Blower Door Testing

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Bill Van der Meer

Introduction

Have you ever had to deal with call-backs from home owners who complain that they aren't comfortable or that their fuel bills are higher than expected? It's a rare builder/remodeler who hasn't. These problems can often be traced directly to air leakage into and out of the conditioned space. Uncontrolled air loss from a building can have a significant impact on comfort, heating and cooling costs, and maintenance; typically, air leakage can account for as much as 25% or more of building heat loss. At the same time, a house should not be made too airtight. Tightening a house too much, in an effort to save energy, can increase the risk of indoor air quality problems.

Builders routinely provide controlled openings for ventilation and for the exhaustion of combustion byproducts. Unintentional air leakage, on the other hand, is undesirable. Air leakage may be due to the building technique used or to a simple lack of attention to air sealing during construction.

How can air leakage problems be avoided? Fortunately, builders don't have to rely solely on guesswork. A useful, reliable diagnostic tool is available to quantify air leakiness: the blower door—sometimes called a door fan. Its application is most practical in single-family residential housing stock, but blower door testing on multiple dwelling units has also been performed.

What can blower door testing do for me?

Fairly simple to use and understand, the blower door helps the builder/remodeler to find out where the leaks are and how leaky the house is. Tests using the blower door enable the builder/remodeler to assess the "tightness" of a building, eliminating guesswork regarding leakage and air tightness

The test methodology is widely accepted and is used as one of the predictors for "energy efficiency" in homes. It has been used by energy retrofitters for years to measure the success of their air sealing efforts.

Builders who carry out repeated blower door testing on finished houses learn to anticipate where and how air leakage problems are likely to occur and are able to find ways of avoiding them during the construction process. By avoiding air leakage problems in the first place, builders can avoid costly callbacks and increase customer satisfaction with their product. The safety of ventilation levels for occupants can also be assessed. In addition, the knowledge that builders or remodelers gain from the frequent use of this testing leads to a better understanding of the dynamics of airflow in buildings, and thus a better understanding of how their buildings actually perform.

The blower door system

The system consists of a powerful, variable-speed fan with a speed controller mounted in an adjustable panel that is temporarily fit into an open exterior doorway. A set of manometers or differential pressure gages are used to measure pressure differences generated by the fan. Airflow across a calibrated opening in the fan housing is also measured.

Test procedures are fairly straightforward. Detailed instructions are usually provided by the supplier or manufacturer of the blower door kit. After the necessary procedures to set up the house have been performed, the test itself takes about 10 to 15 minutes to conduct.

Blower Door System

Components include an adjustable door panel, a variable speed fan with speed controller and a set of gages.

With software packages and various upgrades, the purchase price of a system varies between $1,300 and $1,800. However, builders and remodelers don't have to purchase the apparatus since the testing can be sub-contracted.

Locating air leaks

To obtain meaningful data about the tightness of a building shell, blower door tests are performed on finished houses. All exterior openings such as doors and windows are closed, thereby simulating a heating season configuration.

When operating, the blower door fan acts as an exhaust fan and vents indoor air to the outside. This sucking action causes the air pressure in the house to drop below the pressure of the air outside. Detecting air leaking into the conditioned space is a simple matter of feeling for leaks around openings such as window trim, can lights, or heat registers, to name just a few of the possible sources of air leaks. Alternatively, a smoke-generating device can be used to make leakage paths visible.

Baseboard Air Leakage

Blower door depressurization in combination with infrared thermography can provide graphic evidence of serious air infiltration sites. The infrared image demonstrates air leakage at the interface of the floor and baseboard molding depicted above.

The ability to detect leaks with one's hands or by means of a smoke-generating device works on the principle that what goes out (through the exhaust fan) must come in through the enclosure. An operating blower door turns all of the leaks in the building envelope into leakage paths for infiltrating air. All of the intentional openings (fireplaces with the dampers closed, fan ducts, etc.) as well as all unintended openings contribute to the total measured air leakage.

Measuring Air Leakage

Blower door testing is usually performed in a depressurization mode. As air is exhausted out of the house (or building envelope), the house becomes depressurized relative to the air pressure outside the house. Expressed in pascals (a pascal or Pa is a unit of pressure), the magnitude of the difference between these two pressures will depend upon the capacity of the fan because it works against the backpressure created across the building envelope.

Measuring air leakage using a blower door system depends on the relationship between pressure, air flow, and the holes. As the airflow generated by the fan is increased across the hole in the blower door, the pressure difference between the inside and outside is also increased. Decrease the airflow and the pressure difference is decreased. It also follows that the size and shape of each of the air leakage holes is important. If the size of the holes is reduced when the same pressure difference is maintained (by keeping the fan speed constant), the airflow will decrease. The actual size of the hole may be physically reduced, or the leakiness of the hole may be reduced by "air tightening" measures such as caulking—for example, around window frames.

Blower door values

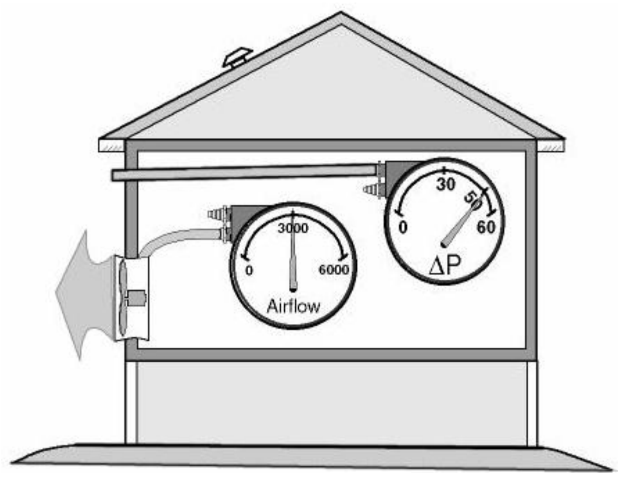
Testing can be done for pressure differences ranging between 10 and 60 Pa. Testing done at the higher end of the range (between 40 and 60 Pa) generally produces the most accurate results. Blower door test results are standardized for an air pressure difference of 50 Pa; better consistency and reproducibility occur at higher pressures.

Air flow at 50 pascals is the preferred value for blower door testing The amount of airflow measured in cubic feet per minute (cfm) for a pressure difference across the enclosure of 50 Pa is expressed as CFM/50. This value is derived by increasing the fan speed until the pressure difference between the inside and the outside of the house is at the desired level, namely 50 Pa.

Airflow readings are taken at numerous pressure differences. These readings, referred to as data sets, are recorded, averaged and corrected for temperature and other variables using a simple computer program. The program then determines the result for an air flow of 50 Pa (or CFM/50). Although multiple data sets are recommended, a simple "one-point" test performed by recording airflow at a 50 Pa pressure difference is often used to provide a quick estimate of the air leakage rate.

Another way to express the results of the blower door test is to use ACH. The expression ACH/50 refers to the number of times in one hour that the inside air volume is replaced with outside air at a house pressure difference of 50 Pa. It is calculated by multiplying the previously obtained CFM/50 value by 60 (minutes) and dividing by the volume of the house, e.g.,

ACH/50 = CFM/50 * 60 ÷ Volume



Blower Door Test Simulation

*The airflow gage on the left measures airflow through the fan housing. The differential pressure gage on the right measures the pressure difference between inside and outside. In this case the airflow shown is 3,000 CFM at a house pressure difference of 50 Pascals (3,000CFM/50) *(Illustration is reprinted with permission of Saturn Resources Inc.)*

The term Estimated Natural Infiltration Rate (ENIR) is used in an attempt to reduce a blower-door-derived value such as ACH/50 or CFM/50 to an estimate of the natural infiltration rate, i.e., the rate under typical operating conditions and thus normal air pressure differences, e.g.,

ACH/Natural = ACH50 / ENIR adjustment factor

Although many professionals use CFMs to express the ENIR, the traditional measure of tightness or ventilation rate is expressed in air exchanges per hour. The ACH value is used in many codes and government- and utility-sponsored energy-efficient building programs.

Blower door software provides other measures including Equivalent Leakage Area and Leakage ratio. For additional information about blower door values, refer to the manufacturer's instructions and to ASTM E779 – 87 "*Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.”*

Leaky vs. tight

At the end of the day, just which numbers define a leaky house or a tight house? What are the acceptable ranges? Although the numbers tend to be somewhat subjective, the chart below provides a reasonable estimate of relative leakiness for a representative, moderate-sized house.

Unit	**Tight**	**Moderate**	**Leaky**
CFM at 50 Pa	Less than 1,500 CFM/50	Between 1,500 and 4,000 CFM/50	Above 4,000CFM/50
ACH at 50 Pa	Less than 5 ACH/50	Between 5 and 10 ACH/50	Above 10 ACH/50
ENIR	Less than 0.35 ACH	Between 0.35 and 1 ACH	Above 1 ACH

For the so-called estimated natural infiltration rate (ENIR), air leakage may be considered to be under control when a house comes in at a 0.35 air exchange rate per hour. If the ENIR falls below 0.25 ACH, the house and its occupants may be susceptible to moisture or indoor air quality problems. Remedial measures, including source control or continuous controlled ventilation, may be necessary.

Conclusion

The depressurization method described here produces a result that generally characterizes the airtightness of a building envelope. As ASTM E779-87 states: “This test method is intended to produce a measure of the air tightness of a building envelope,” but it goes on to caution that “because of differences between natural load and test conditions, such measurements cannot be interpreted as direct measurements of air exchange rates under natural conditions.” It is extremely difficult to accurately and consistently measure air leakage at natural pressures, which are very low.

While a versatile tool, the blower door does have limitations. For instance, the blower door enables the user to measure airtightness and may enable the user to recognize the location of air leaking into the structure, but it can’t always help the user to determine the precise source of the leaks. Air leakage may take circuitous pathways through imperfections in the house framing. Such “indirect” leaks, also referred to as thermal bypasses, can act as conduits for relatively large volumes of air to move through an enclosure. The forces that actually move the air are related to stack, wind and mechanical or fan effects. If air loss occurs across the building enclosure, R values will definitely be degraded. Such hidden bypasses cannot be “seen” by the blower door. The only practical way of detecting them may be through a combination of infrared scanning and visual inspection.

The results produced by blower door tests can be useful for houses that are too tight as well as those that are leaky. Tight houses may need supplemental ventilation.

When used by a builder/remodeler who has a firm grasp of the dynamics of airflow in houses and who understands the importance of paying attention to details, a blower door can be a very effective tool for assuring compliance with the energy code as well as for assuring quality control.

www.engr.psu.edu/phr

PHRC
219 Sackett Building
University Park, PA 16802
Telephone: (814) 865-2341
Fax: (814)863-7304