with a more comprehensive approach to thermal upgrades, in addition to the traditional home-improvement services.

After the first energy crisis, we learned that simply adding insulation is not enough — you have to address air leaks as well. Hopefully that lesson is not lost, and with a new generation of diagnostic tools on hand, there's no excuse not to get it right.

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