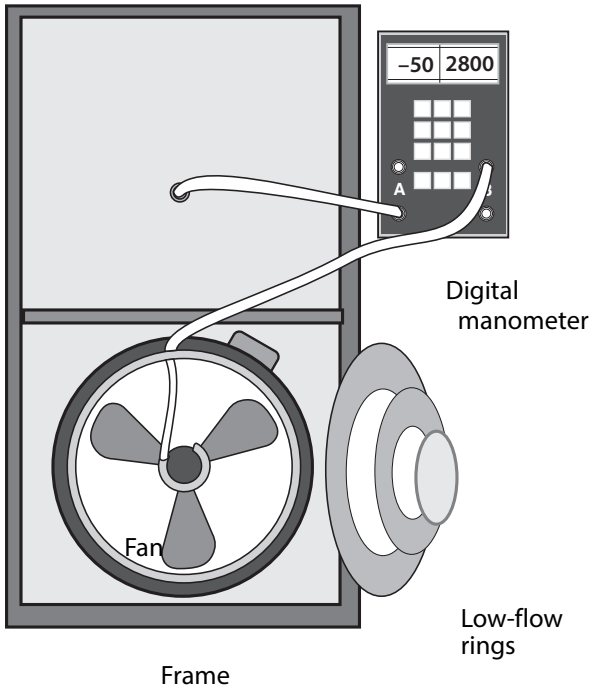
Blower Door



Blower doors create a measurable house pressure and airflow in order to evaluate a building's air leakage.

Chimneys and exhaust fans (including clothes dryers) remove air from the home, creating a slight vacuum, often called depressurization. The wind, furnace blower, and stack effect tend to pressurize some areas of the home and depressurize others.

Beyond air leakage, air can also move around inside building cavities, increasing the rate of heat transmission. Air convects inside building cavities, carrying heat from one surface to another. Air can wash over the insulation's surface, convecting heat away. Or air can convect through an insulation material, reducing its thermal resistance.

Ideally, an effective air barrier surrounds the home on all sides, adjacent to its insulation. An effective air barrier prevents most air leakage and convection. However, many if not most American homes have flawed air barriers that can be significantly improved by diagnosis and air sealing.

Air Pressure and Flow

Air pressure, airflow, and the size of air leaks are directly related to each other. A pressure difference on opposite sides of a hole causes an increase in airflow through the hole. Bigger holes pass more air at the same pressure than smaller ones.

Pressure and airflow can be measured by instruments called manometers. Manometers come in three common types: a transparent tube filled with water; a round gauge with a needle indicating the pressure or flow amount; or a digital manometer, giving a digital readout of pressure.

The air inside an inflated beach ball is denser than the atmosphere outside. Measure this pressure difference by attaching a manometer to the beach ball's valve. The lighter atmosphere presses on one side of the liquid, and the denser beach ball air presses on the other. The distance that the beach ball's denser air moves the water column off level — measured in inches — is a unit of air pressure.

The small air pressure differences caused by wind, blower doors, furnace fans, and chimneys are measured in inches of water column (abbreviated IWC) in the American measurement system. The more common metric unit for small air pressures is the pascal — 249 pascals equal 1.0 IWC.

When talking about pressure differences between two areas, we say that the zone having denser air is pressurized, or is the high-pressure area. The zone with less dense air is depressurized, is under vacuum, or is the low-pressure area.

Another type of manometer is a round gauge with an arc-shaped scale for measuring either pressure (in pascals) or airflow cubic feet per minute (CFM). This gauge has a high pressure tap and a low pressure tap. If the gauge is physically located in the low pressure area — as with typical blower-door testing — its low pressure tap is open to that area (indoors), and a hose is used to expose its high pressure tap to the high pressure area (outdoors).

The digital manometer measures pressure by way of sensors, called pressure transducers. Digital manometers give their readings on a digital screen, and some can measure both house pressure and flow simultaneously.

Airflow is then measured by connecting the manometer's low pressure tap to a hose held parallel to the airflow stream. Air flowing perpendicular to the opening at the hose's end creates vacuum within the hose. This vacuum's strength is directly related to the airflow rate. Manometers convert the pressure they sense to airflow by an airflow scale on the gauge face or by a electronic calculator in the digital manometer.

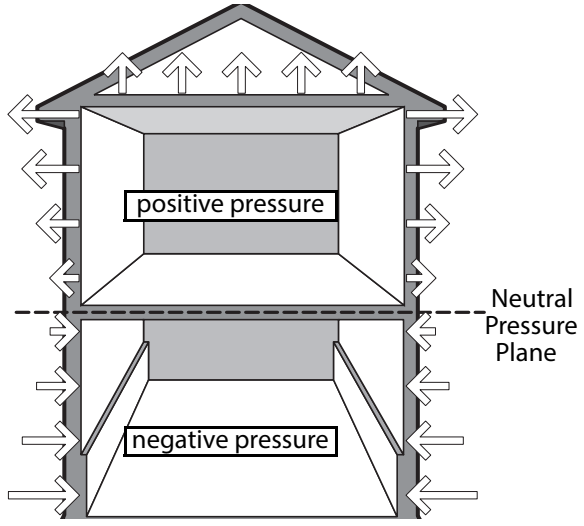
Pressures Driving Air Leakage

Air flowing inside or outside a building creates pressures that affect the building. Buildings aren't equal with respect to their air pressures. Because of differences in pressure, one single-family home may have two to four times the air leakage of another home with the same air leaks. Homes with forced-air distribution systems, fireplaces, and large kitchen exhaust fans have larger pressures than homes without these features. Homes on hilltops in high-wind areas may have twice the air leakage of homes in less windy regions.

This section describes how a building's height, its chimneys, exhaust fans, and furnace blowers, along with the wind, affect its air pressures.

Stack-effect pressure — Cooler air is denser than warmer air, and this density difference creates a pressure that causes air to move. The air inside a home tends to stratify in layers due to density differences. During the heating season, hot air rises to the top and cooler air falls to the bottom. If the home has leaks, warm air leaves through higher openings, and cool air enters through lower openings. This pattern of air leakage is called the stack effect because it resembles airflow in a chimney. During the cooling season the stack effect can reverse causing infiltration higher in the building and exfiltration in the lower.

Stack Effect



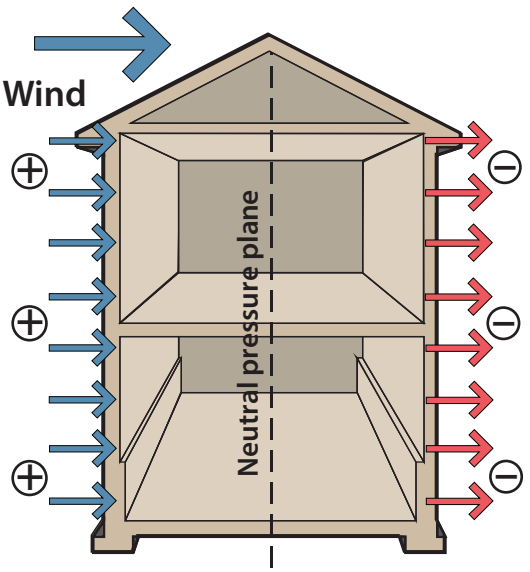
The stack effect is caused by the relative buoyancy of warmer air. Warmer air's upward force exerts an outward pressure. Airflow, through holes in the home's top, creates suction at lower levels, pulling air in. Arrows indicate the direction and intensity of air pressure.

A building's natural pressure difference with the outdoors varies depending on location. Somewhere near the building's midpoint of height is a boundary region, called the neutral pressure plane, which separates the building's negative and positive pressure zones. A hole near the neutral pressure plane allows little or no leakage because there is no indoor/outdoor pressure difference there.

The pressures created by stack effect are greatest at the highest and lowest points in the building. Therefore, a hole in a basement or attic will allow more air infiltration than an equal-sized hole near the neutral pressure plane.

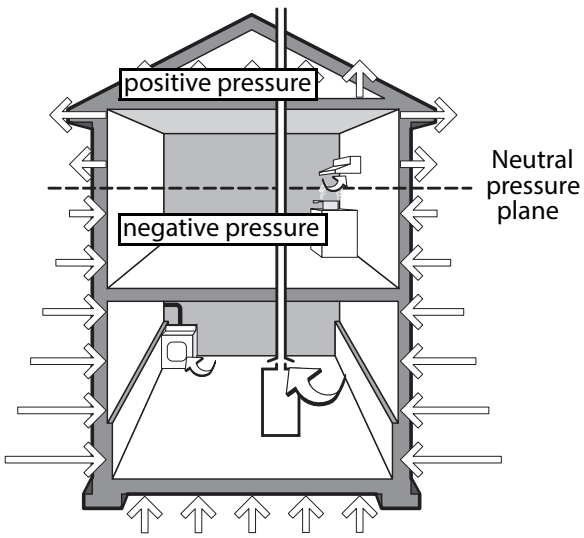
Wind pressure — Wind blowing against a wall creates an area of high pressure, driving outdoor air into the windward side of the home. The wind's force is enhanced or hindered by building and landscaping features that act as dams — porch roofs, overhangs, inside building corners, fences, or vegetation.

Wind Pressure



Wind creates a positive pressure on the windward side of the home and negative pressures on leeward side with reference to the home's interior. Wind pressures push and pull air through holes in the building shell.

Chimney and Exhaust Pressure



The chimney, clothes dryer, and kitchen exhaust fan exhaust air from the home, putting most of the home's volume under negative pressure.

The wind creates a vacuum at wall and roof surfaces parallel to its flow. The leeward side, facing away from the wind, is usually either neutral or depressurized.

The wind's speed is greater the higher from the ground you measure. As building height increases, wind's force against the building increases. Wind speed is affected by trees, fences, neighboring buildings, and hills that block or divert wind. Wind speed varies widely between geographic regions and even within local areas. Strong wind gusts can damage air barriers and permanently increase air-leakage rates.

Chimney and exhaust pressures — Chimneys, exhaust fans, and clothes dryers create a slight vacuum indoors because they exhaust air out of the building. They also move the neutral pressure plane up because more of the building's interior space is under negative pressure. A fan that forces air into the home moves the neutral pressure plane down, putting more of the home under positive pressure.

Replacement air, for air exiting exhaust devices, is called make-up air for exhaust fans or combustion air for combustion appliances. Make-up air and combustion air enter through air leaks, intentional openings, or ducts. Make-up air or combustion air may even come down a chimney if negative pressures become too great — a dangerous situation called backdrafting.

Duct pressure — The furnace blower circulates air through the furnace and its supply and return ducts. Supply registers blow air into a room, pressurizing nearby areas of the room. Return registers suck air out of rooms, depressurizing areas near these registers.

If the ducts are leaking, or return air is restricted, rooms may have high positive or negative pressures. These pressures are often large enough to double or triple the building shell's air leakage, compared to air leakage when the furnace blower is off.