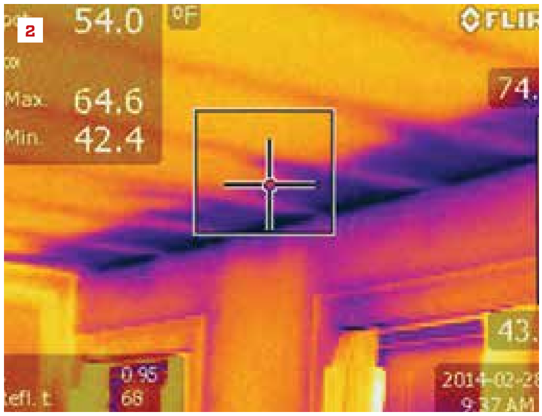
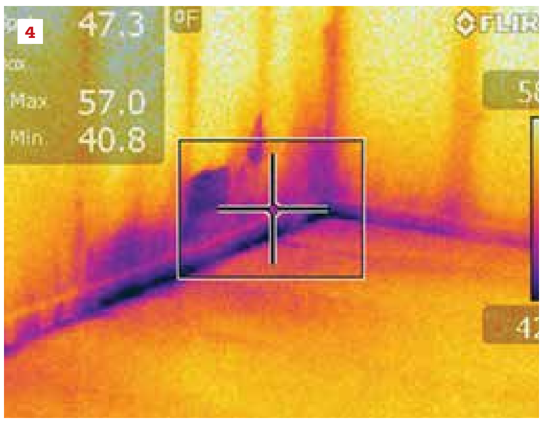
BY MATT BOWERS

Blower Doors and Energy Retrofits





Combined with a blower door, an infrared camera can reveal cold air leaks. While the naked eye can see a water stain on the ceiling **(1)**, the infrared image reveals the reason for the ice dam that caused it: heat loss through the ceiling and roof of the kitchen bump-out **(2)**. In the bonus room over a garage, a cold wall and floor brought comfort complaints **(3)**. The infrared camera revealed the cold air infiltration's leak point **(4)**.

Photos by Matt Bowers

As an energy auditor for a home-performance contractor in upstate New York, I use a blower door and an infrared camera on a routine basis to identify air leaks and thermal bridging in building envelopes. In July in this column, *JLC* wrote about an extreme example: the airtightness testing I performed on my own home under construction (see "Testing House Tightness With a Duct Blaster").

That house qualified for Passive House certification, with airtightness better than 0.6 ACH50 (air changes per hour at 50 pascals of depressurization). But most houses I work on are nowhere near that airtight or that well insulated. In this story, I'll describe how I use the blower door in my daily work to guide and verify home-performance airtightness and insulation retrofits on old, leaky, poorly insulated existing homes.

The photos on this page and the next show a few typical examples of situations that can be identified using a combination of blower door and infrared inspection: on this page, leaks in the ceiling of a kitchen bump-out and at the base of a wall in a bonus room above a garage, and on the following page, a leak in a recessed light fixture in a ceiling. For each example, I've paired a visible-light photo with an infrared image of the same location. The purple color in the infrared image shows the cold surface where the building is leaking. These photos were taken while the blower door was creating a negative pressure in the house, pulling cold air in through leaky spots.

By itself, the infrared camera tells only part of the story. Depressurizing the space with the blower door while viewing the

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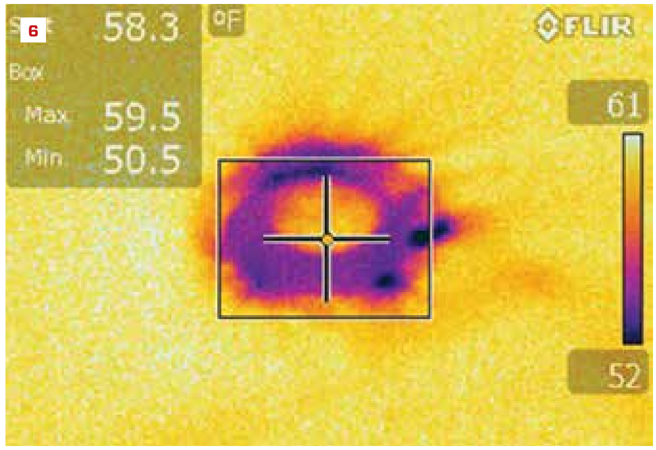

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Recessed light fixtures in ceilings **(5)** are a common source of heat loss in modern homes. When a house is depressurized with a blower door, the infrared scan reveals tell-tale “fingering” as cold air gets pulled along the ceiling **(6)**. Many older can lights of this type are not rated for contact with insulation. In that case, the repair involves building a sealed box of rigid foil-faced insulation around the fixture, making sure the box is large enough to provide the required air space **(7)**.

thermal image provides a more complete understanding.

THE INSPECTION ROUTINE

When I take the initial phone call from new clients, my first question is always, “When was the house built?” This alerts me to the possible presence of classic problems from that era.

There is no manual on how and where to look when you’re inspecting a house of a certain age. But with years of experience, you become well acquainted with the usual suspects. If the house was built before 1940, it’s probably balloon-framed. In that case, the interior walls won’t have top plates, and they’ll be open and exposed to an attic. If the home was built in the 1950s or 1960s, it might be a Cape Cod-style house, with problems relating to second-story knee walls. And when we inspect homes built in the 1970s and 1980s, we know to look closely at dropped soffits, chases on the underside of staircases, chases for furnace vents, and recessed lights in ceilings.

When I meet with the clients at their home, I let them tell their story. Sometimes their concern is utility bills. Or it might be that a single room is too cold, or that the house is too noisy. All these little clues help me focus my search for deficiencies.

After interviewing the clients, I walk through the whole house with an infrared camera, noting locations that appear to be poorly insulated. By itself, the infrared camera helps to identify locations where insulation is either wet, or damaged, or even just missing altogether. (To see this, we need a temperature difference of at least 20°F between the inside and the outside. In mild weather, we leave the infrared camera at the office and inspect the insulation by drilling small holes in the wall and inserting a scope.)

Next I set up the blower door and depressurize the house, then walk through again to identify the effects of air leakage. If areas that were cold have grown and spread, or gotten colder, I know that air infiltration is a factor. In this way, operating the blower door together with the infrared camera lets us identify deficiencies in the insulation, as well as a lack of air-sealing. In the case of recessed lights, air leakage shows up as what we call “fingering,” where wisps of cold air are being pulled in through the recessed light and across the drywall, as in the infrared image on the facing page.

Isolating rooms. Next, with the house depressurized, it’s useful to carry the manometer around the house and examine the pressures in different rooms. I throw a hose under a bedroom door and close the door to test the pressure difference between the house, which is under negative pressure, and the bedroom. The greater the pressure difference, the more that room is connected to the outside.

For example, if I have the house depressurized to -50 pascals and I stick the manometer hose out a window, the manometer will read 50—that’s the difference in pressure between the house and the outdoors. So if I put the hose under a bedroom door and the reading is 2 pascals, I’ll know that the bedroom is pretty well sealed off from outside—its pressure is very close to the house pressure. But if I see a reading of 10 pascals (and I’ve seen readings as high as 30), I’ll know that I should look for big leaks—badly installed windows, a leaky attic hatch, or the like. This method helps me zero in on those big leaks, room by room.

Attics and basements. Once I’ve tested the room pressures and I have a list of issues to keep in mind, I put the blower door away and climb up into the attic. I always look for soil pipes coming through top plates, and at how the bath fans have been vented, how the attic hatch has been sealed, and how chimneys coming through the attic have been sealed.

Bath fans, of course, should be vented to the outdoors, not into the attic. In fact, we prefer to see bath fans vented either out a gable end wall or through the roof, and not under a soffit at the eaves. That way, moist air vented out of the bathrooms won’t get sucked into soffit vents and pulled into the attic. We also want to make sure that the bath-fan vent pipe is a solid pipe, not flexible duct. A solid pipe creates less friction and allows more airflow, which helps the fan operate more quietly and effectively.

I always take pictures in the attic to show the homeowner. And before I come down, I put back any insulation that I may have pulled away. I like to leave the attic the way I found it in case the homeowner decides not to hire us to do the work; I also don’t want to clue in my competition to whatever I’ve seen.

The next stop on my tour is the basement. Usually, the pressure testing has identified the basement as the part of the home that is the most connected to the outside. There are lots of potential big leaks: chases from the attic, an unsealed rim joist, a dry sump crock, basement windows, or basement bulkhead doors that aren't weatherstripped. Again, I photograph all these likely problems for my presentation to the homeowner.

A plan of action. Once I've collected all this information, I sit down with the owners and present them with a few options. If they have one big complaint, I'll make a recommendation that addresses it. For example, if they are more concerned about one room because their neighbors are loud and they just want that one side of their house insulated so that it's quieter, I might break out the exterior wall project into different walls. But I don't want to make it too complicated. If they decide to air-seal and insulate the attic, I'm not going to offer to do just half the attic.

Realistic airtightness goals. How much of an improvement can people expect from our work? That depends on the starting point, of course, and on how extensive a job the clients choose. If we're just doing attic work, we can get a blower-door reduction of up to about 25%. If we're doing the attic and the basement rim joists, we might be able to get a reduction of 35%. And if we're doing the whole thing, including air-sealing and insulating walls, I've seen blower-door reductions of up to 70%.

In terms of air changes, the typical old house starts out in the neighborhood of 7 to 10 ACH50. For an average-sized house, that translates to about 3,000 CFM50 (cubic feet per minute at 50 pascals of fan pressure). And in a typical case, we might get that house down to about 4 or 5 ACH50. But if it's a very old, uninsulated house that hasn't been upgraded since it was built, and we insulate and air-seal the whole thing—attic, basement, and walls—we might cut the home's leakage by 70%. In that case, we're taking a 10 or 15 ACH50 house and bringing it down to 3 or 4 ACH50.

Mechanical ventilation. Our estimates always include the cost of changing out any existing bath fans to Energy Star–labeled fans that are rated for continuous operation, and making sure those are properly ducted. That way, we always have the option of installing a timer on a bath fan to provide whole-house ventilation.

Whether or not a house requires ventilation after air-tightening work can be a judgment call. There's more than one applicable standard, and the standards change occasionally. We're careful not to violate any rules. But as a rule of thumb, we recommend that if the house gets below 5 ACH50, the bath fans should be operated on a timer, and if the house is tighter than 3 ACH50, the bath fans should be run continuously. We perform combustion safety tests to make sure the flues operate properly after the job. But so far, we've never needed to provide combustion makeup air on an old house.

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