Built Wrong from the Start

Top 10 blunders that rot your house, waste your money, and make you sick

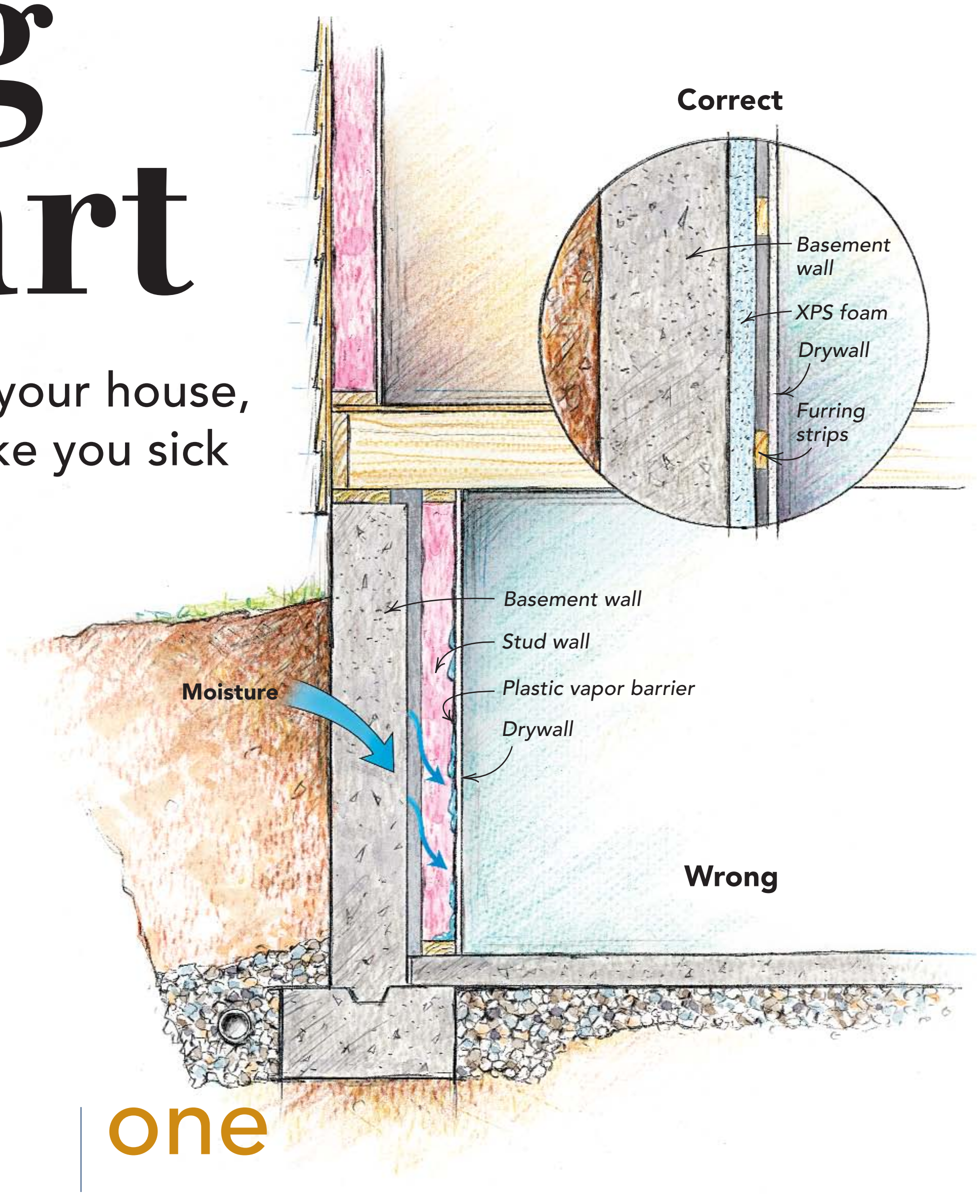
BY JOSEPH LSTIBUREK

I've been a building scientist for more than 20 years. Before that, I was a builder. Even though I followed standard building methods, some of my houses were turning into drafty wrecks that were rotting on their foundations. What went wrong?

In 1983, I went back to college to get my Ph.D. in building science, the study of how buildings work and why they fail. Houses are more complex than they used to be. They have more insulation, they have elaborate heating and cooling systems, and they are built to be nearly airtight. These components can make comfortable, energy-efficient houses that serve their owners well. But if they're put together wrong, a house and its occupants can be in for some serious problems.

I've turned the basis of the mistakes I made as a builder into one of the lectures that I give at building conferences across North America. While I deliver these seminars in a somewhat lighthearted manner (sometimes to standing-room-only crowds), I can assure you that these blunders are not funny. □

Joseph Lstiburek, P.E., lives in Westford, Mass., and works just about anywhere. His Web site is www.buildingscience.com.



one

VAPOR BARRIERS ON BASEMENT INSULATION WILL ROT YOUR WALLS

We expect a house's walls to get wet during construction, either from the weather or from the materials (that's why joint compound is called *mud*). But they also can get wet once the house is finished and occupied. Wet walls need to dry.

There are two types of wall that can get wet: regular walls above the ground and basement walls below the ground.

Additionally, there are two sides to a wall: an inside and an outside. It's smart to design walls to dry to both sides, but drying to at

Drawings: Don Mannes

least one side is a pretty important objective. A vapor barrier on the inside of a wall means that the wall can dry only to the outside. This is OK for regular walls in cold climates (like Canada, where there are only two seasons: last winter and this winter), but it's not OK for basement walls, not in any climate. Basement walls can't dry into the ground because—you guessed it—the ground is wet. Because basement walls can dry only to the inside, wrapping the inside of a finished basement wall with a sheet of plastic is a bad idea. Wet basement walls wrapped in plastic can't dry. We must build walls so that they can dry during wet seasons (drawing facing page). By using extruded polystyrene (XPS) foam for insulation, you can eliminate the inside condensing surface and prevent water intrusion from the outside, too (see *FHB* #160, pp. 50-55).

two

VENTED CRAWLSPACES ARE MOIST ENOUGH TO GROW MUSHROOMS

In the old days, we didn't insulate crawlspace floors, and we didn't air-condition houses. Crawlspaces (especially the floor framing) were warmed by the houses themselves. Now that we insulate floors, crawlspaces are within a degree or two of ground temperature. During most of the summer, this temperature is below the dew point of the outside air, even up north.

Ventilating a crawlspace allows moist outside air to condense on cool crawlspace surfaces. Consequently, the ventilation air is wetting the crawlspace rather than drying it. It's like opening a basement window in July: The walls sweat. And wet walls become moldy walls quickly.

The whole point of venting a crawlspace is to remove moisture. If we could import hot, dry air from Tucson to vent moist crawlspaces in Tupelo, venting crawlspaces would be a great idea. But for Tupelo air to vent Tupelo crawlspaces, the air needs to be dry enough to pick up moisture, and it needs energy (heat) to evaporate the moisture. This isn't going to happen, and here's why: Tupelo air isn't hot and dry. Neither is Toledo air, Tallahassee air, nor Toronto air.

A crawlspace is just a mini-basement and should be treated as such. It's like a basement for a troll. You should condition the air in your mini-basement. Make it part of the house because, despite what you may think, it already is. Heat it in the winter and cool it in the summer with a supply duct or grille (but ask your fire inspector about this). Don't insulate the floor; insulate the perimeter and install a continuous ground cover to keep out moisture (see *FHB* #153, pp. 94-99).

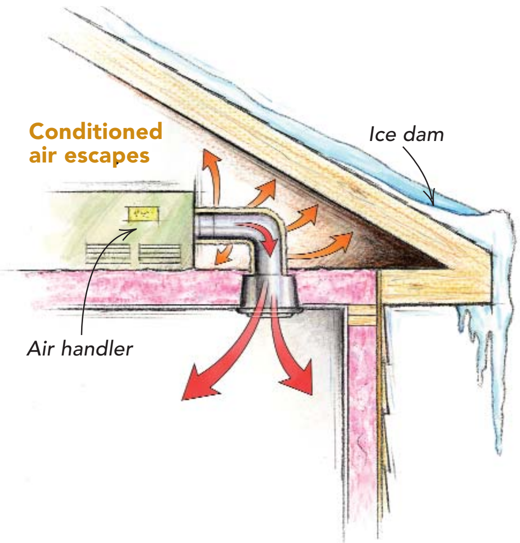
Photo this page: Harold Shapiro

three

DUCTS AND AIR HANDLERS IN ATTICS WASTE MONEY AND SUCK IN BAD STUFF

Why put the heating and cooling system outside the space that it needs to heat and cool? We insulate walls to R-19 and ceilings to R-50, yet we slip an R-4 sleeve over ducts and call it good. Where were the adults when this decision was made?

What's more, ducts leak. Let me rephrase that. Ducts leak a lot—about



15%. It's like installing a large exhaust fan in the attic to suck conditioned air out of the house and pull unconditioned air in through the cracks. If radon were a valuable commodity, we could mine it this way.

And think about winter. Heating bills go through the roof, and escaping air heats the attic, melting snow and forming ice dams. Goodbye, heated air; hello, water damage.

You can't make ducts and air handlers tight enough so that they won't leak (don't even think about duct tape). The least you can do is put them in a conditioned zone such as the basement or a conditioned crawlspace, or you can move the attic insulation up to the roof.

Sheet metal/stud duct

four

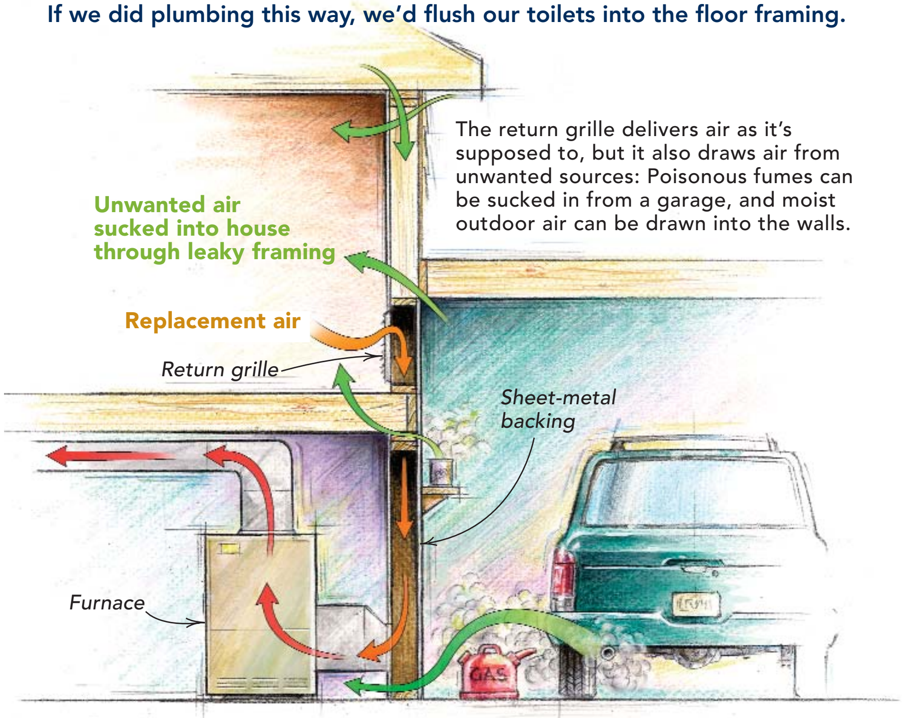
USING JOISTS OR STUDS FOR DUCTWORK ROTS FRAMING

A panned stud or joist cavity is an air return that uses framing members, sheet metal, and drywall as ductwork (photo above). Why is this bad? Because the air is pulled through a leaky framing cavity instead of a duct, contaminants come along with it. The result is that air will be sucked from any leak available to equalize the pressure (drawing below). In a humid climate, the house will suck wet air into the wall cavities. If the house has a vapor barrier inside the face of the drywall, the water will stay inside the wall (air will make it through the cracks). Wall cavities are a bad place to store water.

If the stud-bay or joist-bay return is in the garage, pollutants such as carbon monoxide or vapors from gasoline or solvents can be sucked into the living space. If the air return is in a furnace room, combustion gases can be sucked out of the flue (backdrafting).

Here's the test: Turn on the HVAC unit and spend a romantic candlelit evening with your significant other. Burn those cloying perfumed candles; the fine soot particles in the candles act wonderfully as tracers for airflow. Next day, look for stains on the carpet at the baseboards near a stud-cavity air return. Air is being sucked into the wall under the baseboard, filtered by the carpet, and marked by the soot.

If we did plumbing this way, we'd flush our toilets into the floor framing.



The return grille delivers air as it's supposed to, but it also draws air from unwanted sources: Poisonous fumes can be sucked in from a garage, and moist outdoor air can be drawn into the walls.

Photo this page: Joseph Lstiburek

five

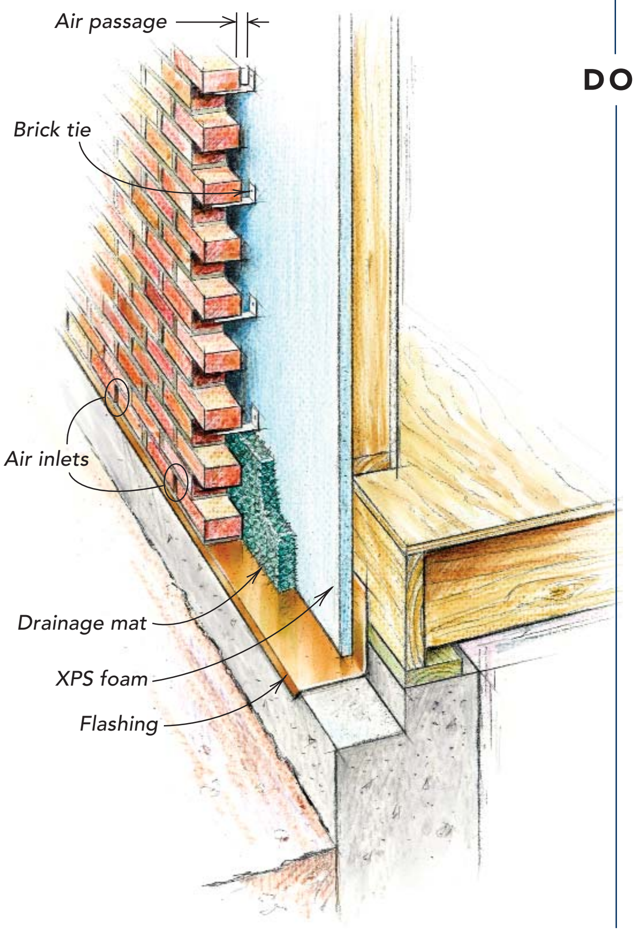
WINDOWS AND DOORS WITHOUT PAN FLASHING CREATE A WATER-INJECTION SYSTEM

There are only two kinds of windows in the world: windows that leak now and windows that will leak later. The only things that leak more than windows are doors. And the more expensive the door, the more it leaks—especially big French doors with sidelites. And sliding doors. I know, I know, I can hear the salesman already: "My windows don't leak. They were tested at the factory." Right, they didn't leak at the factory. But they will leak after they're in a house. If not today, then tomorrow.

Windows are like people; their characteristics change as they age. As windows and people get old, they leak. I don't leak now, but I will someday. Windows and doors need a dependable backup system: a gutter. These gutters are known as pan flashing, that thing with a back dam, end dams, and a slope toward the outside. They're simple to install; many come in two pieces that slide together (Jamsill; 800-526-7455). Just don't put a hole in it because a dab of silicone won't seal the hole. Silicone is like people: When it gets old …

six

DON'T LET BRICK WICK WATER INTO WALLS



I hate brick. No, I don't—I love brick. I hate bricklayers. No, I hate lazy bricklayers who don't ventilate cavities and clean up mortar droppings.

Let me rephrase that. The old way of installing brick worked. There was a 1-in. cavity behind the brick with air inlets at the bottom, outlets at the top, and a clear pathway connecting the two. Why is this important? Because brick essentially is a dense sponge. When it rains, brick gets wet.

Now, let's pause for a minute to review the second law of thermodynamics: Water moves from hot to cold and from wet to dry.

OK, back to the brick. What happens when brick is rained on? Brick gets wet, and we know that water moves from wet to dry (inward toward the dry part of the brick). Now what happens when the sun comes out? Yup, water moves from hot to cool (inward toward the cool part of the brick). If the cavity behind the brick is vented properly, the ventilation air intercepts the flow of moisture and carries it out the top of the wall. No problem.

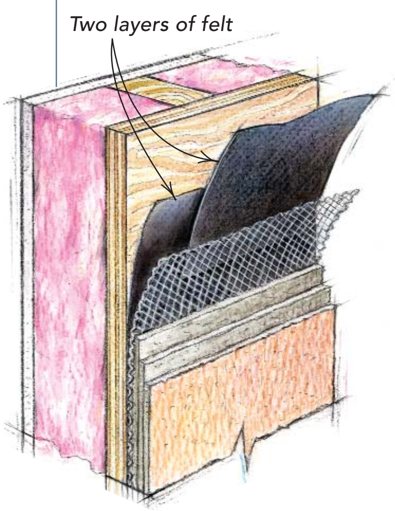
If the cavity is vented improperly, however, water vapor is driven inward, toward the cool, dry house, and through the vapor-permeable exterior housewrap and plywood sheathing; it then condenses on the interior plastic vapor barrier. Here, the water sits and waits for mold to drink it. If the vapor barrier is leaky or if there isn't one, the mold eats the drywall instead.

If you're going to install brick, make sure there's a clear cavity vented at the top and bottom. If you can't use brick responsibly, don't use brick.

Photos this page: Jamsill Inc.

seven

STUCCO NEEDS TO DRAIN



Stucco is a simple product. A few thin coats of reinforced mud provide a strong, good-looking protective layer for a house. The entire key to successful stucco is drainage: There must be a drainage space between the stucco and the tar paper that the stucco is installed over. This used to be easy because in the old days, tar paper was more robust than it is now: It weighed more, was thicker, and had higher rag and cellulose content. The first coat of stucco would swell the tar paper. After the stucco and tar paper dried, the tar paper shrunk back and debonded from the back of the stucco. The resulting wrinkles formed a drainage space. Today's tar papers and housewraps don't debond because they don't swell enough. Because they don't debond, they don't drain, and worse, they lose their water repellency over time.

To apply stucco successfully with contemporary tar paper, use two layers of tar paper. The first will act as a bond break, and the second will act as a drainage plane between the two layers.

eight

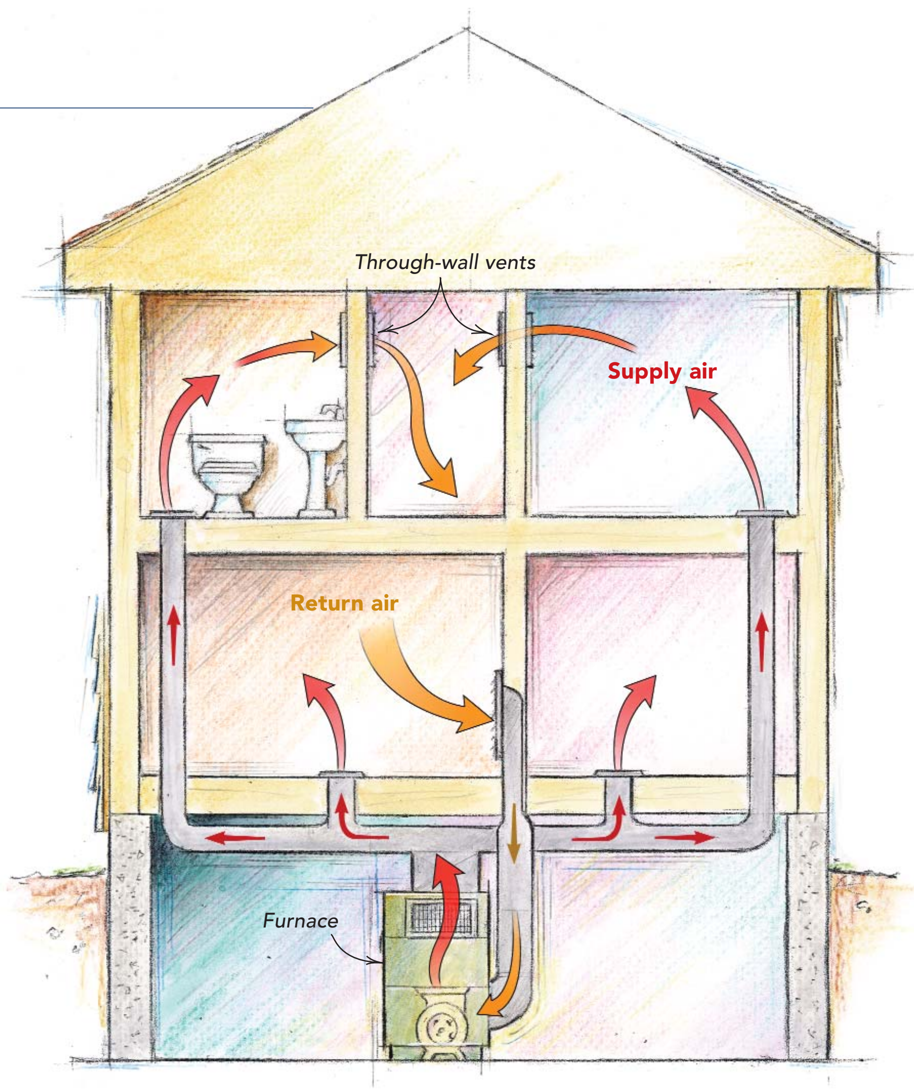
WITHOUT THE RIGHT PATHWAY, CONDITIONED AIR GOES TO ALL THE WRONG PLACES

Let's see. We duct conditioned air (supply air) to a bedroom on the second floor and place the return-air grille in some other room on the first floor. So how does air get back to the return when the bedroom door is closed? It's sucked under the door. According to my calculations, for this to occur efficiently, the gap at the bottom of the door should be roughly 1 ft. to prevent pressurization of the bedroom.

Why is pressurization bad? Because uncontrolled air changes are bad. If your bedroom is pressurized, conditioned (paid-for) air is being pushed through the walls and ceiling. If the pressurized air is moist, water is being pushed into the walls. Remember, wall cavities are a dumb place to store water.

Because a knee-high gap at the bottom of the door is unlikely to sell houses, we (repeat after me) ignore the problem. Air rushes under the door, is filtered by the carpet, and creates racing stripes at every door opening. Again, those romantically sooty candles enhance this effect.

The retrofit solution at my house was through-wall vents.



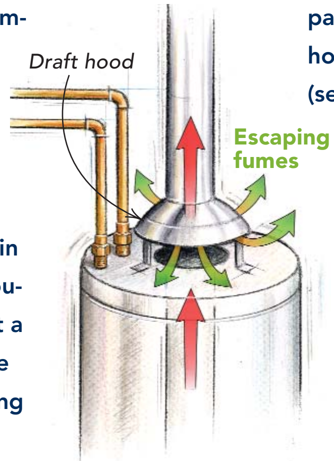
nine

AERODYNAMICALLY COUPLED GAS APPLIANCES CAN'T EXPEL ALL TOXIC GASES

More than 10,000 people visit emergency rooms each year with carbon-monoxide poisoning, and more than 500 people die from it annually. A little more than half of these cases are the result of automobile-exhaust inhalation; the rest are caused by consumer products. About 100 people die yearly because of malfunctioning gas furnaces and water heaters.

We've come a long way since the caveman days, but when it comes to managing combustion by-products, we haven't advanced much. Back then, we'd put a hole in our cave, light a fire, and hope the smoke would leave.

We've advanced from a hole in the cave to aerodynamically coupled gas appliances. We've put a pipe over the fire and stuck the pipe through a hole in the ceiling to vent smoke.

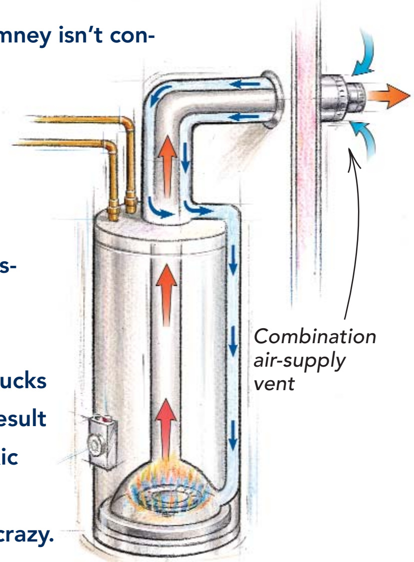


Typical water heater

In typical gas water heaters, the chimney isn't connected to the top of the water heater; there's a gap. Building scientists call this gap a bad idea. Everyone else calls it a draft hood.

Except in Germany, where things always are ordered and precise, combustion by-products don't follow arrows past the draft hood, especially if your house, range hood, or clothes dryer sucks (see No. 4). If your house sucks, the result is called backdrafting, sucking toxic gases into your breathing air.

Installing appliances this way is crazy. You should use only sealed combustion water heaters and furnaces, which are vented directly to the outside. And by the way, they should have a dedicated supply of combustion air piped directly to the flame (drawing above right), also with no holes in the pipe.



Direct-vent water heater

ten

THE MOST DANGEROUS THING TO DO TO YOUR HOUSE

UNVENTED GAS SPACE HEATERS AND FIREPLACES PRODUCE COMBUSTION EXHAUST THAT DOESN'T BELONG INSIDE

You'd never run your car in an enclosed space, would you? So why would you run a gas heater or fireplace in one? I'm not talking about portable space heaters, which everybody knows are dangerous in enclosed areas; I'm talking about actually installing an unvented gas heater or fireplace permanently. Sure, they're inexpensive, but the potential price tag is very high. At Building Science Corporation, we call this the Kevorkian option.

Let me explain: There's really no such thing as an unvented gas space heater or fireplace. The combustion by-products, quite simply, are vented into the room, then into your lungs and shuttled to your brain. This is bad.

When installed, maintained, and operated according to the fine print on their warning labels, gas space heaters and fireplaces have a pretty good safety record. But the potential for mistakes is too great.

A window should be open when these heaters or fireplaces are on, but if it's cold out, many people won't open a window. Unvented gas heaters and fireplaces can't be the primary heat source, but if their thermostat is set at the wrong level, they become the primary heat source. What's more, the room size necessary for a 30,000-Btu unit is unfathomably large. Why in the world would you want to increase your risk of carbon-monoxide poisoning?

Let's revisit my cave analogy: We've got a fire in the cave and a hole in the ceiling for ventilation. Using an unvented gas appliance is like plugging the hole in the ceiling. By this time, we should have figured out that it makes sense to locate the fire outside the cave.

One more thing: Unvented gas space heaters and fireplaces are illegal in five states. Sealed-combustion appliances, good. Unvented combustion appliances, bad. Period.