Building for Better Breathing

by Bruce Davis

When my family and I had our home built here in North Carolina, good ventilation and air filtration were top priorities because my daughter has problems with allergies and asthma. We considered occupant health and comfort, combustion safety, building and equipment durability, and energy efficiency. Before construction began, we made simple but important decisions concerning siting, foundation, framing, insulation, exterior surfaces, and heating and cooling systems. We figured that high-quality air filtration and ventilation systems would add very little to our installation and operation costs. And we were right.

Bruce Davis teaches the basics of building science.

Simplicity for Savings

The first step we took to keep energy costs low was correctly orienting the house and the windows. We faced most of the windows south, for solar-tempering. Next, we created a simple design, without complex gables, transitional ceilings, or unusual room layout. This allowed the framers to take a straightforward approach to the job, leaving less chance for gaps, ill-fitting members, and other mistakes. While you don't have to opt for a simple design in order to save energy, doing so certainly makes it easier and less costly.

The simple design also made it easier to build a continuous air barrier and insulation layer. The home has R-30 insulation in the ceiling, R-19 in the walls, and R-22 in the floors (the local code requirements are R-30, R-13, and R-19, respectively). I made sure the insulation was properly installed for maximum effectiveness; that is, the material was installed in all the right places, was not compressed anywhere, and was continuous—there were no gaps.

The windows we chose are simple, too. They are moderately priced, with separated metal frames and plain double-glazed glass. The doors are foam-core steel with double-glazed windows. I feel that you don't have to have some kind of "magic windows" that cost a lot in order to have comfort and efficiency.

To promote durability and avoid moisture problems, we made sure that the crawlspace was sealed and that vapor-retarding plastic sheeting was used to completely cover the crawlspace floor and walls (see "Educating Builders, Updating Codes," HE Mar/Apr '98, p. 35). We put plastic sheeting under the pier footers and sealed it to the rest of the ground cover to keep moisture from wicking up through the concrete.

The Heat Is On—Low

To select the right sized heat pump, I began with a *Manual J* room-by-room load calculation. The heat pump system we chose (a 13 SEER) met both the temperature and the humidity demands calculated for the house. It's important to note that, for our almost 1,800 ft² house, we have a 1.5-ton heat pump (which equals about 1 ton per 1,200 ft²). The heat pump is controlled with a simple, old-fashioned mercury bulb thermostat that cost just a few dollars rather than one of the expensive, programmable units that range from $50 to $150 or more. Since the heating and cooling system is so well matched to the house, we just set it and forget it. Given the correct sizing and installation of the system, it is more energy efficient to keep the thermostat setting the same all the time rather than allow the house to get too cold and then force the system to work longer than it should in order to reheat it.

Testing the Contractor

Being aware of the many problems associated with leaky ducts, I knew that the first step was to choose an HVAC contractor who specializes in installation quality guarantees. Since I work in the business, I knew what to ask potential HVAC contractors before selecting one.

Typically, I would request a room-by-room load *Manual J* calculation, and system specifications based on those results; I would get references; and I would ask what kind of tests the contractor does. At the minimum, they should perform Duct Blaster and blower door tests. It is essential that they use mastic to seal the ducts. I would also find out what kinds of ongoing training they and their crew have had, what they do for quality control, and what kind of guarantee they would agree to.

By choosing the right HVAC contractor, I ensured that the duct system was correctly designed for my house and was installed to be airtight. After installation, Design Aire owner Jack Orum and I pressure-tested the system with a duct blower to confirm that it did not leak—at all. After the air filters were in place, we measured and properly adjusted the total system air. We made sure the refrigerant charge for the heat pump was accurately calculated, measured, and installed, and that the air flow to each room was measured and balanced. We provided return air-flow

paths from each room back to the central return, with code-compliant door undercuts; and we installed an extra return register and duct in the master bedroom so that, when the bedroom door is closed, the house would still be pressure balanced.

Filter for Life

All forced-air central heating or cooling systems use some type of filter. However, most homeowners are unaware that the standard 69¢ fibermesh furnace filter is designed only to protect the furnace or heat pump, *not* to protect people's lungs. Testing has shown that these filters remove less than 20% of all particulates and are almost completely useless for removing smaller airborne contaminants like smoke, dust, bacteria, and viruses.

I used 2-inch paper-media pleated filters in each return grille; these offer a tremendous increase in filtering ability for just a few dollars (see Figure 1). I need to change them every three months. I also installed a special 6-inch pleated Space Gard filter at the heat pump air handler located in the crawlspace. These filters are changed once each year and cost about $17 each; they have pores small enough to trap 65%–90% of most pollen, mold spores, animal dander, and hair, and even do a good job of removing airborne fibers, skin flakes, and some bacteria. Their pleated design yields much greater surface area than a flat filter, allowing less resistance to air flow and a longer useful life. Plus, they're easier to maintain. Some other types of filter, such as electrostatic precipitator (ESP) filters, require continuous maintenance in order to work well. If they lose their charge and stop filtering, you may not know it for weeks—by then, your coil is dirty. In contrast, the 6-inch pleated filter has a good efficiency rating and is simple. Note that every extra filter adds static pressure drop, and the system must be designed with that in mind.

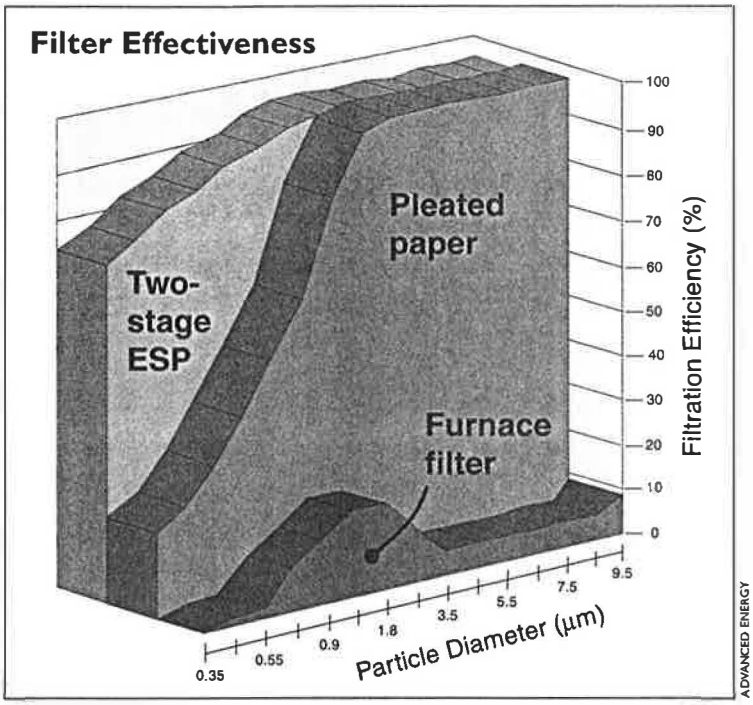


Figure 1. For many particles, a pleated paper filter is as good as an electrostatic precipitator. It's also more dependable. And almost anything is more effective than the furnace filters that come standard on most units. We chose simple pleated paper filters for our home.

Let It Flow

Many home designers today seem to think we can have either tight, energy-efficient homes *or* fresh air. Proper ventilation allows both.

To ensure proper ventilation of my home, I installed a balanced mechanical ventilation system that provides filtered outdoor air to each room in the house, continually removing stale, contaminated air at the same rate. It operates 24 hours per day, removing pollutants that are released from construction materials, household chemicals, and the like. The particular ventilation system I installed is an energy recovery ventilator (ERV) made by Honeywell, the ER200-ERV. This one cost about $1,000 installed (including ductwork and controls), but other ERVs run from $600 to $2,000. Its installation as a separate system with simple direct ducting did not interrupt the construction schedule. It used 1,157 kWh in the first year. This type of ventilator is designed to strip out much of the moisture and heat from the incoming air during the summer and transfer it to the exhaust air, thus reducing the load on the conditioning system. During the winter, the ERV retains much of the moisture and heat that would otherwise be exhausted with the stale outgoing air. And since equal amounts of exhaust and supply air are going out and coming in all the time, the air pressure in the house is neutral with reference to the outside, meaning the house is neither sucking air in nor blowing it out. With this balanced ventilation system in operation, we breathe fresh outdoor air all year long. We avoid the unpleasant and often unhealthy "new house" smells that come from outgassing chemicals.

Another simple step I took to improve ventilation was to be sure that the ducts from the standard exhaust fans in both bathrooms and from the exhaust hood over the kitchen range were all tight and ran smoothly to the outdoors.

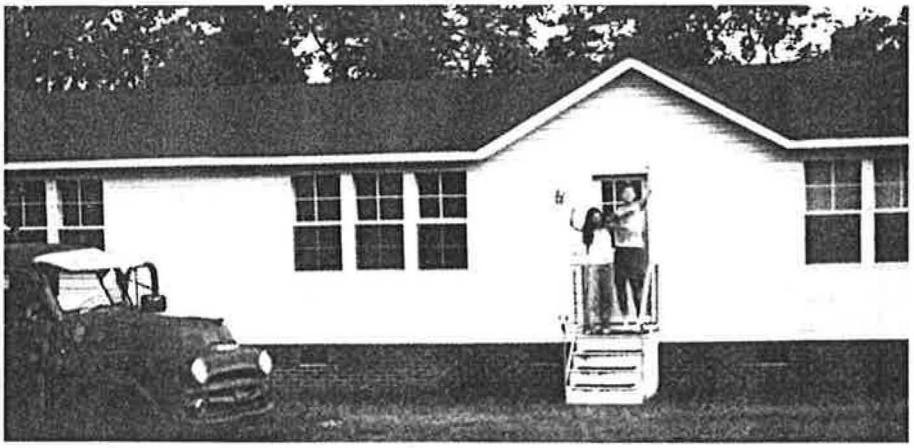
The Devil Is in the Materials

Along with cleaning the air of particulates and keeping allergen concentrations lower, the ventilation and filtration systems remove volatile organic compounds and other natural and artificial pollutants from the indoor environment. This is important, because toxic chemicals from new furniture, carpets and the like can be hazardous (see "Occupants Pollute Healthy Homes, p. 6). To help offset these problems, I also chose construction materials and furnishings with fewer sources of outgassing chemicals. Furthermore, since our heat pump is sized correctly and removes excess internal humidity, the indoor air has the right moisture content for human health, while discouraging the growth of mold and dust mites in clothing, bedding, and furniture.

To avoid the pollution and safety issues surrounding combustion appliances, I chose an all-electric heating and cooking design. This eliminates any combustion by-products from the air (unless you burn your food) and greatly reduces the associated fire hazards.

I Bought What I Taught

Our family's choices are not the only options; there are many choices to make for ventilation systems, construction design, and finishing and furnishing materials. It's important to investigate each of these before buying, building, or remodeling your next home and to remember that even ordinary, simply designed homes can be comfortable and energy efficient. We avoided the big mistakes—exposure to auto exhaust and combustion by-products; conditions that might cause excess moisture to condense in the house; misaligned and discontinuous air barriers and insulation; and installing leaky ducts, leaky duct insulation, or leaky duct vapor barriers. We made the most important choices in getting the ductwork right; sizing the HVAC system correctly by using load calculations to select equipment; making sure the system had the right air flow and refrigerant charge; getting the right air flow to each room, upgrading the filtration; and sealing the crawlspace. Because of these choices, our house is living up to its full potential.



BRUCE DAVIS

The simple, energy-efficient design and low-cost features of our home, plus a state-of-the-art ventilation system, means we have the cleanest air possible while keeping energy costs low.

We love our new home. It's the most comfortable house we've ever lived in or visited. Even though it is fairly ordinary, it has no drafts, excessive humidity, high energy bills, odors, noises, or hot and cold spots. Instead, what we have is an energy-efficient and extremely comfortable home.

My daughter feels her home is a haven to retreat into when her allergies to everything in the outside world are causing her problems. This means that her stress levels are lower, and because she is less exposed to allergens, her sensitivity levels are a bit lower as well. She says the only bad thing about the house being so tight is that she can't hear the rain on the roof.

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