

Creating Airtight and Healthy Homes



With the ill effects of poor indoor air quality often in the news these days, it pays to design and build a house that's healthy from the start.

by Bruce M. Small

After many years of trial and error, a comprehensive approach to residential design has emerged that makes both energy conservation and good indoor air quality (IAQ) achievable in homes. Innovative building scientists have figured out how to combine all the best energy conservation features with the best health features, without substantially increasing the capital costs of the house.

At the Envirodesic Certification program, we are developing stringent health requirements for building materials and pioneering the design of healthier indoor environments. In so doing, we have identified and confirmed, through testing and experience, building designs and products that contribute to optimal IAQ for healthy homes. (For a

compact listing of the most important design and construction details, see "Design and Construction for Healthy Homes.")

Some of the worst offenders, when it comes to poor IAQ are water intrusion, air leaks, poorly designed or installed heating and cooling systems, troublesome architectural design features, the use of high-emission building materials, and the improper handling of materials on the building site (see Figure 1).

Water Intrusion

The more attention the builder pays to preventing rain from leaking into the building, the better the indoor environment will be years from now. Just waterproofing the basement wall is not enough. Houses with an extra basement wrap (which

channels rainwater directly to the footing drainage pipes) have less chance of flooding after a heavy rainfall. However, the best insurance for all homes is to pay attention to the gutters and grading around the entire building, to ensure that all rainfall moves away from the building, rather than toward it.

Many homeowners I have met who were experiencing health problems experienced their worst symptoms in the basement, where rain leakage had moistened the walls or floors and allowed mold growth in the drywall or carpet. In most cases the damaged material had to be removed completely and the source of the water leak pinpointed and fixed before the problem was solved. Usually the most effective way to stop leaks is to fix all the gutters, improve the grading around the

1. Gutters
2. Grading

Air Leakage Culprits

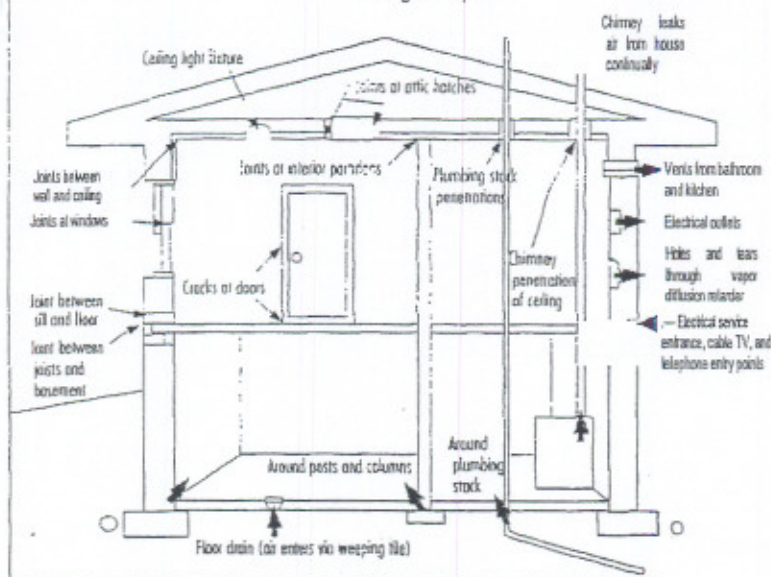


Figure 1. Air leakage happens in numerous trouble spots throughout a home.

house, and seal cracks between walkways and the basement walls. Some basements may also require patching with an acrylic cement compound from the inside, or a complete resealing with waterproofing compound, basement wrap, and new drainage tile from the outside, which is very effective but also very expensive.

A homeowner who was sensitive to the smell of the damp and mildewed basement that was circulating throughout her house is a good example of the problems associated with water intrusion. She separated the basement from the main floor by sealing all holes, cracks, and pipe chases and closing off supply and return air vents in the basement. This gave her clean air upstairs while she tackled the problem of removing moldy material and sources of moisture in the basement.

Most of the problem in the basement was caused by water leaking at the base of the foundation in one corner of the building during rainstorms. She cut out the moistened and moldy drywall and insulation in that corner, and cleaned the block wall behind it with

chlorine bleach. By observing the exposed wall during a rain and inspecting the outside of the house, she determined that the water source was a faulty gutter and drainpipe. She replaced these, checked to make sure that the inside wall no longer leaked when it rained, and then rebuilt the interior wall.

Air Leaks

Envirodesic frequently encounters building air leakage problems during health inspections. One woman in a Toronto, Canada, bungalow began to feel ill when her neighbor installed a high-efficiency furnace. The cold exhaust was entering the walkway between the two houses and filtering through the woman's leaky walls, making her sick. When the exhaust pipe was

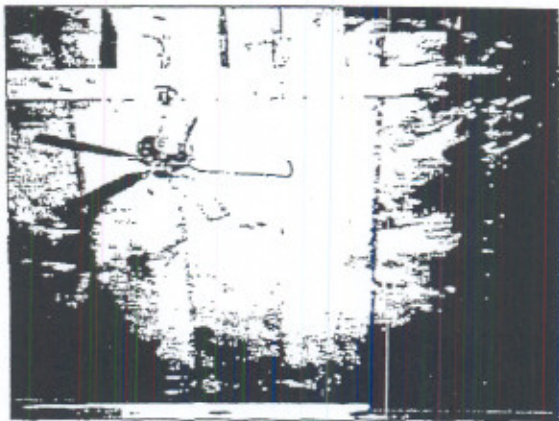
extended upward away from the leaky wall, the problem was solved.

Another family was forced to move because a ground spill from an old chlorinator reacted with soil moisture, and the resulting gas entered their home through cracks and holes in the basement walls. Complete sealing of the cracks and negative ventilation of the soil gasses solved the problem.

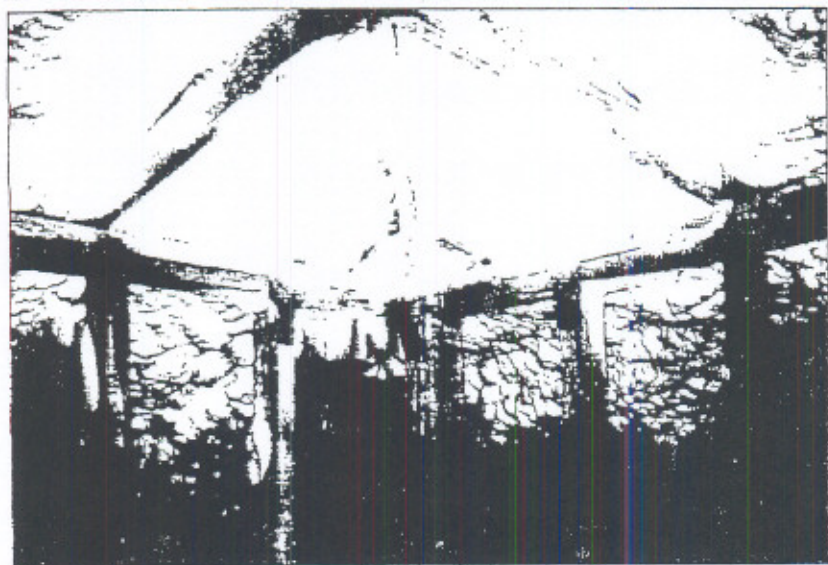
Allergic people also know that in a leaky home, it is impossible to escape from airborne pollens, even if you install niters or air conditioning. In an airtight and well-ventilated home, you can avoid breathing pollens during those critical morning hours when pollen levels are highest outdoors. You can also regulate air intake when the smog index is high, when traffic is heaviest, and even when a skunk walks by.

In our search for IAQ solutions, we have found that using spray-in insulation works for both insulating and air sealing, without adding any emissions of its own. Called polyisocyanurate, this spray-in insulation expands into flexible foam that moves with the building as it expands and contracts. Its emissions are so low that it is now being specified for even the most allergic families.

An added bonus to using air barrier insulation is that occupants can more easily afford to install and use proper ventilation in a home that



Black mold can be a problem in homes lacking an air barrier. Here, black mold grows in three-year-old insulation installed in a cathedral style ceiling.



The corners of rooms, including floors and ceilings, are typically spots for energy to escape. Because it is highly adhesive, spray-in foam insulation works well in corners such as these.

costs less to heat or cool. Another bonus is that HVAC equipment can be downsized, saving more money and better controlling thermal comfort and humidity. The benefit to the builder is that air barrier insulation is easy and quick to install, and unlike labor-intensive wrapping and taping methods, it is effective and nearly foolproof.

Heating and Cooling Systems

During most building inspections for allergic families, I check the furnace carefully to determine whether it is leaking oil, natural gas, or combustion products. Old-style gas furnaces often leak natural gas as well as combustion gasses while the unit is starting up and before a full draft is established in the flue pipe. Oil tanks are notorious for leakage, and the oil often penetrates into cement basement floors.

Envirodesic encountered one family that had to move out of its home, because aldehyde gasses from their badly tuned gas furnace were re-entering their home through the clothes dryer exhaust. After an inspection, we realized that so much lint had accumulated in the dryer outlet that the flap was being held

permanently open. Positioning of the furnace outlet farther away from the dryer inlet could have helped to prevent this disaster, since random wind changes can cause sufficient back

pressure to generate the blowback—hence the need for a dryer cover in the first place.

Positively pressurizing the house sufficiently would also have solved this particular problem, but it would have caused other problems, such as more mold buildup in the outside walls and attic. Fixing the furnace and changing the position of the vents was easier and more effective, and had no such drawbacks.

Modern mid- and high-efficiency furnaces have eliminated many of the problems associated with older heating systems, although installers must adhere to strict standards to avoid mistakes. Dedicated air intakes must be installed on all furnaces and fireplace units, for example, to prevent chimney backdrafting, which plagued houses during the early years of house tightening. For sensitive families, sealed gas boilers that allow heating with a hot water coil have proven to be among the safest of options, since there is no chance of gas or combustion products entering the airstream.

Design and Construction for Healthy Homes

Here is a compact list of the design and construction details that architects and builders ought to know by heart.

- Superb rain-shedding properties including the detailing of roof and wall sealing, adequate drainage of rainwater, appropriate grading away from basement walls, effective foundation waterproofing, and protection from seasonal flooding;
- Airtightness and proper building envelope design to prevent moisture transport and condensation within walls, ceilings, and attics and the attendant growth of mold;
- Proper selection, sizing, venting and installation of HVAC equipment for maximum efficiency and safety, minimum pollution, and adequate humidity control;
- Interior building layouts that isolate polluting activities from living and sleeping spaces, prevent garage odors from entering the home, pro-

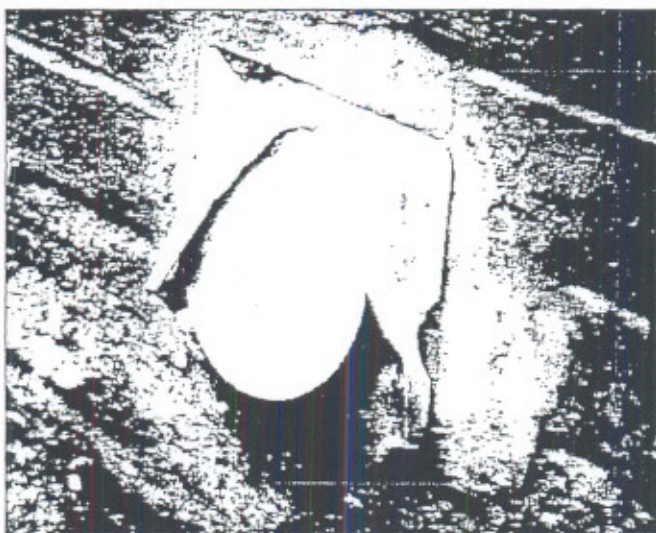
vide adequate storage to prevent clutter, and take into account the ways in which the occupants will use the home;

- Good natural and mechanical ventilation with appropriate positive or negative pressures where needed, with energy recovery and directed fresh air delivery;
- Careful selection of structural, insulation, and interior finishing materials to prevent long-term emission of gaseous or particulate pollutants into the living space;
- Use of filtration that is appropriate to protect both HVAC equipment and the occupants, depending on the occupants' health needs; and
- Proper precautions on the building site to prevent indoor pollution from gasoline or oil spills, solvents, construction dust, tobacco smoke, water damage, and other sources of indoor gasses, particles, or mold growth.

We have also encountered problems on the cooling side. One man allowed his air conditioner drain to plug up with lint that had not been caught by his furnace filter. When the water spilled into the furnace and onto the basement floor, mold grew aggressively and spores were distributed throughout the house whenever the fan kicked in. Another woman was so sensitive to mildew growth that she had to replace her air-conditioning coil every two years. If the coils are made more accessible for periodic cleaning, problems of this kind could be avoided.

In hot-humid climates, we always inspect the design of the ductwork, especially if it runs through an uninsulated attic. Humid air blowing into ventilated attics can condense on uninsulated cold ducts, causing mold and rust. This can easily be fixed by covering the ductwork with an air sealing insulation, such as spray-on polyurethane, that will block air from reaching the ductwork (no more than R-9 is required), or by insulating under the roof deck and including the whole attic in the conditioned space.

It is always important to use filtration on an HVAC system to protect the ductwork, heat exchanger, and air conditioning coils from dust buildup. Whether additional filtration is needed depends on the specific health requirements of the occupants. Most of the time it makes sense to first reduce the source of the problem and use proper ventilation and then use filtration only for any residual pollution that cannot be removed (see "Clean Breathing in Production Homes," *HE* May/June '01, p. 29).



A faulty dryer vent was held open by lint accumulation, allowing furnace fumes to enter the home. A high-efficiency furnace exhaust pipe should be at least 6 ft away from the dryer vent.

For highly allergic individuals, it may make sense to zone the home and create local areas that are highly filtered, for example, to exclude outdoor allergens, pet dander, or cooking odors. The more air sealed the building is, the easier it is to separate filtered areas from unfiltered areas.

Architectural Design Features

Attached garages are notorious sources of CO and other dangerous gasses that infiltrate the living space. I inspected a home where gasoline odors from the garage reached the second-floor bedrooms. The homeowners were using the open garage as a convenient way to ventilate the house during the summer. Once they developed the habit of keeping the weatherproof door to the garage closed—and used the windows for ventilation instead—the problem vanished.

In another home, the renter of a unit above a large garage became ill because solvent fumes and exhaust gasses were entering her unit from repair activity below. The owner tried to seal the cracks between the two spaces, but the leakage persisted. The renter ultimately moved to a healthier place.

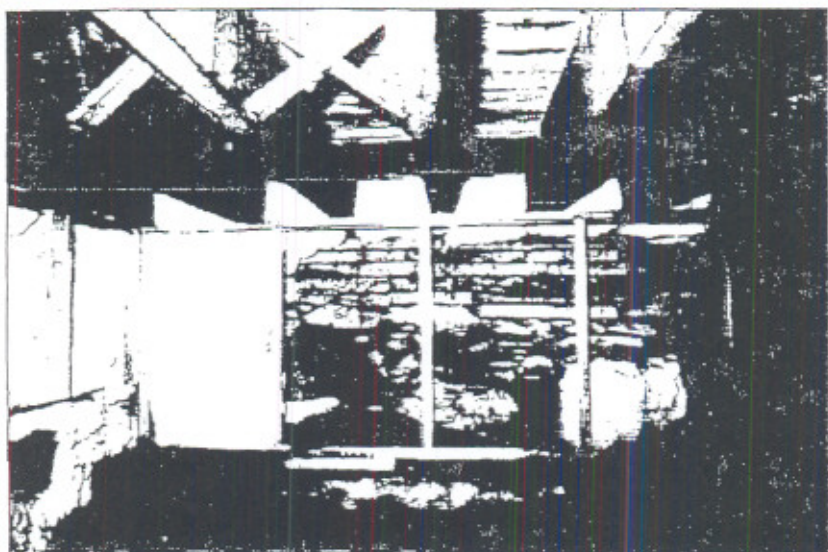
If you are designing a new home, consider building a separate garage with a covered walkway to the house, or a ventilated vestibule between the attached garage and the rest of the house. Functioning airlocks help to prevent toxic gasses from filtering in from the attached garage and compromising IAQ. Sealing with spray-in foam insulation helps to prevent infiltration of CO from garages.

Many indoor air problems can be prevented by the design of home layout and venting systems that separate the garage, workshop, hobby, and home office activities, or even the entire basement, from the living spaces.

An extremely valuable health feature in any home layout is the storage cupboard. Every home needs enough storage to adequately separate the occupants from many of the hundreds of items they accumulate in a lifetime. Not only is it difficult to dust and clean a home when there is too much clutter, but each box, toy, or magazine can add odors to the indoor air if it is left out in a room for a long time.

Where you put the storage is also important. If you put a linen closet in the bathroom, the stored sheets may smell of mildew; so may the clothes in a walk-in closet directly connected to the shower room. Chemical and volatile items should be stored in the garage or in a special shed at some distance from the home.

Of course, the more pollutants that are produced in the home, the more difficult it is to make that home healthy by ventilation. It always makes sense to reduce the pollutants coming from paint, flooring, carpeting, or structural materials. For example, if exterior walls are full of formaldehyde-emitting materials, and there is even a small uncontrollable air flow through the wall, the indoor space will be polluted.



Here, spray-in foam insulation is installed in a crawlspace—typically a damp and troublesome area.

Choosing low-odor structural materials is therefore important, though it is less critical if the walls are properly air sealed.

There have been many news stories about healthy people becoming ill after breathing strong fumes from latex-backed carpeting or from other hazardous materials like strong-smelling glues or caulk. As a result, carpets are ripped out and many allergic homeowners turn to more traditional surfaces like hardwood or tile in an attempt to restore or maintain their good health. Selecting better materials in advance can prevent these problems.

The Building Site

Good rules of conduct on the building site will help to prevent indoor pollution from gasoline or oil spills, solvents, construction dust, tobacco smoke, water damage and so forth. If the HVAC ducts aren't sealed off during the drywall process, fine dust particles will circulate through the house for months and aggravate allergies and asthma. If the builder doesn't properly protect the building from rain before drywalling, water can cause mold damage and the affected pan-

els must be removed. On one site, I saw a builder try to paint over moldy drywall, but as *Home Energy* readers know, mold just keeps reappearing no matter how many coats are added.

One allergic woman I know could no longer visit the site of her dream home because the contractor had spilled gasoline from a cement finishing machine on the soil near the building. He removed the affected soil, and the situation improved. If this had happened on the floor slab, the mistake could have been more costly. Homeowners who are tobacco sensitive can also specify a no smoking site, particularly once the building is closed in and the drywalling has started.

More Simple Design Changes

Other simple design changes will lead to better LAQ. Here are some important ones.

Exhaust Ventilation. Small exhaust fans, such as a bathroom fan or a continuous muffin fan (the kind computers use to keep cool), installed in a walk-in closet can minimize the amount of dry cleaning chemicals the body absorbs. Some individuals wake up with headaches or stuffy noses when

freshly dry cleaned clothes are hung in the bedroom.

Edge-Wrap Laminate. Installing laminate all the way around kitchen cupboard shelves can drastically reduce emissions from particleboard shelving. Otherwise, each time homeowners open a cupboard they breathe in a lungful of formaldehyde. This is still a problem with the low-formaldehyde materials available now, particularly for hypersensitive homeowners. Likewise, opting for mirror doors that do not have fiberboard backing can reduce formaldehyde and other odors in bedrooms.

Central Vacuum System. Think about a central vacuum system in your portfolio of new-home options. With portable vacuums, dust and ozone escape into the air. Central vacuums exhaust all the panicles and motor odors, so there is nothing left to bother the homeowner. This feature is a must for families with asthmatic children.

Everyone Benefits

Building tight, shedding rain, avoiding pollutants, and using common sense in architectural, mechanical, and interior design—all these goals can now easily be achieved in every new home or renovation. These new approaches and new products will enable every architect and builder to advertise healthier and more efficient homes.

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