PDHonline Course C208 (3 PDH)

Indoor Air Quality - Home

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8.1 Indoor Air Quality

EPA has determined that the average U.S. citizen today spends 90% of his or her time indoors, and indoor air pollution levels can be up to 96 times greater than outdoor pollution levels. This makes indoor air quality, or IAQ, one of the greatest health concerns in this country. Poor air quality can have a significant impact on workers' health and productivity.

Opportunities

IAQ problems can be caused (or avoided) at virtually any stage in the design, construction, and operation of any facility. During *building design*, such issues as roof overhangs (to keep out rain), location of outside air inlet ports, glazing specifications (relative to potential condensation and mold growth), formaldehyde content of cabinetry, and entryway design to hold down tracked-in pollutants all can influence IAQ. During *construction*, such issues as wall system detailing to keep out wind-driven rain and practices to remove VOCs released from new building materials will affect IAQ. During *operation and maintenance*, such issues as the choice of cleaning agents, regulation of tobacco smoking, and maintenance of filters in air handlers affect IAQ.

Facility managers should not wait to address IAQ risks until problems arise. Become proactive in identifying and solving potential problems *before* they occur. Involve workers in the solution and take their complaints about IAQ seriously. Consider IAQ when renovating spaces, maintaining HVAC and other equipment, or contracting for janitorial services.

Technical Information

The three concepts below are often used to describe IAQ problems:

- **Sick building syndrome** (SBS) is a condition in which a significant number of building occupants (sometimes defined as at least 20%) display symptoms of illness for an extended period of time, and the source of these illnesses cannot be positively identified.
- **Building-related illness** (BRI) refers to symptoms of a diagnosable illness that can be attributed directly to a defined IAQ pollution source.
- **Multiple chemical sensitivity** (MCS) is a condition in which a person is sensitive to a number of chemicals, all at very low concentrations. This condition is not well understood but is often attributed to high levels of exposure to certain chemicals.

Other IAQ problems do not clearly fall into these three categories, however. Asthma and allergies (including allergic rhinitis—hay fever), for example, are very common and can be medically diagnosed, but there are many triggers, which vary widely from person to person; as a result, the source of particular triggers is not always easily identified.

IAQ SOURCES

Many factors can cause—or contribute to—IAQ problems. Sometimes it is a *combination* of different factors that causes problems—though any one of those factors, by itself, does not cause problems. Among these potential factors are the following:

Biological contaminants—including molds, bacteria, and dust mites—can result from roof leaks, water vapor entry from basements, inadequate drainage around buildings, leaking pipes, condensation from air-conditioning equipment, and the pests in a building (rodents, insects, etc.). Relative humidity that consistently exceeds 50% should be avoided. Bioaerosols emitted from certain organisms are recognized as a very significant problem. Some molds are particularly toxic, such as *Stachybotrys atra*, which has been implicated in infant deaths in Ohio.

Volatile organic compounds, or VOCs, can cause IAQ problems, particularly in new (or newly remodeled) buildings. Common sources of VOCs are paints, carpeting (especially carpet backings and adhesives), furnishings, and chemicals (such as solvents and cleaning agents).

Combustion by-products can create hazardous conditions if allowed to enter or accumulate in a building. Improper ventilation, inoperative or undersized exhaust fans, poor placement of ventilation air supply ports, and improper pressurization of the building can all lead to a buildup of combustion gases.

Particulates from a number of sources can cause IAQ problems. These include fiber shedding from fiberglass or mineral-wool insulation, ductboard, and mineral-fiber acoustic ceiling tiles; heavy metals and other compounds tracked into a building by employees or visitors; and soot from combustion devices.

CONTROLLING IAQ PROBLEMS

Avoiding or minimizing IAQ problems involves a seven-part strategy:

1. **Keep the building dry**—this is arguably the most important strategy, especially in quite humid regions of the country.

2. **Keep the building clean and pest-free**—for example, install a track-off system to capture particulates that might enter from outdoors.
3. **Avoid potential contaminant sources**—for example, particleboard and MDF products that offgas formaldehyde, adhesives, solvent-based cleaning agents, and sources of combustion gases.
4. **Reduce unplanned airflows**—these can result from unbalanced HVAC systems, the stack effect, or depressurization in buildings; and they can enable air pollutants to enter from outdoors (combustion gases, pollen), as well as moisture and radon or other soil gases through the floor slab or basement walls, for example.
5. **Provide exhaust ventilation** for unavoidable, strong, stationary pollution sources—these include photocopiers and laser printers in offices, cooking equipment, restrooms, and designated smoking areas.
6. **Provide filtered dilution ventilation** for people, interior finishes, and furnishings in a building—mechanical ventilation is necessary in most buildings to meet minimum ASHRAE standards.
7. **Educate designers, builders, and building occupants**—education is critical in minimizing the risk of creating IAQ problems, identifying problems as they occur, and effectively dealing with those problems.

A few specific recommendations for avoiding IAQ problems are provided in the list at right.

References

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A SAMPLING OF SPECIFIC MEASURES THAT PREVENT IAQ PROBLEMS

- **Air handlers** should be easy to clean and tightly sealed, have a minimum of joints and other dust catchers, and have effective filters.
- **Inspection of air handlers** should be made easier by good access doors and light- or white-colored surfaces inside the air handlers.
- **Condensate pans** inside air handlers should drain fully, and debris should be removed from the pans regularly.
- **Fresh air intakes** should be inspected to ensure that poor-quality air is not drawn into the building from “short circuits” between exhaust and air intakes or as a result of site-specific conditions such as wind. Look for standing water on the roof, bird feces or nests, and proximity to cooling towers, parking areas, waste stacks, exhaust vents, loading docks, and other nearby sources of contamination.
- **Ducts** should be easily cleaned, should be installed without interior insulation, and generally should be air-sealed; textile ducts, while not air-sealed, are the easiest to clean.
- **Floor drains** should be refilled periodically to prevent sewer gas from entering the building through dry traps.
- **Wall-to-wall carpeting** should be minimized and the use of carpet adhesives eliminated; install only products that meet the Carpet & Rug Institute IAQ standard.
- **Paints and adhesives** should contain no—or very low—VOCs. Interior painting should be done during unoccupied periods, such as weekends. Adequate “airing out” should be done to remove the majority of the VOCs from the air before re-occupancy.
- **Durable and easily cleaned building materials** should be used to eliminate the need for strong cleaning chemicals. For example, ceramic tile makes a good substitute for carpeting in entry areas and hallways.
- **Vinyl wall coverings** should not be used on interior surfaces of exterior walls where moisture from wall cavities can condense on the back of the vinyl and harbor mold.
- **“Wet” applied** and formaldehyde-containing wall coverings should be minimized.
- **Ventilation, temperature, and humidity** should comply with ASHRAE Standards 62-1989 and 55-94.
- **Isolate renovation work areas** with plastic sheeting. Tape off HVAC ductwork in renovation work areas to prevent dust and debris from entering the ducts.
- **Newly installed materials**, such as carpets and other flooring products, should be “aired out” before installation.

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8.2 Controlling Soil Gases

The entry into buildings of soil gases—including, but by no means limited to, radon—is an important area of concern. The few studies that have investigated soil gas entry report that 1–20% of the outdoor air entering buildings enters from below grade. Some gases, such as radon and hydrocarbons (from fuel or chemical spills), are health and safety risks to building occupants. Others, principally water vapor, may put the building at risk or cause secondary IAQ problems such as mold growth. Controlling soil gases is an important priority to ensure a safe working or living environment. Fortunately, the strategies for keeping soil gases out are relatively easy.

Opportunities

Soil gases are very easy to control in new buildings through proper design and construction practices. Specific measures for soil gas control should be included in all new buildings, but they are especially important in areas known to have high soil radon levels, on brownfield sites, and on land previously used for agriculture. In existing buildings, dealing with soil gas problems is more difficult and more expensive—but still doable. Before investing in a soil-gas remediation program in an existing building, however, test the area carefully to determine the type and extent of the contamination.

Technical Information

In order for radon or other soil gases from an underground source to end up in a building, there must be a way for the soil gases to enter (passageways) and a driving force to bring them in. The driving force is usually a combination of differences in air pressure (airflow through the below-grade material) and differences in contaminant concentrations. Passages include pores in the soil matrix, fissures and cracks in the underlying bedrock, porous fill around buildings, and cracks and holes in the building foundation walls and floor.

The most common driving force is negative pressure in the building. Exhaust fans, the stack effect, or air-handler returns may create negative pressure in the basement or crawl space that draws air from the soil into the building. Natural systems can also be the driving force. For example, a low-pressure weather system accompanied by a heavy rain may force the soil air mass to equalize with atmospheric air through a building. Rapidly rising water tables displace a large amount of soil air, generating positive pressure in the soil around a building. Air moves easily through gravel and rock that is fractured or has been dissolved by water, so pressure differentials can move large amounts of underground air and soil gases.

UNDERSTANDING SOIL GASES

The soil air contaminants we know the most about are radon, vapors from petroleum products, gases released by other volatile compounds, gases released by anaerobic or aerobic decomposition of carbon-containing materials, and water vapor.

Radon is a radioactive gas released when radium, a trace element in many soils, undergoes nuclear decay. These decay products include radon and various other radioactive "daughter products" from the breakdown of radon. The only known health effect from exposure to radon and its short-lived decay products is an increased risk of lung cancer. Radon is the only carcinogen that is documented with human exposures at levels that may actually occur in buildings. It is classified by the EPA as a Group 1 (known human) carcinogen and is considered the second leading cause of lung cancer in the United States (after tobacco).

Gasoline and fuel oil are the most common sources of below-grade petroleum vapors. These hydrocarbons can get into the soil through spills, leaks, and intentional dumping. Gasoline fumes present an explosion hazard at levels of 14,000 ppm; fuel oil vapors entering a building are not generally explosive. Petroleum products contain a host of other compounds, including benzene, toluene, ethyl-benzene and xylenes (collectively referred to as BTEX). Although there are many other compounds released by petroleum products, these BTEX compounds are always present and pose substantial health risks; they can be detected very easily with portable, relatively inexpensive equipment.

Nonpetroleum VOCs disposed of underground or present in contaminated groundwater can be a big problem if they make their way into buildings. The best known example is the contamination at Love Canal in New York State. Common VOC soil gases include solvents, thinners, and de-icers—the constituents are as varied as the activities that produced them. A wide variety of short-term and long-term health effects could result from exposure to VOCs, depending on the contaminant(s) involved.

Buried materials that contain carbon are often decomposed by bacteria or fungi. Fungi most commonly digest organic matter in the presence of oxygen (aerobic decomposition), while bacteria generally operate in the absence of oxygen (anaerobic decomposition). Gases released by aerobic decomposition are primarily carbon dioxide, water vapor, and trace VOCs; the associated smell is often described as "moldy," "musty," or "earthy." Compounds released by anaerobic bacterial decomposition include methane, nitrogen, hydrogen, and sulfur compounds—and the associated smell can be very bad (often described as "old socks," "locker room," "rotten food," and "sewer gases"). Landfills contain a lot of buried organic matter that decomposes anaerobically, producing methane. Methane reaches explosive concentrations at 40,000 to 150,000 ppm, depending on the temperature and oxygen content. Such explosions have occurred at landfill sites. Buildings near landfills may end up with high methane levels—rarely at explosive concentrations but often at levels where the methane and associated gases can cause "nuisance odor" and health risks.

Water vapor is not itself a contaminant, but it creates an environment that can support populations of fungi, bacteria, mites, insects, or rodents. Potentially high levels of water vapor can enter a building from the ground. Whether this water vapor becomes a problem depends on the rate at which it is being added to and removed from the building by other means. Some studies have shown that strategies to keep soil gases out of buildings can significantly reduce indoor humidity levels.

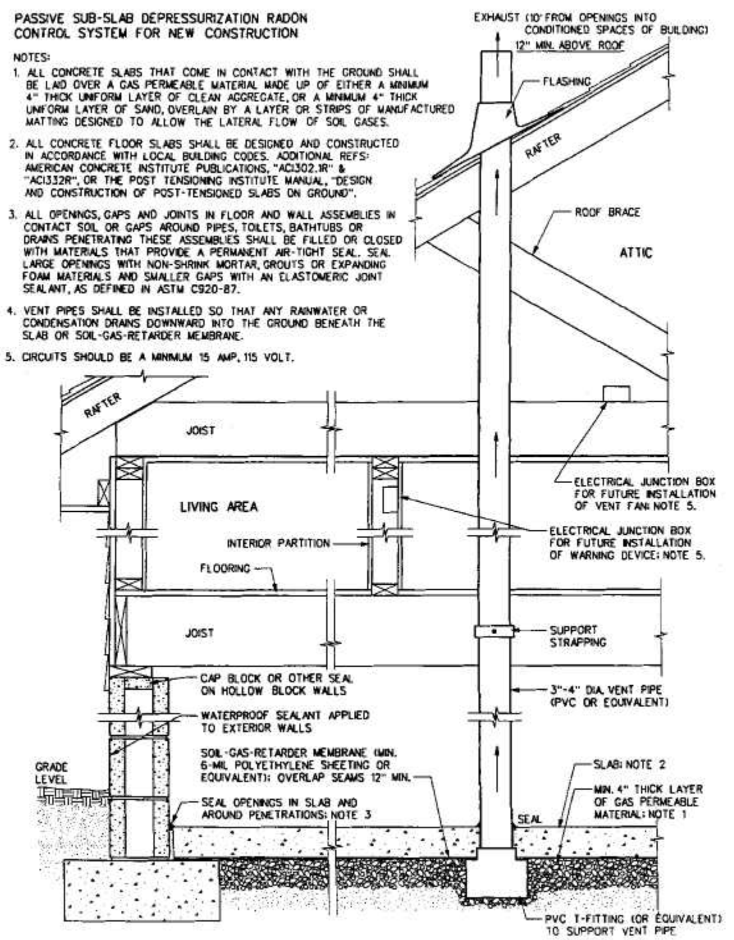
DEALING WITH SOIL GASES

A two-prong approach is recommended: prevent soil gas entry and provide dilution ventilation air as called for by codes or professional guidelines.

Preventing soil air entry is the primary control method. It solves soil gas problems that would be impractical to solve using ventilation alone. To prevent soil air entry:

- Provide a relatively airtight foundation;
- Avoid depressurization of the building through improperly balanced exhaust fans and air-handling equipment or through the stack effect (most pronounced in tall buildings);
- Provide a highly permeable layer of material beneath the building (e.g., crushed stone) that can be easily depressurized; and
- Install a passive stack that runs from the subslab layer through the heated part of the building to the outdoors.

The last two of these steps will create a low-air-pressure zone beneath the foundation that will intercept soil air and divert it through the passive stack. In the event that the passive stack is not powerful enough to keep problem gases out of the building, the stack can be powered with an in-line fan. Detailed correctly, a very small fan can treat a large footprint. In research conducted by the EPA, a single stack using a 90-watt fan has depressurized the drainage layer beneath a 100,000-square-foot (9,300 m²) slab.



This schematic illustrates the basic operation of a soil-gas control and mitigation system for a residence. Source: EPA 402-95012, May 1995

References

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Contacts

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