Putting Tightness to the Test

Provided you include controlled ventilation, look for every opportunity to tighten the shell. Here's how to measure its performance.

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I was intrigued that the recently announced Home Star energy efficiency program has been nicknamed "Cash for Caulkers." Certainly all of us in the energy efficiency business appreciate the value of air sealing as one of the most cost-effective solutions to reduce energy consumption in houses. Yet there are still those in the industry who are asking whether it's possible to make houses too tight.

The short answer is "No. Homes can't be too tight." But that comes with a caveat: A home can't be too tight, provided it also addresses the air quality problems that result from reducing air leakage.

As houses get tighter they face more potential for indoor air quality problems due to buildup of moisture, stale air, dust, pollen, and chemical pollutants. Tighter homes also pose combustion safety concerns because chimney-vented furnaces, water heaters, and fireplaces need adequate fresh air for proper operation, which is compromised by negative air pressure. We need to recognize that natural infiltration of air into a home, especially as we reduce air leakage, is not a reliable or adequate source of fresh air to maintain air quality. As we've emphasized in previous columns, to meet healthy air quality standards today's homes need continuous mechanical ventilation and provisions for safe operation of combustion appliances.

Assuming you are taking these steps to address air quality, the goal then is to seal the home as much as possible. But even that is not enough. Unless you test and measure how tight you're building—and understand the resulting metrics—you won't know where you stand. And beyond understanding how tight your homes are, you'll also be able to apply the information to training of your labor crews and subcontractors who are critical to reducing defects and improving the quality of workmanship on your projects.

TESTING PROCEDURES AND METRICS

The method of choice for measuring a home's tightness is a blower-door test. The most common techniques follow the ANSI/ASTM-779-99, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization" and the CAN/CGSB 149.1 "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method."

In fact, these standards are very similar and give almost identical results. They also follow the same procedures: Close all windows, doors, and other intentional openings in the enclosure. Open all interior doors and turn off air handlers and exhaust fans. Install the large blower door fan in an exterior door with a pressure tap or housing to the outside. Either use the fan to exhaust air out of the house, thus causing a negative pressure in the house, or blow air in and create a positive pressure.

Usually a pressure difference of 50 Pascals (Pa) is the goal; this is the pressure roughly equal to a 25-mph wind acting on all sides of the house at once. While this is clearly an exaggerated pressure that a house would rarely experience, it does enable simple detection of leaks and helps negate wind effects that could skew results. The fan is calibrated and the operator records the air flow that the fan is delivering at 50 Pascals of pressure. Testing typically records a range of pressures and air flows so that the results can be extrapolated and reported in a variety of ways depending on what form of evaluation is required.

Here are four metrics used to report air leakage from test results:

Metric 1: CFM@50Pa (Cubic feet per minute required to create a 50-Pascal pressure difference across the house.)

The early weatherization programs were looking for a quick metric that didn't require measurement or calculation of volumes or surface areas. They use the CFM@50Pa as a way to track their air sealing efforts in any individual house. This is still the most common metric used in the United States because it is a simple, definable number for a specific house. Often, weatherization programs or air sealing companies will simply set a simple improvement target of 20% to 30% reduction in the CFM@50Pa number. If we consider a typical 2,000-square-foot ranch or single-story home without a basement, a really tight result would be anything under 450 CFM@50Pa. A really leaky house would be anything over 2,000 CFM@50Pa.

A variation on this metric, to allow comparison of houses of different sizes, is to divide the CFM@50Pa by the square footage of the total surface area (floors, walls, and roof) of the house. A very tight house would be 0.15 CFM/ft^2 and a leaky house would be over 0.6 CFM/ft^2.

Metric 2: ACH@50Pa (Air changes per hour at a pressure difference of 50 Pascal.)

The simple math of this metric is to take the CFM@50Pa number as above, multiply it by 60 (minutes in an hour), and divide that result into the volume of the entire heated area of the house. This helps factor out the house size so that comparisons between different houses can be made. This is the metric used by the Energy Star Qualified Homes program in most states, although the requirements do vary by climate zones. Energy Star requirements are 7 ACH@50Pa in hot areas, Climate Zones 1 and 2; 6 ACH@50Pa for Climate Zones 3 and 4; 5 ACH@50Pa for Climate Zones 5 to 7; and 4 ACH@50Pa for Climate Zone 8.

From my experience, a really tight house is anything under 2 ACH@50Pa and a really leaky house is anything over 7 ACH@50Pa.

Metric 3: ELA@10Pa (Equivalent leakage area, defined as the size of a theoretical hole in a wall you'd have if you combined all air leakage points in a house, and how much air would leak through that hole at a pressure of 10 Pascal.)

I like this metric for two reasons. First, I find that builders and contractors can relate to the size of a hole in square inches rather than trying to imagine stopping cubic feet per minute of air. Second, the 10 Pa of pressure is a more typical or realistic pressure that a building experiences on a cold or windy day. Again, using the 2,000-square-foot house, a really tight house would be less than 80 square inches of leakage and a really leaky house would have an air leakage "hole" larger than 300 square inches.

A variation on this metric is to divide the ELA by the total surface area of a house, so that comparisons between different sized homes can be made. This is referred to as the "normalized leakage area" (NLA). A very tight house would have an NLA of less than 1.5 square inches per 100 square feet of surface area, and a really leaky house would have an NLA higher than 6 square inches per 100 square feet.

Metric 4: Estimated Annual Infiltration (A calculated number from mathematical models that take into account leakage areas, height of the building, and weather location.)

This metric has been used to estimate actual average infiltration for energy usage modeling and evaluating the need for mechanical ventilation, and while it can be useful in energy simulation calculations to show how much energy is being wasted due to unwanted air leakage, it isn't very useful in helping contractors focus on air sealing, and it contributes to the confusion with respect to how tight houses should be. As discussed above, mechanical ventilation should be provided in all houses, regardless of natural leakage.

Any of these metrics can be used to help focus on the real task: looking for ways to improve the air tightness of houses. Be sure to test your homes and get to know the results so that you can measure your progress on each project. But at the same time, don't neglect proper ventilation. Combining ever-improved levels of air tightness with the capacity for modest amounts of continuous ventilation ensures you are building comfortable, durable, healthy, and efficient homes.

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Comparing Blower Door Test Results

RESULTS METRICS		OPTIMUM PERFORMANCE	POOR PERFORMANCE
Cubic feet per minute	CFM@50Pa	< 450 CFM@50Pa	> 2,000 CFM@50Pa
	CFM/ft^2	< 0.15 CFM/ft^2	> 0.6 CFM/ft^2
Air changes per hour	ACH@50Pa	< 2.0 ACH@50Pa	> 7.0 ACH@50Pa
Equivalent leakage area	ELA@10Pa	< 80 in^2	> 300 in^2
Normalized leakage area	NLA	< 1.5 in^2 per 100 ft^2	> 6.0 in^2 per 100 ft^2