

Spring, 2017: Air Matters
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We know that air flows outdoors, because we can feel the wind on our faces, and we hear leaves flutter in a breeze. Air also moves indoors: up if warmer, and down if cooler; and from higher pressure to lower pressure. That's why you can smell bacon cooking when you are in another room or even another floor in your home.

Air is relentless in its movements, so walls and ceilings do not prevent the movement of all air flow if they have gaps or small openings, or larger openings for fixtures.



A smoke pencil confirms warm air flow into a crawl space at the top of the basement-access window.
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Cooled air flows out of the crawl space at the bottom
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Warm basement air flows into a moldy crawl space and cooled air flows out of a crawl space due to convection. If there is mold growth in the crawl space, air can carry the spores into adjacent spaces such as a basement, and then the spores will be carried on airflows up into habitable rooms above.

Air flow can carry particles (like mold, dust mites, pollen, pet dander, bacteria), as well as gases and vapors (including carbon monoxide and solvents), so air flows matter when considering indoor air quality concerns.

Defining Terms

I was educated as an organic chemist, and my scientific training is an important underpinning of my work as an indoor air quality consultant. As a scientist and indoor air quality professional, I know how important it is to define terms. Bear with me, then, as I take a moment to discuss some scientific terms and principles that are relevant to indoor air quality.

Matter has three common states: solid, liquid and gas. In everyday language, the words “gas” and “vapor” are often interchangeable. To a scientist, though, they mean different things.

A gas is matter in a gaseous state that originates from a liquid that boils below room temperature. For example, nitrogen is a liquid that boils at a temperature of -320.4°F , so at room temperature, nitrogen is a gas. Hospitals and scientists use liquid nitrogen and liquid oxygen, and occasionally you may see tankers on a highway containing these very cold liquids.

I am fearful when I see such a tanker and always drive past it quickly, because if a tanker containing nitrogen crashes, anything that the cold liquid nitrogen touches will be instantly frozen. (Remember the evil mercury-filled cyborg in Swartzenager's Terminator who is frozen solid by liquid nitrogen from a tanker?)

A vapor is matter in a gaseous state that originates from a substance that is a liquid at room temperature. Water is a liquid at room temperature, and it becomes a vapor when it evaporates at room temperature or boils at 212°F .

Temperature and energy-content changes transform H₂O from one state to another.

Liquid water can be frozen into ice, or turned into vapor through evaporation or boiling. Water vapor can be turned back into a liquid through condensation. That said, an ice cube, water in a glass, and water vapor in the air are all made up of identical molecules of H₂O (two hydrogen atoms and one oxygen atom). The main differences between the three states of matter is the varying distances between the molecules and their freedom to move about in space.



Ice damming: Liquid to Solid. The large icicle destroyed the deck when it fell.

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Condensation of moisture on a cool crawl-space foundation wall: vapor to liquid. Mold is growing on the flexible duct due to high relative humidity.

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Vapor condensing to liquid to create cloud droplets. Note clear zone of vapor at stack top.

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The cars' shadows blocked early-morning sunlight and slowed down the snow melting.

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In the end, a gas and a vapor are both molecules in a gaseous state – so in this article, I will use the terms interchangeably.

Inhaling Contaminants

Most healthy adults inhale 12 to 20 breaths per minute. Think of all the molecules of gas and vapors in the air that enter your body every time you inhale. Some of those gases and vapors can be irritating or even deleterious to your health.

If you are sensitive to solvents, you know what I mean. Ever walk through a room that has been freshly painted? Or a room where the floors have just been sanded and refinished? Ever sat near someone who is refinishing her nails? In each of these cases, solvents are evaporating into the air and entering our lungs with every breath.

How about fragrances, which are also airborne vapors? Do you enjoy fragrances in perfumes and cleaning products? Or find them irritating? These are vapors that people inhale on a nearly daily basis.

People who live in a residential building constructed over a parking garage can inhale car-exhaust fumes. Some people who live in multi-unit buildings or a densely populated neighborhood complain about cooking odors from a nearby kitchen – odors that they find annoying.

I don't recommend that people burn scented candles, especially those in jars. Scents are chemical vapor that enter the air we breathe indoors; in addition, jar candles produce soot particles, which not only stain ceilings and walls, but which are also unhealthy to inhale.



Soot stains above bathroom lights due to jar candles; such staining can also be due to soot from spillage of combustion products from an oil burner.

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Soot particles collide and stick to surfaces, especially where airflows are greater: over light fixtures, for example, and on exterior-facing walls and cold ceilings.

“Gas” Leaks

Sometimes a toilet seal is loose, or a trap in a sink or tub has dried out; then sewer gas can backdraft into a house.

I've worked with several clients who in each case had a gas stove in which a burner was not properly adjusted, so the flame produced excessive amounts of carbon monoxide (CO); in one case, occupants suffered mild symptoms of CO poisoning.

I was once hired to inspect a real estate office building because people were complaining about two things: a smell of “gas” in an unfinished basement used for storage of old files, and a sewer-gas odor in a below-grade office next door.

I found a small gas leak in the storage room, and a serious sewer-gas leak adjacent to the office. A vertical four-inch drain pipe inside a wall had been cut during a renovation and left open; the drain was no longer in use but was still connected to the sewer system, and the odor was entering the room through large openings at the top of a wall.

Gas – whether from a stove, toilet or sewer pipe – is one of the contaminants in indoor air that can make people feel sick.

Cigarette Smoke

Every month we receive a few calls from people who live in multifamily buildings and worry about exposure to cigarette smoke because a smoker lives in a unit either next door to or beneath theirs, and they can smell the smoke.

Cigarette smoke is a known carcinogen and contains the following dismal list of ingredients:

- Particulates – ash as well as aerosolized droplets containing nicotine and tars
- Gases – hydrogen cyanide, formaldehyde, carbon monoxide, carbon dioxide, and nitrogen dioxide
- Vapors – acrolein, acetone, and methyl ethyl ketone.

Not a pretty picture! Even cigarette manufacturers today recognize that smoking causes lung cancer and heart disease. And exposure to second-hand smoke can be irritating, can exacerbate asthma symptoms, and can even be carcinogenic.

Since smoking has increasingly been banned inside buildings, I often see people smoking right outside hospitals and school buildings, among others.

I recently saw a young woman standing outside an elementary school, probably waiting for her child to be released from school. She was carrying a baby in a carrier, and in her right hand was a lit cigarette. A sad image, don't you think?

I can't tell you how many times I've walked through clouds of smoke on my way into my doctor's office building. And just last week, my wife and I went to dinner at one of our favorite local restaurants; there were four people smoking right outside the front door. By the time we passed them and entered the restaurant, our clothes smelled of cigarette smoke.

In my opinion, people should not be allowed to smoke in any public building or near entrances to such buildings. I'd also like to see smoking banned inside and near entrances to multifamily residential buildings.

If a smoker lives in a townhouse or apartment that abuts other units, neighbors can be exposed to the cigarette smoke, because the smoke and odor are carried on hidden air currents within the building's structure: up through elevator shafts, through interconnected or "communicating" ceiling and wall cavities, and through spaces under doors.



Air flow through a floor crack carried smoke and soot across ceiling cavities from a fire in a distant condo unit
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I investigated a cigarette-smoke odor problem for a young couple who lived on the third floor of a triple decker. The building owner's mother, a smoker, moved into the second-floor apartment. She smoked in her living room at the front of the apartment, but the young couple smelled the smoke most strongly in their bedroom at the rear of their apartment above.

Relations between the couple above and the smoker below were getting ugly, but the smoker agreed to allow me in to do some testing. I found that the smoke from her living room flowed up into the "porous" recessed ceiling fixtures set into the living-room ceiling (the flow was accelerated by very hot air rising from a steam radiator).

The smoke then moved by convection through the ceiling cavities to the rear of the structure and out into the couple's bedroom through openings around the piping to the baseboard convectors. I suggested that replacing the recessed fixtures with newer, airtight cans or with track lighting might mitigate the problem.



Smoke pencil confirms airflow through a light fixture
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If you are a smoker and thinking about "vaping," don't be seduced by the idea that e-cigarettes aren't as dangerous to your health as tobacco cigarettes are. Glycidol (probably carcinogenic), formaldehyde and acetaldehyde (both possibly carcinogenic), and acrolein (an eye irritant) have been reported to be present in the vapor produced by e-cigarettes. Propylene oxide (irritating to the respiratory system and possibly carcinogenic) has been reported to be in the liquid heated to produce that vapor. (Environ.Sci.Technol.,DOI:10.1021/acs.est.6b01741; Chemical and Engineering News, August, 2016; <http://cen.acs.org/articles/94/web/2016/08/New-chemicals-add-concern-over.html>)

For more information on mitigating cigarette smoke in buildings, go to: <http://www.mayindoorair.com/client-newsletter/>

Some Steps to Indoor Air Health

If you live in a multi-unit building, what can be done to prevent cigarette smoke and cooking odors from flowing from other units into your private air space?

The first thing that you must do is seal cracks (such as those at floor/wall joints) with clear caulk; any openings around pipes and wires should be sealed with expanding foam or rope caulk. Leaky recessed lights should be replaced.

Another mitigating strategy might be to pressurize your apartment or townhouse, so that the air pressure is higher where you live than in adjacent units. Then air will flow out of rather than into your unit.

An HVAC (heating, ventilation and air conditioning) system may be adjustable to increase the pressure in your unit by bringing in some outdoor air (but only if your HVAC system is independent from other such systems in the building).

If you live in a single family home, you could consider installing an air-to-air heat exchanger, such as a heat recovery ventilator (HRV), which may help to dilute (with outdoor air) vapors and gases, and therefore odors.

All HRVs require quarterly maintenance, though, which doesn't always happen. In addition, most HRVs are equipped with inadequate filtration, so I always recommend tossing out the original filters and using supplemental in-line filtration (such as a Fantech FB-6 but with MERV-8 rather than MERV-12 filters) on both air intakes.



Neglected HRV with mold, rust and debris
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Whether you live in a multi-unit building or a free-standing home, you can open a window and operate a portable fan on supply in mild weather (which hopefully is headed our way!). If you have outdoor allergies, you can even purchase a fan with a filter.

If a room in your home has recently been repainted and/or the floors refinished, and you find the solvent odor irritating, you can open two windows in the room (preferably on opposite-facing walls). Put a box fan on "exhaust" in one window, and a box fan on "supply" in the other window. Add an oscillating

fan to the room to blow air at the newly refinished or painted surfaces to speed up off-gassing.

These steps aren't very practical in cold or very hot weather, though, when you want to heat or cool the rooms. It's always a good idea, therefore, to have remodeling work done during times of the year when you can air out the house.

You can also ask members of your family and people you invite into your home to stop wearing perfumes, to stop using fragranced laundry, cleaning or body products, to stop cooking recipes with strong spices, and to stop smoking inside or near entrance doors to the house.

If you live in a multi-unit building or next to another house, you can ask your neighbors to stop smoking outside near your home, to stop using their wood-burning fireplaces or stoves, and/or to stop barbecuing their steaks outside on a patio next to yours. But such requests are almost never granted, and to be frank, such requests are often met with incredulity or even hostility (so be diplomatic).

As an indoor air quality consultant, my goal is to identify the sources of indoor air quality problems in order to help my clients recognize practical solutions. But sometimes the only solution is to relocate, unfortunately, to a home which is more isolated from neighboring properties.

Refer to our book Jeff May's Healthy Home Tips for guidance on some general, practical steps you can take to have healthier indoor air quality.

