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Why You Need Blower-Door Testing

Understanding where structures leak is the first step toward building tighter, more energy-efficient homes

BY RANDY WILLIAMS

I bought my first blower door in 2009, when new construction was in a downturn and energy auditing and weatherization projects were on the rise. I took a 40-hour course in energy auditing at a local college that included hands-on blower-door training. It took many tests before I became comfortable using it and understood the information it was providing. Though it's one of the more expensive tools I own, I've been able to keep it busy and to add this specialized testing to my business's income stream—as well as improve the airtightness of my own projects.

The main purpose of a blower door is to test the integrity and continuity of the air-control layer, or air barrier. The test is conducted by either pressurizing or depressurizing a building to a specific pressure, typically 50 pascals, and measuring the cubic feet per minute (cfm) of air moving across the fan. The cfm can then be added to a formula to calculate the air changes per hour at 50 pascals (ACH50). For the house shown in the photos, we were checking airtightness and looking for leaks before the walls were insulated, but there are other reasons to perform blower-door tests (sidebar, facing page). What follows is an explanation of how the process works.

Equipment for measuring airflow

There are two manufacturers making blower-door test equipment in North America—The Energy Conservatory (TEC) and Retrotec—and their designs are similar. There's an adjustable frame that fits in most door and some window openings, a nylon panel that fits over the frame, a powerful fan with adjustable flow rings or range plugs that change the size of the fan opening, and a manometer that measures pressure and airflow.

The latest versions of both companies' manometers are very versatile and intuitive. Basically, they are small computers designed specifically for blower-door testing. Both offer several different ways to control the equipment, simply with the

5 REASONS TO RUN A BLOWER-DOOR TEST

CODE COMPLIANCE
Recent versions of the building code require new homes to achieve a certain level of airtightness. Depending on location, a test result of 3 or 5 ACH50 is likely required.

PRE- AND POST-REMODELING
There may be opportunities that can be shown with the test to improve the performance of an existing home during a remodel. You can also determine if changes will hurt indoor-air quality or cause backdrafting of fossil fuel–burning equipment.

ENERGY AUDITS
An energy audit is an inspection and analysis of energy flow in a building. Outside air moving through a home affects heating and cooling costs; testing can determine how big an effect air leaks have on these costs.

ENSURING ENERGY GOALS
A home may have a target airtightness level to achieve design goals. One or more tests during construction will confirm if the home is on track to meet these goals.

AIR-SEALING
Blower doors can help find leaks in new and existing homes so they can be sealed. Theatrical fog and infrared cameras are often used in conjunction with a blower door to find leaks.

MEASURE THE HOUSE

MEASURE THE EXTERIOR Use measuring wheels and laser measures to calculate a home's exterior size. While doing this, make note of any likely sources of air leaks.

CHECK EXTERIOR PENETRATIONS Exhaust, dryer, and plumbing vents, electrical chases, and any parts of the heating and cooling system are likely spots for air-sealing before or after the test.

LOCK WINDOWS AND DOORS Close and lock all windows and exterior doors, which seal better when locked. Interior doors should remain open.

TURN OFF MECHANICALS The blower-door fan can cause combustion appliances to spill flue gasses, including carbon monoxide, so turn off all HVAC equipment, including ventilation fans.

MEASURE THE INTERIOR Use a laser measuring device to calculate the home's interior volume in cubic feet. This is often the most time-consuming part of the test.

manometer and speed control or by connecting to a computer, tablet, or smartphone. When connected to a device, software supplied by the two companies will control the test and also generate a test report.

Preparing inside and out

I always follow the same procedure when preparing for a blower-door test, which prevents skipped steps. I start by walking the exterior of the home. This gives me an idea of the shape of the structure, which may not always be evident from the interior. While on the outside, I look for any penetrations through the air barrier, which will be the most likely spot for air leaks.

After moving inside, I follow the same process of inspecting the home, taking note of potential problem areas and checking all windows and exterior doors to make sure they're closed. All interior doors within the conditioned space of the home must be open. Doors separating conditioned and unconditioned parts of the house, access panels, and attic hatches should be closed.

I turn off any heating and cooling equipment, fossil fuel–burning equipment, exhaust fans, and dryers. I leave my car keys near the controls so I can't leave without turning this equipment back on. I also make sure any fireplace or woodstove fire is out and that any ash is cold and contained; otherwise, it could be sucked into the living space.

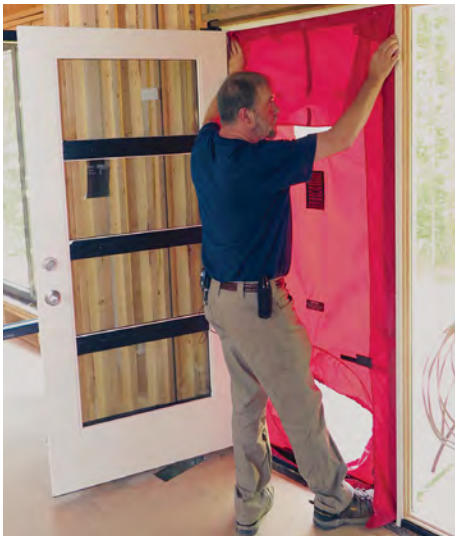
I then move on to measuring the home's volume. The Residential Energy Services Network (RESNET), which helps set standards for blower-door tests, suggests that all measurements be taken from the exterior dimensions. I prefer to take all measurements from the interior, however. This gives me a chance to see all of the interior finish material, which is often part of the (if not the main) air-control layer. Measuring from the interior also simplifies the process. I use a laser measuring device, which is easy to see indoors.

I begin by measuring the square footage of the floor area, and then I multiply that number by the height of the building. The calculation is seldom that simple, though. Convoluted designs, varying ceiling heights, and cathedral ceilings all complicate measuring the volume.

Running the test

Once the measurement is complete and entered into the software, I assemble the blower door and connect the digital manom-

ASSEMBLE THE DOOR



INSTALL THE DOOR
Assemble the door's metal frame, and place it on top of the fabric cover before placing it in the opening. Make sure the frame is tight to the opening, and run the outdoor tube before placing the blower in the opening.

ATTACH THE FAN
The blower-door fan forces air in or out of the house and creates a pressure difference. It has a variable-speed motor and an adjustable aperture so that it can measure homes of various sizes and airtightness levels.

CONNECT THE GAUGE
A digital manometer measures the amount of pressure (in pascals) inside and outside the house. Flexible vinyl tubes convey the fan pressure to the manometer and measure the reference pressure with a tube that runs outdoors, its end at least a few feet beyond the house.

eter to my phone, which is now my preferred way to conduct most tests. I choose the exterior door where I'll install the blower door based on wind speed and direction. Wind can have a large effect on the test result, and the blower door should be on the leeward side of the building when winds are greater than 5 mph.

After the equipment is set up, I input some additional information into the software. This includes the indoor and outdoor temperatures (that becomes important when there is a 30°F or larger difference between inside and outside) and the elevation (important above 5000 ft.). Then I can begin the test by taking a baseline pressure. The baseline pressure, which can be positive or negative, is the difference between inside and outside the home and will be accounted for with an automatic adjustment by the equipment software.

After the baseline adjustment is complete, the test prompts me to remove the appropriate flow ring or range plug, which adjusts the size of the fan opening to match the expected leakage rate of the home. If the fan cannot reach pressure, another ring or more range plugs will need to be removed, or if the fan is moving at too slow of a speed to register flow, either the size of the flow ring will need to be reduced or a smaller range plug will need to be installed.

Occasionally, a home may be so leaky that a single blower-door fan will not be able to reach the desired test pressure. When this happens, there are two choices. The first is to use a second fan (or more) to move more air. In a residential setting, this option is rarely used. A second choice is to extrapolate the test pressure. This can be done mathematically, but it is easier to have software calculate the "can't reach 50" number along with the estimated cfm.

Single- vs. multipoint testing

I do multipoint testing on nearly every test I perform. The multipoint test I most often use is the ANSI/RESNET/ICC 380 standard, which starts the test at a 60-pascal difference in pressure and reduces this to 10 pascals; at least five test pressures at equally spaced intervals are required. Each of the test-pressure samples is to be recorded and averaged over a 10-second interval.

I feel this test is accurate and repeatable, and it supplies me with the most accurate effective leakage area (ELA) data. ELA is

RUN THE TEST

ESTABLISH BASELINE
Outdoor temperature, atmospheric pressure, and wind can affect test results. Compensating for natural pressure differences inside and outside the house is part of calibrating the manometer, a process called "establishing baseline." The process has gotten easier as manometer technology has improved.

the cumulative area of air leaks in the shape of a smooth hole. Basically, this gives us an idea of how big a hole is in the building's shell at a natural building pressure. This is a handy visual for homeowners.

There is also the option to conduct a single-point test, which requires only a baseline and then conducts one test sample at 50 pascals with at least a 10-second average. Both test results are supplied in cfm of airflow across the blower-door fan. If you're using Retrotec or TEC software to control the test, it will calculate the ACH50 and cfm per sq. ft. of surface area if the building-size information is supplied. If you're not using software, you'll have to do the calculations yourself.

What can go wrong?

The key to performing an accurate test is inputting accurate data into the formulas or software. Measuring a home for its volume, and to a lesser extent its surface area, can be a challenge. An error in the volume calculation will have an effect on the test results that confirm whether a house has reached code-required levels of airtightness. Temperature, elevation, and wind can also affect the precision of a blower-door test. Using software will improve accuracy; a manual test will require these conditions be taken into account.

Another mistake I've caught myself making is having the wrong setting in the software or manometer for the ring size or number of range plugs. This setting changes a calculation in the manometer as to how many cfm are moving through the fan. I now double-check those settings in the software or manometer so that they match the equipment settings. It takes practice using a blower door to feel like you know what you're doing, but it gets easier with time. □

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TESTING
With the house prepped and the blower door ready, it's test time. The latest generation of manometers are Bluetooth-enabled, allowing you to control blower speed, monitor and receive test results, and stop the test from a laptop or phone. Modern manometers and their software also make generating reports for clients, builders, and code officials much easier.

TRACK DOWN LEAKS

SMOKE OUT THE LEAKS
A chemical smoke pencil such as this Fog Puffer from TEC (see p. 26) allows you to see small amounts of leakage. Penetrations like this electrical service are common sources of air leaks.

FIND IT ON INFRARED
If indoor and outdoor temperatures are sufficiently different, you can see air leaks as changes in surface temperature. More-expensive cameras can detect smaller temperature variations.

FILL IT WITH FOG
If you fill an interior space with theatrical fog and pressurize the house with a blower door, you can often see the fog escaping through air leaks from the outside. Consumer-grade fog machines are available for less than $100.

AIRTIGHT MEASUREMENTS

The data used to designate the airtightness level of a home is communicated in the following industry shorthand.

CFM50
This number represents the cubic feet of air moving across the fan per minute at the test pressure of 50 pascals. This is the most important information supplied by the blower door. We need this number to calculate the ACH50 and cfm50/ft² described below. I have seen numbers as low as 100 cfm50 (a very tight home) and as high as over 5000 cfm50 (very leaky). To be meaningful, the cfm50 metric must also consider the surface area of the home's exterior and its conditioned volume.

ACH50
ACH50 stands for air changes per hour at 50 pascals. Think of the volume inside a structure—the ACH50 number indicates the number of times that all inside air is exchanged with outside air per hour under test conditions. A home that tests at 3 ACH50 will exchange all its inside air with outside air three times per hour at the test pressure of 50 pascals. The formula for figuring out ACH50 is cfm50 x 60 minutes ÷ volume of the structure.

New houses being tested need to meet the code requirement of 3 or 5 ACH50 or less depending on location in the country. When testing existing buildings in my climate, I like to see results under 5 ACH50. Higher results mean there is an opportunity to increase comfort and reduce energy costs. The best test that I ever conducted was 0.33 ACH50, and the worst was just over 15 ACH50.

CFM50/FT²
Air leakage happens through surfaces, yet building codes require testing to be reported as a volume calculation. Many testing professionals and building scientists prefer the information shown as cubic feet per minute per square foot of surface area of the home, or cfm50/ft². A test of 3 ACH50 will be the rough equivalent of 0.15 cfm50/ft². There isn't an exact relationship between volume and surface area; it's dependent on the size and shape of each home.