FESC
Florida Energy Systems Consortium

HOME ENERGY ANALYSIS:
HIGHLIGHTING THE BLOWER DOOR TEST

Introduction

If you've lived in Florida for any length of time during the summer you've either told someone to "close the door…you're letting the air conditioning out" or you've been at the receiving end of the same message. Any openings in the shell or envelope of your home, whether big (like an open door) or small (like around an electrical socket on an outside wall), can allow conditioned air (i.e., cooled or heated) to "leak" out or unconditioned air to come into the home.

For "leakage" to occur, there has to be a source, a hole, and a driving force (like the wind or the difference between high and low temperature or humidity, etc.). So, if you air condition the building, which also helps dehumidify, the moisture outdoors (humidity) can come into your home through large openings like doors and windows and small openings like cracks and crevices, thereby leading to possible air quality problems. In Florida, we usually realize there is a problem because our homes become either uncomfortable (hot and/or damp) and/or our energy bills are extremely high.

What can be used to measure these leaks?

It would of course be almost impossible to try to measure the actual cracks and holes in the building shell. These leak sites can be measured indirectly, however, using a "blower door test." The blower door test measures the airtightness of a building by changing the building's static pressure relationship with the outdoors and noting the amount of air flow required for that change. The amount of air flow required is proportional to the total size of the cracks and holes.

The blower door test provides a standard measure of the leakage of a home in cubic feet per minute (CFM) of airflow. This number is then converted to air changes per hour so you can compare your house to standard recommendations for healthy and energy efficient homes. Keep in mind that a home that is "too tight" can also have health issues caused by poor indoor air quality.

How do air leaks occur?

Building contractors provide for ventilation and exhausting of unwanted odors or combustion byproducts in your home—think of exhaust fans in your bathroom and above the stove. However, unintentional air leakage is undesirable. This unintentional air leakage can be due to the construction techniques used or just lack of attention to air sealing during construction. As homes age and settle, air sealants may fail, contributing to unintentional air leakage.

Even remodelers or repair professionals can unintentionally cause air leakage problems. Think of the remodeler changing out your kitchen cabinets and leaving an opening to the attic above the cabinets or the cable technician drilling a hole in the side of your home to place a cable line and not sealing the hole properly.

When and why should you have the blower door test done to your home?

The blower door test is often required to determine if a home meets part of the criteria for energy efficiency or "green status" by many of the certification programs. These third party certification programs generally have monetary incentives for you and/or the licensed building contractor for homes meeting or exceeding the requirements. Weatherization Assistance Programs require a blower door test to assess where air leakage is occurring before approving any improvements in the home. Some utility companies offer incentives to builders and/or homeowners who have houses tested and air leakage reduced. [Keep in mind that the standard blower door test does not involve identifying where leaks occur, only quantifying the amount of leakage.]

Building contractors, who have the test performed on homes they build, learn to expect where and how air leakage problems are likely to occur and find construction techniques to avoid them. The buyer's/owner's incentive, in addition to possible mortgage inducements, is the fact that if a home is reasonably air tight the utility bill should be expected to be lower than that of someone with a "leaky" home.

If you're thinking about purchasing a home, whether new or pre-owned, you may want to consider having a home energy rating done to help assess the home before you buy. In fact, there has been a voluntary statewide energy-efficiency rating system for Florida homes since 1994 and, as you can imagine, unplanned air leakage is a major part of the energy rating. More information can be found in the Florida Energy Gauge publication available at http://energygauge.com/FlaRes/info-brochure.pdf

While there are many well-known sources of air leakage, almost all buildings have unexpected air leakage sites called bypasses. These areas can be difficult to find and correct without the use of the blower door test. See http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.thermal_bypass_checklist for information on thermal bypasses and http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_airsealing_report.pdf for more information on air sealing.

Why the funny name ("blower door") to the test?

Figure 1. A blower door test set-up on a new home as it appears from the outside of the building.

There are a number of parts to the blower door test. First, a temporary frame is placed in an exterior door. This frame (i.e., "door") is generally covered with a piece of vinyl or canvas specifically made for this purpose with an opening at the bottom in which to place the fan (i.e., "blower"). The fan can either pressurize (force air into the house) or depressurize (force/pull air out of the house). Figure 1 shows how the set up appears from outside the home.

In addition, the blower door test uses a pressure gauge (manometer) that measures the fan pressure relative to the location from which air is entering the fan (Figure 2). This pressure is converted to air flow as the air passes through the fan.

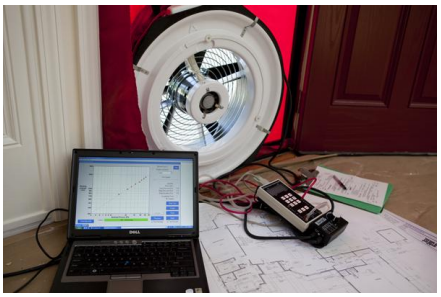

Figure 2. A view from the inside of the home showing the blower door test equipment: temporary door, fan, and manometer along with helpful tools including a laptop computer, clipboard and blueprints of the home.

How is the test conducted?

In Florida, it is very common to operate the fan in the depressurizing mode, meaning that air is drawn, pulled or exhausted out of the house. When the fan operates in this way, it is easy to feel air coming in through cracks in the building's exterior envelope (shell), including around windows, recessed lights, electrical sockets, air handlers, etc., while walking around inside the home. Remember that the air going

(exhausting) out of the home through the blower has to come in from somewhere—what goes out, must come in—so spots where you feel air entering the envelope are air leakage sites.

What do the numbers mean?

One measure of a building's air leakage rate is air changes per hour (ACH), which estimates how many times in one hour the entire volume of air inside the building is exchanged with outside air. To determine ACH, the blower door can be used to perform an airtightness test with the house depressurized (or pressurized) to 50 Pascals. A Pascal is a small unit of pressure about equal to the pressure that a pat of butter exerts on a piece of toast — about 0.004 inches water gauge. Fifty Pascals is approximately equivalent to a 20 mile-per-hour wind blowing against all surfaces of the building.

The leakier the house, the higher the number of air changes per hour, the higher the heating and cooling costs, and the greater the potential for moisture, comfort, and health problems (Table 1). Energy efficient builders generally strive for less than 5 air changes per hour at 50 Pascals pressure (ACH50).

Table 1. Typical infiltration rates for home

ACH50 (Air changes/hour at 50 Pascals)	
New home with special airtight construction and a controlled ventilation system	1.5 – 3.0
Energy efficient home with continuous air barrier system (based on registered ratings)	3.0 – 5.0
Standard new home (based on registered ratings)	5.0 – 7.0
Standard existing home (based on field data)	7.0 – 10.0
Older, leaky home (based on field data)	10.0 – 25.0

To determine ACH50 we first determine the amount of air flow, measured in cubic feet per minute (CFM), exhausted out of the home with the home at a pressure of 50 Pascals (Pa) with respect to the outside. To achieve this, the professional usually takes air flow readings at several house pressure differences, generally between 15 and 60 Pa. These measurements are then entered in a software program to determine the air flow rate at 50 Pa (referred to as CFM50).

To determine ACH50, multiply the CFM50 value by 60 (minutes) and divide this number by the conditioned volume of the house (cubic feet). For example, a home that has 2,000 square feet of living area and 8-foot ceilings has a volume of 16,000 cubic feet (2,000 square feet multiplied times 8 feet). If the blower door measures a CFM50 leakage of 1,333 then the equation would be 1,333 cubic feet per minute times 60 minutes divided by the volume of 16,000 cubic feet to equal 5 air changes per hour. The home therefore has an infiltration rate of 5 ACH50 (5 air changes per hour at 50 Pa test pressure).

Given ACH50, a natural infiltration rate (resulting from wind and temperature effects) can be estimated. In Florida's climate, ACH50 can be divided by 40 to yield an expected natural infiltration rate reported as air changes per hour (ach) (Cummings, Moyer, and Tooley, 1990). For example, if ACH50 = 10, then the estimate for natural infiltration for Florida homes would be 10/40 = 0.25 ach. This means that under normal wind and temperature conditions, we would expect about 25% of the house air to be replaced with outdoor air each hour with no mechanical equipment running. Note that this is only an estimate of long-term average infiltration. Actual infiltration will vary considerably based on changes in wind, temperature, and time of day.

In the example above, with an ACH50 of 5, what would be the expected natural infiltration rate? (5 divided by 40 = 0.12 ach) This means that under normal wind and temperature conditions, we would expect about 12% of the house air to be replaced with outdoor air each hour.

How big are the air leakage sites ("holes") in my house?

Now that you know the CFM50, which is the air flow through the building's leak sites at a 50 Pa house pressure differential, we can determine the approximate cumulative size of the holes. The "holes" in this case are areas of air leakage. To determine the approximate cumulative hole size in square inches, multiply the CFM50 by 0.13. In other words, you are trying to determine the approximate size of all the air leakage sites added together. In our example above, where CFM50 was 1,333, what would be the approximate cumulative hole size? (1,333 times 0.13 = 173 square inches). This means that if you added all the air leak sites together in the example home you would find a little over 170 square inches (1.18 square feet) of potential areas that need sealing, caulking, fixing, etc.

Who can do the test?

Generally, for "green" certifications requiring a blower door test, a State of Florida Certified Class 1 Home Energy Rater is required to conduct the test. However, some Florida utilities have energy conservation services that can conduct the test while also providing an energy audit without requiring a Class 1 Home Energy Rater. To find a State of Florida Certified Class 1 Home Energy Rater, who can conduct a blower door test for "green certification" purposes, search from the following website:

http://securedb.fsec.ucf.edu/engauge/engauge_search_rater.

There are a number of websites that show blower door tests being performed. See http://cec.ishow.com/player/qtp.cfm?ModCon=bldo&id=t24p01&speed=&video=1 and

http://videos.howstuffworks.com/science-channel/37257-deconstruction-building-a-house-blower-door-test-video.htm. Keep in mind that in Florida, we typically depressurize (i.e., the fan blows air out) the building while conducting the test.

Are there any limitations to the blower door test "finding" leaks?

As helpful as the blower door test is in determining areas of air leakage, it's important to know that the blower door test does have limitations in finding the actual locations of leaks. For instance, sometimes indirect leaks or a combination of very small leaks can be in place that the blower door cannot directly locate. In this case other tools, such as infrared thermometers or cameras (discussed later in this fact sheet), are used to detect changes in temperature that can indicate leakage locations.

What about testing the duct system?

There are a number of tests that can be performed to determine if duct systems in a home are working correctly. If ducts are not installed correctly the mechanical systems can be using more energy than necessary. For example, if ducts are located outside the conditioned portion of the home, such as in the attic, and they are leaking, the homeowner may not realize they are paying to heat or cool the air outside their living environment.

Auditors and energy raters often use a tool referred to as a duct airtightness tester that can depressurize or pressurize the duct systems and determine the amount of air leakage (Figure 3). The use of a pressure pan in conjunction with the blower door can isolate where "leaks" can be found. The pressure pan resembles a large cake pan. This test and/or a "smoke" test can be used to help locate duct leaks once a duct airtightness test determines that sealing would be warranted.

Figure 3. Part of the set up for the duct airtightness test.

What are some other tests that might be performed at the same time?

Remember the example we gave in the opening paragraph about letting hot air enter an air-conditioned home? Well, anything with a temperature gives off infrared radiation—the greater the heat, the more infrared radiation. Infrared thermometers and cameras can be used to detect air leakage sites as air leakage heats or cools surfaces. When used with a blower door, the leaks are much more noticeable. Although primarily written for North Dakota conditions, the publication *Determining Insulation and Air Infiltration Levels Using an Infrared Thermometer* (http://www.ag.ndsu.edu/pubs/ageng/structu/ae1373.pdf) provides useful information on the process of evaluating your home for air leaks using an infrared thermometer. There are a wide variety of infrared cameras, but with all models it is critical that the user know how to correctly interpret the visual images.

Added Value of the Florida Energy Systems Consortium

Methods to make homes more energy efficient, yet still provide adequate ventilation, may originate or be refined from research currently being conducted by faculty within the Florida Energy Systems Consortium (FESC). From technological research, to policy evaluation, to behavioral campaigns and community outreach, FESC is helping Floridians reduce energy consumption and demand while creating a healthy environment.

Additional References and Resources

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Acknowledgements

Authors: Craig Miller[a], Kathleen C. Ruppert[a], and Tei Kucharski[b]

Editor: Barbra Larson[a]

Reviewers: Jeff Sonne[b] and Wendell Porter[c]

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[a] *Program for Resource Efficient Communities, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL*
[b] *University of Central Florida, Florida Solar Energy Center, Cocoa, FL,*
[c] *Department of Agricultural and Biological Engineering, University of Florida, Gainesville, FL*

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