



STEP 3

Steps in the Mobile Home Series

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E³A: The Blower Door Test

Introduction

All houses leak air and most leak more than they need to. When the wind blows, or the attic heats up, outside air is drawn into the house and inside air is forced out through hidden cracks in the building shell. For the person living in a home, excessive air exchange results in drafty rooms and high utility bills. Air leaks can also drive moisture into wall cavities and cause long term degradation.

In the early days of weatherization (the 1980's), weatherization workers relied on caulk, gaskets for electric boxes, and plastic storm windows to try to stop air leakage. Baseboards were sometimes removed to caulk the wall/floor juncture. These measures seemed to make sense, but no one really knew if they were effective at reducing air leakage. There was no way to know if workers were finding the biggest air leaks, if they were effectively sealing up those holes, and whether the measures made economic sense.

Along came the blower door test. This tool has turned weatherization into a building trade grounded in measurement and building science. Using this tool, auditors now can measure how "leaky" a house is and crews can find and fix the big energy problems in mobile homes. The blower door has made weatherization more beneficial and cost effective, and can be used to test and measure a home in four ways.

1. To identify and quantify the overall air leakage of the home
2. To find and size big leaks
3. To help locate leaks in the heating ductwork
4. To balance air pressures within the home



This fact sheet is rated (3) because blower door tests require both specialized equipment and training on interpretation of the data. Mobile home owners can use this information to better understand this important step in an energy audit and to assess the competency of potential energy auditors during the hiring process. For video on blower door tests, go online to:

<http://wxtvonline.org/2010/10/blowerdoor-1/>

<http://wxtvonline.org/2010/10/blowerdoor-2/>

<http://wxtvonline.org/2010/10/blowerdoor-3/>



Source: The Energy Conservatory

What Happens in a Blower Door Test?

For an experienced auditor, setting up the blower door test is pretty simple. First, the house is put in “winter” mode. The auditor shuts all windows and outside doors and opens all interior doors. The auditor checks that woodstoves are out and the ashes are cold and shuts the flue damper. The gas furnace, gas water heater, stove hoods, dryers and all bath fans are turned off.

Next, the blower door is assembled and inserted into an exterior door frame. The auditor then connects the fan to the air speed controller and the manometer. One air hose connects the manometer to the fan housing and the other is placed outside to monitor outside air pressure. When the fan is turned on, the manometer reads the pressure difference between the inside and outside of the house and the resulting rate of air movement through the fan.

The following tests are then performed by the auditor to better understand the air flow in your home:

Test #1: Find the current level of air leakage and establish an allowable building tightness level

After installing the blower door in an exterior door opening, the auditor’s first step is to get a baseline reading to correct for any outside wind or unusual pressure conditions. The auditor checks the manometer setting, opens the appropriate fan ring and turns on the fan.

The fan speed is increased slowly until a pressure of -50pa is reached.

At -50pa, the auditor reads the airflow in cubic feet per minute (cfm). The higher the number, the leakier the house is. Numbers such as 2000 or 2500cfm50 are common, though airflow as high as 5500 cfm50 is possible. A reading of 5500 would be a house with serious (but perhaps easily fixed) problems.

This number, the existing air leakage rate, can tell the auditor several useful things about a house. For instance, in a home that produces a reading of 2500cfm50, the size of the total leaks in the house would be equivalent to a 16 inch by 16 inch opening. Similar to leaving a window open all the time. The reading on a fully weatherized house might have half that amount of holes.

The second number that an auditor calculates is the “Building Tightness Limit” (BTL). Unless an additional exhaust fan is installed, a mobile home can be tightened up too much, causing air quality (such as carbon monoxide) and moisture issues. The auditor calculates a “BTL” and the crew uses this limit as a



stopping point in their work so the house still “breathes” a little. The formula uses average wind speeds, the height of the house, number of occupants and other factors. A typical tightness limit might be 1100-1200cfm50 (cubic feet per minute). In this way, the blower door results can be used to protect the home from excess moisture problems and air quality issues.

Auditors also can convert the cfm50 reading into ACH50 (Air changes per hour at -50 Pascals). Auditors multiply the blower door reading times the minutes per hour, then divide by the house volume (length x width x room height). This tells the auditor that, with the blower door running, this house exchanges all the air inside the house 20 times an hour. This number is useful to compare with other homes. A home with 5-6 ACH50 is considered tight, and a home over 20 is very leaky.

Of course, having a blower door running all the time isn’t typical. To estimate how much air moves through a house under “natural” conditions, the auditor might convert the reading to ACHNAT. This result tells the auditor that under “natural” year-long conditions, the air in the house will be replaced 1.12 times every hour (24 hours per day/7 days per week). The goal of weatherization should be to reduce air exchanges to around 0.35 CFMNAT.

CFMNAT can be used to calculate the annual cost to reheat the air that is lost out of the house.

Test #2: Find the big leaks

Once these quick calculations are made and noted down, an auditor will systematically explore the house to find the big leaks. From our example, the auditor is looking for about 250 square inches of holes. These holes will be large and small, obvious and hidden. The first thing to do is find out which rooms are the leakiest by using one of two methods: the manual method or the manometer. The auditor might walk around the house and stop by every door and close the door (which has been open during the blower door test) until it is only open one inch. By placing a wetted hand up to the crack, the auditor can get a sense of how strong the air is blowing through the opening



Gap around flue.



Open wall cavity after plumbing repair.

for every door. The auditor will know which rooms have the biggest holes very quickly. The auditor will then go into those rooms and check around, using a wetted hand and a close visual inspection. There are other methods, including smoke pencils and infrared cameras, which also can assist in finding the leaks.



Large hole in ceiling.

In mobile homes, leaks typically are found where the furnace and water heater flues penetrate the roof, the corners of the water heater enclosure (if there is an outside door on the water heater cabinet), all heating registers, inside the sink cabinets where the plumbing goes down under the mobile home, around the bathtub plumbing and behind washing machines. These types of holes can often be seen from underneath the floor if the belly wrap has been opened. Jalousie windows are also culprits. The main joint between the two parts of a double wide manufactured home should be checked. After these leaks are sealed, another blower door reading can check the progress.

While the actions in Test #2 will be undertaken in a professional energy audit, you can also do many of these steps yourself to help find leaks in your mobile home. 💡

Test #3: Inspect the duct work and measure duct leaks

Ductwork is checked using the Pressure Pan method. We know that mobile home ducts almost always leak, and usually leak a lot. Heating ductwork is located under the floor of the mobile home, where leaks push warmed furnace air to the outside. The goal of duct work weatherization is to make the duct work completely leak free and sealed to the building enclosure. The Pressure Pan test is used to locate and compute the level of leakiness at each floor register.



Source: DOE

With the blower door fan running at -50pa, the auditor walks around the house with the manometer. The manometer is connected to the pressure pan with a short hose. The auditor places the pressure pan over each floor register, presses down on the pan and takes a reading. This number is the pressure difference between the inside of the house and the inside of the ductwork at that location. This number should be close to "0" because the ducts should be

inside the envelope of the house. Readings on mobile home floor registers are however commonly in the 5 to 15 Pa range. The leakiest part of the ductwork is often the last register, near the end wall of the mobile home. The ends of the main trunk line are often very poorly sealed, so the pressure reading at that last register will be high.

The auditor can also isolate parts of the ductwork by stuffing a towel into the duct to seal it temporarily and then testing other sections of the ductwork.

After the ductwork is inspected, cleaned and sealed, the ductwork should be within the envelope of the house and the pressure pan readings should be under 1 Pa at each register, with a total reading under 5 Pa. If the auditor's readings are higher than this, another round of inspections and sealing are in order.

Test #4: Balance the air within the house

Finally, with the ductwork sealed and the house insulated, one last test is undertaken. The house is likely operating with unequal pressure balances. In most mobile homes, each room has a supply (heat) register, but no return air duct. The heated air is meant to return to the furnace via the doorways, the common areas of the home and the hallway. If bedroom doors are closed, for example, the bedroom is being pressurized and the warm, moist air is forced out through cracks and joints in the building structure, contributing to long-term moisture problems. If an auditor gets a reading of more than 3 Pa between a bedroom and the main part of the house then a route must be created so that air can return to the furnace. The easiest method is to cut an additional inch or two off the bottom of the bedroom door. Another method is to install grills in the door or above the door in the wall.

A few mobiles have a ducted return air duct system which routes air back to the furnace via floor joists and the belly. You will see more than one floor register in rooms, often near the outside walls, and a big floor opening either in front of or behind the furnace. These systems should be converted to an open return system and the return ducts should be abandoned. Plug the return registers and the floor opening at the furnace and make sure that a return air pathway is created by the doors.

What to Do Without a Blower Door Test

It is important not to over-seal your home. An overly tightened home may grow mold, or have poor indoor air quality. Unfortunately, there is no way to know when you have gone too far. However, even without the blower door test, you can do the following: 💡

- Seal the ductwork.
- Plug any hole bigger than your fist in walls, floor or belly before insulating.

- Weather-strip the front door if daylight is observed.
- Install interior storm windows if affordable.
- Be observant: Check for odors. Watch for condensation and icing on windows during the winter, which may indicate problems with building tightness.
- Control moisture and contaminants. Use the bath fan while showering and take short showers. Install an outside exhaust fan over gas kitchen stoves. Smoke outside.
- If moisture, mold or odors are evident, it may be necessary occasionally to open a window or install an additional fan in a central area that runs continuously at low speed.

- Do not tighten up the house beyond these measures without a professional audit.

Conclusion: Using the blower door is the single most effective tool in reducing the air leakage in your home and providing protection from excessive air quality problems. Even if you cannot get a blower door test on your home, understanding the process and tests described above will help you to better understand weatherization measures for your mobile home.

Notes
