BY STEVE BACZEK

Air Barrier Basics

Many folks argue that airtightness is the most important aspect of energy efficiency. But I try to look at energy efficiency as a two-part equation: Convert the energy as inexpensively as you can, and then hold onto that energy for as long as you can. It's the latter part of that equation where airtightness plays a major role. Even if you maintain adequate thermal control through good insulation levels, a lack of a good, airtight control layer will either let in unconditioned outside air (infiltration) or let out conditioned inside air (exfiltration). Both of these conditions are detrimental to a home's performance and result in wasted energy dollars.

THE MOISTURE CONNECTION

The airtightness issue goes beyond how well a building's HVAC system performs. Uncontrolled air leakage can also provide a vehicle for unwanted moisture to enter a building assembly, which can become the reason for a building to fail, leading to costly building repairs.

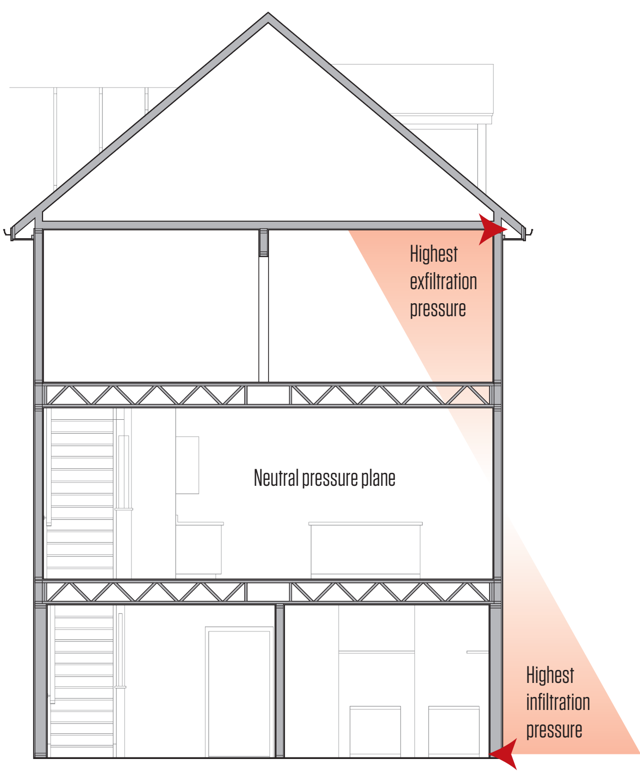
In older homes with little or no insulation and no control over air movement, the energy lost through air exfiltration simply "baked" the home dry. The energy inefficiency of those older homes extended their lives, because most failures in air and moisture management simply used the energy being lost through the assembly to dry it out and to minimize damage.

Current energy conservation requirements in the energy code severely limit the amount of energy moving through the building assemblies that we are building today. This lack of energy movement coupled with airborne moisture can lead to a shortened lifespan of the assembly. In other words, our efforts to build better houses have removed the forgiveness factor that once existed in older assemblies.

Recently, the building code has recognized airtightness as an integral part of energy conservation. Buildings now must pass airtightness tests using a blower door that pressurizes or depressurizes a building. The code requirement for airtightness is 3.0 ach (3.0 air changes per hour) at 50Pa (50 pascals of constant pressure). This requirement is very modest compared with more stringent criteria such as the Passive House standard at .60 ach 50Pa. Understand, buildings cannot be "too tight," but rather they can be underventilated. I have designed numerous homes that meet or significantly exceed the Passive House standard. All of them are performing exceptionally well, and all of them are mechanically ventilated. A proper mechanical ventilation strategy is an absolute requirement for an effective air-barrier system.

THE STACK EFFECT

Before we discuss strategies for air-sealing a building, we need to talk about what that building typically experiences in terms of air



Layers of pressure. As warm air rises inside a typical home, the pressure changes from inward pressure (infiltration) at the bottom of the building to outward pressure (exfiltration) at the top, with a neutral pressure plane in the middle. Because the pressure increases with the distance from the neutral plane, the top and bottom of the building are the most critical for establishing an air barrier.

All illustrations adapted from drawings by Steve Baczek pressure. Most buildings undergo both infiltration and exfiltration (if not, they would implode or explode). Buildings constantly try to equalize their internal pressure: 1 cfm comes in to equal 1 cfm going out, or vice versa.

Pressure in a building is not arbitrary. On the contrary, it is pretty predictable (see The Stack Effect, page 7). Because warm air rises, the highest exfiltration area is at the top of the house or the upper limits of the air barrier. Consequently, the area of highest infiltration pressure is at the lower limits of the air barrier or the basement. The median of the two is known as the "neutral pressure plane." The neutral pressure plane sees neither infiltration nor exfiltration, but rather it is the line where the pressure changes direction. Looking at this illustration, the farther you move from the neutral pressure plane, the greater the pressure, and the more critical it is to maintain an airtight barrier. Your air-barrier strategy should start at the points of highest pressure and move towards the neutral pressure plane. This strategy is applicable to both new construction and remodeling.

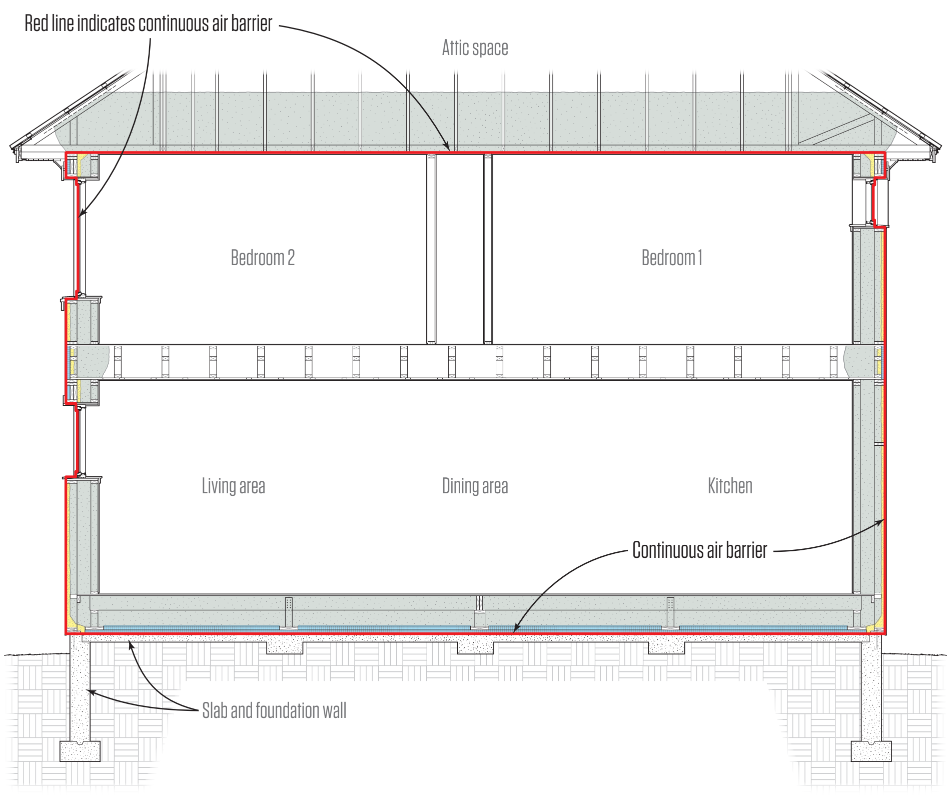
THE RED LINE TEST

With a clear understanding of the challenges, it is time to develop an effective air-barrier strategy. I like to begin all discussions of air-barrier strategies with the "Red Line Test," which I first learned about from Joe Lstiburek of the Building Science Corporation (see Red Line Test, below). He explained it like this: "You should be able to take any section of a building on paper, put a red pen on the paper, and trace the building's air barrier without lifting the pen. Eventually, the red line of the pen should connect to the starting point."

The most important point that Lstiburek is making with his test is *continuity*. In other words, a successful air barrier must be continuous and unbroken around the entire perimeter of the building envelope. This crucial point bears repeating: The success of an effective air-barrier strategy is in its continuity. When I am asked what the best material is for an air barrier, my answer is always the same: "The one that is installed properly." And with that answer, I reference Lstiburek's Red Line Test.

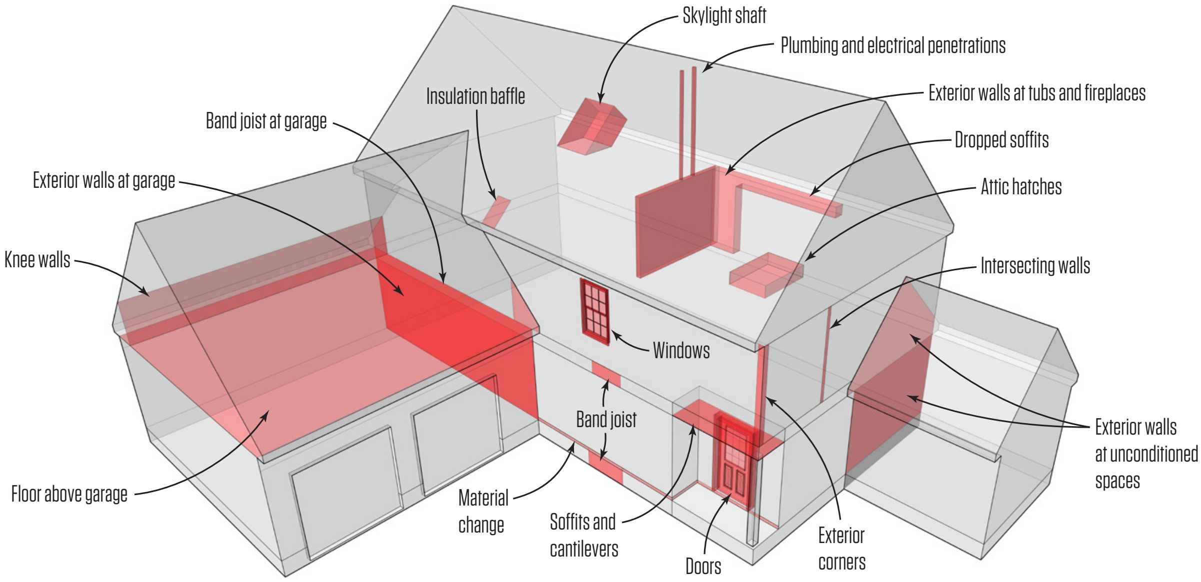
Specific air-barrier strategies seem to be the topic of endless debate. Should the air barrier be on the outside of the building? Should it be inside? Should it be in the middle of the wall assembly? The truth is that an air barrier can be effective in any of those areas. The two most important criteria for achieving a successful air barrier are that all the materials used in the air barrier must be installed properly, and that the air barrier must be continuous.

Red Line Test



Red Line Test. The key to a successful air barrier is continuity. On any section drawn through a building, it should be possible to follow the air barrier around the entire perimeter of the building envelope with a red pen without lifting the pen from the page. In this fairly complex building envelope, the air-barrier line passes from an insulated slab, through the walls and attic, and back down to the slab.

3D Thermal Bypass Checklist



Three-dimensional thermal bypass checklist. Many organizations have published lists of areas in a building that are likely to challenge the air barrier. Making a 3D rendering takes the checklist one step further, giving users a visual graphic to better understand and deal with these areas of concern.

It is incredibly rare that a building's air barrier is ever made from just one or two materials. While some materials may dominate the composition of the air-barrier system, there are always points where multiple materials are responsible for maintaining continuity. For example, exterior sheathing might be the primary air barrier in a home, but most homes also have doors and windows—areas where the exterior sheathing doesn't exist. The window or door then becomes part of the air barrier. With this change in material comes the critical connection of the exterior sheathing to each of the windows and doors. These areas where materials change are where the air-barrier continuity can be easily challenged. An effective air-barrier strategy is not just choosing material for each specific location, but also being able to trace the Red Line through those critical areas where the air barrier may comprise four or five different materials in just a few short inches. Again, the key to an effective air-barrier strategy is *continuity*.

THE THERMAL BYPASS CHECKLIST

There are many critical areas where the continuity of an air barrier is likely to be challenged, and many organizations such as Energy Star have compiled extensive lists of those areas; Energy Star calls its list the "Thermal Bypass Checklist." But for most people, a graphic representation of a checklist like that is the best way to get the point across.

With that in mind, I developed my own three-dimensional version of the checklist to visually illustrate the points where an effective air barrier is most likely to be challenged (see 3D Thermal Bypass Checklist, above). Instead of depending on a written list, the areas of concern are highlighted in a 3D representation of the building. These areas are common to the work that all of us do every day.

But as common as these challenges seem to be, I often see that many of them are not being solved for in our industry. The failures I see most often are where the continuity of the air barrier is broken. The solution for creating a successful air barrier is being able to visualize and think through every inch of the barrier—especially in critical areas—to maintain continuity.

Steve Baczek (stevenbaczekarchitect.com), of Reading, Mass., is an architect specializing in energy-efficient design and certified passive homes. Follow him on Instagram @StevenBaczekArchitect.

For a more detailed discussion of air barriers, go to **www.jlconline.com/training-the-trades/air-barrier-basics**.