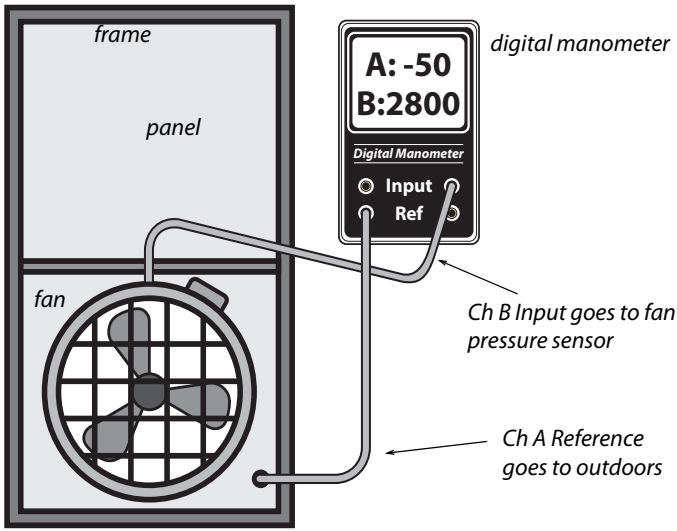
12.2 Single-Family Airtightness Testing

House airtightness testing was made possible by the development of the blower door. The blower door measures a home's leakage rate at a standard pressure of 50 pascals. Energy auditors use this leakage measurement to compare homes with one another and to established air-leakage standards.

The blower door also allows the auditor to test parts of the home's air barrier to locate air leaks. Sometimes air leaks are obvious. More often, the leaks are hidden, and you need a blower door to find their location.

This section outlines the basics of blower-door measurement along with some techniques for gathering clues about the location of air leaks.

Blower-Door Components

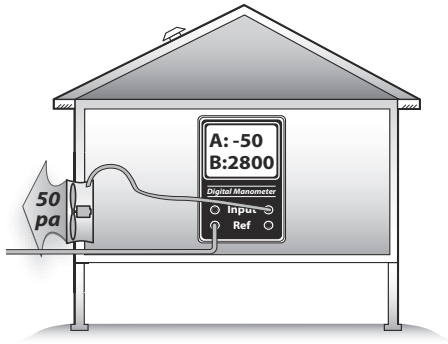


12.2.1 Blower-Door Principles

The blower door creates a 50-pascal pressure difference across the building envelope and measures fan pressure in order to cal-

culate airflow in cubic feet per minute (CFM_{50}) to estimate the leakiness of homes. The blower door also creates pressure differences between rooms in the house and intermediate zones like attics and crawl spaces. These pressure differences can give clues about the location and combined size of a home's hidden air leaks.

Blower-door test: Air barriers are tested during a blower-door test, with the house at a pressure of 50 pascals negative with reference to outdoors. This house has 2800 CFM_{50} of air leakage. Further diagnostic tests can help determine where that leakage is coming from.

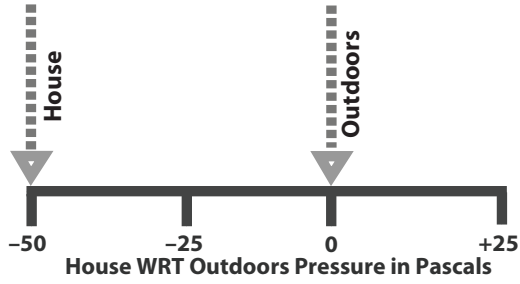


Blower-Door Terminology

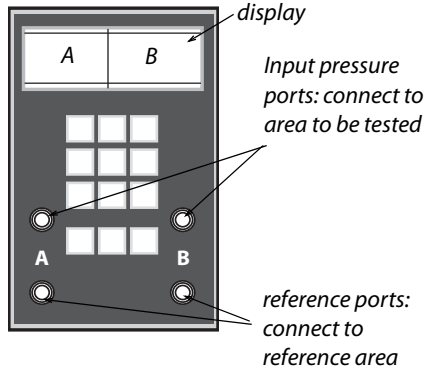
Connecting the digital manometer's hoses correctly is essential for accurate testing.

This method uses the phrase *with-reference-to (WRT)*, to distinguish between the input zone and reference zone for a particular measurement. The outdoors is the most commonly used reference zone for blower-door testing. The reference zone is considered to be the zero point on the pressure scale.

For example, *house WRT outdoors* = –50 pascals means that the house (input) is 50 pascals negative compared to the outdoors (reference or zero-point). This pressure reading is called the house pressure.



Digital manometers: Used to diagnose house and duct pressures quickly and accurately.



Low-Flow Rings

During the blower-door test, the manometer measures airflow through the fan. This airflow (CFM_{50}) is the primary measurement of a home's airtightness and is directly proportional to the surface area of the home's air leaks. For the blower door to measure airflow accurately, the air must be flowing at an adequate speed. Tighter buildings and smaller buildings don't have enough air leakage to create an adequate airspeed to create the minimum fan pressure. This low-flow condition requires using one or two low-flow rings, to reduce the blower-door fan's opening and to increase air speed, fan pressure, and measurement accuracy.

When the air speed is too low, the DG-700 displays "LO" in the Channel B display. After installing one of the low-flow rings, follow the manufacturer's instructions for selecting the proper range or configuration on the digital manometer.

12.2.2 Preparing for a Blower-Door Test

Preparing the house for a blower-door test involves putting the house in its normal heating-season operation with all conditioned zones open to the blower door. Try to anticipate safety problems that the blower-door test could cause, particularly with combustion appliances.

- Identify the location of the thermal boundary and determine which house zones are conditioned.
- Identify large air leaks that could prevent the blower door from achieving adequate pressure, such as a pet-door.
- Put the house into its heating-season operation with windows, doors, and vents closed and air registers open.
- Turn off combustion appliances temporarily.
- Open interior doors so that all indoor areas inside the thermal boundary are connected to the blower door. This could include the basement, conditioned kneewall areas, and closets.

Avoiding Risky Situations

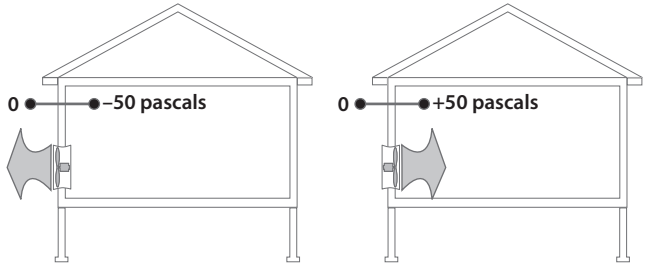
Don't perform a blower-door test in risky situations like the following until you remove the risk or perform an acceptable building repair.

- A wood stove is burning or contains ashes that may be pulled into the home.
- Holes in the ceiling that could lead to dust pollution during a blower-door test.
- Extremely weak building components, like a poorly installed suspended ceiling or loose wood wall paneling.
- Lead or asbestos dust is present.

12.2.3 Blower-Door Test Procedures

Follow this general procedure when performing a blower-door test.

- ✓ Set up the house for winter conditions with exterior doors, primary windows and storm windows closed. The door to the basement should be either open or closed, according to whether or not the basement is considered to be within the thermal boundary.
- ✓ Install blower-door frame, panel, and fan in an exterior doorway with a clear path to outdoors. On windy days, install the blower door on the home's leeward side if possible. Pay attention to the blower door's location and any other conditions that may affect test results.
- ✓ Follow manufacturer's instructions for fan orientation and digital-manometer setup for either pressurization or depressurization. Depressurization is the most common orientation.
- ✓ Connect Channel A of the digital manometer to measure *house WRT outdoors*. Place the outside hose at least 5 feet away from the fan.
- ✓ Connect Channel B to measure *fan WRT zone near fan inlet*. Don't place the hose directly in front of the fan intake.
- ✓ Ensure that children, pets, and other potential interferences are at a safe distance from the fan.



Conducting the Blower-Door Test

Follow these instructions for performing a blower-door test, when using a DG700 digital manometer.

1. Turn on the manometer by pushing the ON/OFF button.
2. Select the MODE: PR/FL@50.
3. Select the correct DEVICE that matches the blower door you're using.
4. With the fan covered, conduct the BASELINE procedure to cancel out the background wind and stack pressures. Let the manometer average the baseline pressure for at least 30 seconds.
5. Remove the cover from the blower-door fan. Complete the next two steps for tighter buildings.
6. Install the flow ring in the blower-door fan which matches the expected flow rate. The fan pressure should be at least 25 Pa while measuring CFM@50.
7. Push CONFIG or Range button until you match the flow ring being used.
8. Turn on the blower-door fan slowly with the controller. Increase fan speed until the building depressurization on the Channel A screen is between –45 and –55 pascals. The reading doesn't need to be exactly –50 pascals.
9. The Channel B screen displays the single-point CFM_{50} air leakage of the building. If this number is fluctuating a lot, push the TIME AVG button to increase the averaging time period.
10. You can also use the cruise-control function to automatically control the fan speed to create and hold –50 pascals of pressure.

Be sure to return the house to its original condition.

- ✓ Inspect combustion appliance pilot lights to ensure that blower-door testing didn't extinguish them.
- ✓ Reset thermostats of heaters and water heaters that were turned down for testing.
- ✓ Remove any temporary plugs that were installed to increase house pressure.
- ✓ Document the location where the blower door was installed.
- ✓ Document any unusual conditions affecting the blower-door test.

12.2.4 Approximate Leakage Area

There are several ways to convert blower-door CFM_{50} measurements into square inches of total leakage area. A simple and rough way to convert CFM_{50} into an approximate leakage area (ALA) is to divide CFM_{50} by 10. The ALA can help you visualize the size of openings in a home or section of a home.

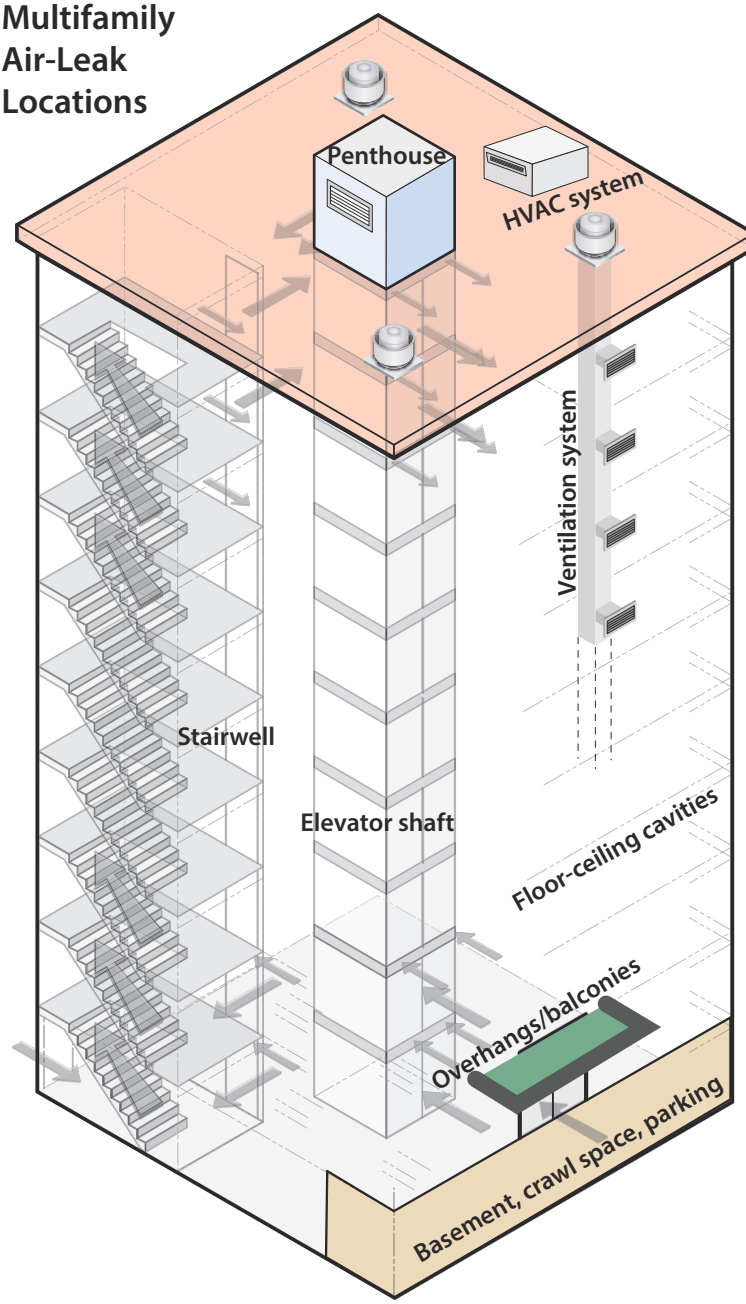
$$\textbf{ALA (SQUARE INCHES)} = \textbf{CFM}_{50} \div \textbf{10}$$

12.3 Multifamily Airtightness Testing

Air sealing, indoor air quality, and fire safety complement one another in multifamily buildings. Beyond sealing leaks in the exterior envelope, the most universal concept in multifamily air sealing and airtightness testing is compartmentalization. Compartmentalization means sealing the air leaks between dwelling units to provide these benefits.

- Prevent odors traveling from one dwelling unit to another.

Multifamily Air-Leak Locations



- Prevent the rapid spread of fire and smoke from one dwelling to another.
- Save energy by sealing air leaks and reducing the stack effect.

Leak-testing multifamily buildings is considerably more difficult then testing single-family homes. A whole-building blower-door test is the ideal, but is often impossible because of the huge airflow needed to pressurize the building along with the practical problems of testing a building with many occupants. These practical problems often necessitates zone testing and compartmentalization testing.

12.3.1 Testing Equipment

The quality and quantity of test equipment and the experience of the testing technicians determines the effectiveness of the testing. The larger the building, the more air-moving horsepower and technology the testing equipment requires.

Several software packages can automate the process of monitoring multiple blower doors and tracking pressures throughout a large building. Wireless sensors and wireless gauges make the process of remote measurement more practical.

Detailed instructions about operating a large-building air-leakage testing system are beyond the scope of this field guide.

12.3.2 Multifamily Air Leakage

Energy auditors develop an air sealing strategy by evaluating the chase leakage, according to the presence and location of the following building components.

- Direct air leakage through roofs, walls, and foundations.
- Vertical chases; including stairs and elevators
- Leaks through floors allowing airflow from one floor to another.

See the following sections for more information on multifamily air leakage.

- *"Weatherization Materials" on page 93*
- *"Air-Sealing Attics and Roofs" on page 121*
- *"Air Sealing Foundations and Floors" on page 208*

12.3.3 Multifamily Blower-Door-Test Strategies

Here we discuss three different strategies for blower-door testing a multifamily building: the whole-building test, the compartmental test, and the guarded test.

Testers also measure zonal pressures to evaluate air barriers in multifamily buildings, like they do in single-family dwellings.

Whole-Building Test

Although increasingly difficult as buildings get larger, the whole-building blower-door test is a preferred approach. The testers usually need multiple blower doors for this test along with an automated blower-door-testing system.

The whole-building test provides an air-leakage measurement for the entire building. Also, this blower-door test gives the best information about where the critical leaks to outdoors are located.

Compartmental Test

The compartmental test requires only one blower door. This test measures air leakage to both the outdoors and indoors.

The compartmental approach gives the energy auditor a sample of the air leaks in a single dwelling unit. The leaks in this single unit may inform the auditor about typical leaks in all dwelling units or in units with the same characteristics.

Guarded Test

Testers use the guarded test when they want to measure a single dwelling unit's air leakage to outdoors. This test is another strategy to characterize a single unit—like the compartmental test—by only measuring leakage to outdoors. This test requires pressurizing surrounding dwelling units with the same pressure applied to the tested unit.

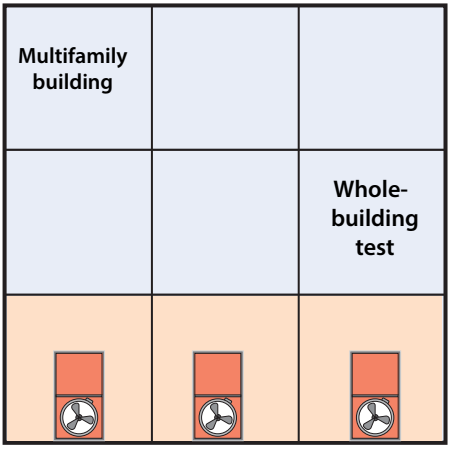
Zonal Pressures

Creating and measuring zonal pressures is one of the most effective ways to evaluate air leakage in multifamily buildings. Testers observe the building's assemblies and architectural features and formulate assumptions and questions to guide their air-leakage testing and air sealing.

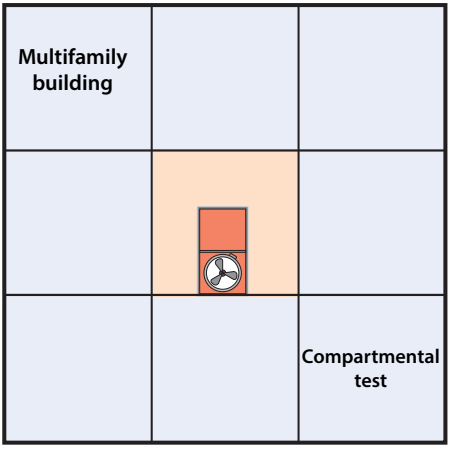
The testers may decide to isolate various zones and assemblies to determine their individual leakage to outdoors or to adjacent zones. The goal is a testing and air-sealing process that is cost-effective. The tests may be quantitative or qualitative. Here are some zones and assemblies that you may want to pressure-test.

- Stairwells and elevator shafts.
- Ventilation and HVAC ducts, duct joints, and duct chases.
- Overhangs and balconies.
- Basements, crawl spaces, and penthouses.
- Floor and ceiling cavities.

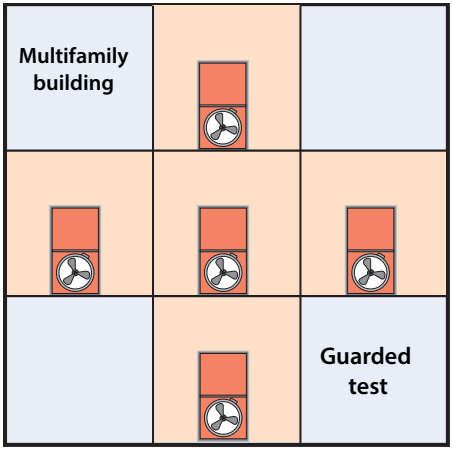
The next section, *"Testing Air Barriers" on page 556*, gives many examples of zone pressure testing.



Whole-building test: Multiple blowers in entrances pressurize the whole building at once. A preferred method but sometimes impractical in existing buildings.



Compartmental test: A single blower door pressurizes a single dwelling unit. Identifies features of the unit that leak air to the outdoors and to surrounding units.



Guarded test: Attempts to measure the leakage to outdoors of a single dwelling unit. One blower door measures the units air leakage while other blower doors pressurize adjacent units to the same negative or positive pressure.

Based on Sean Maxwell