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Health and Safety Guide for Home Performance Contractors

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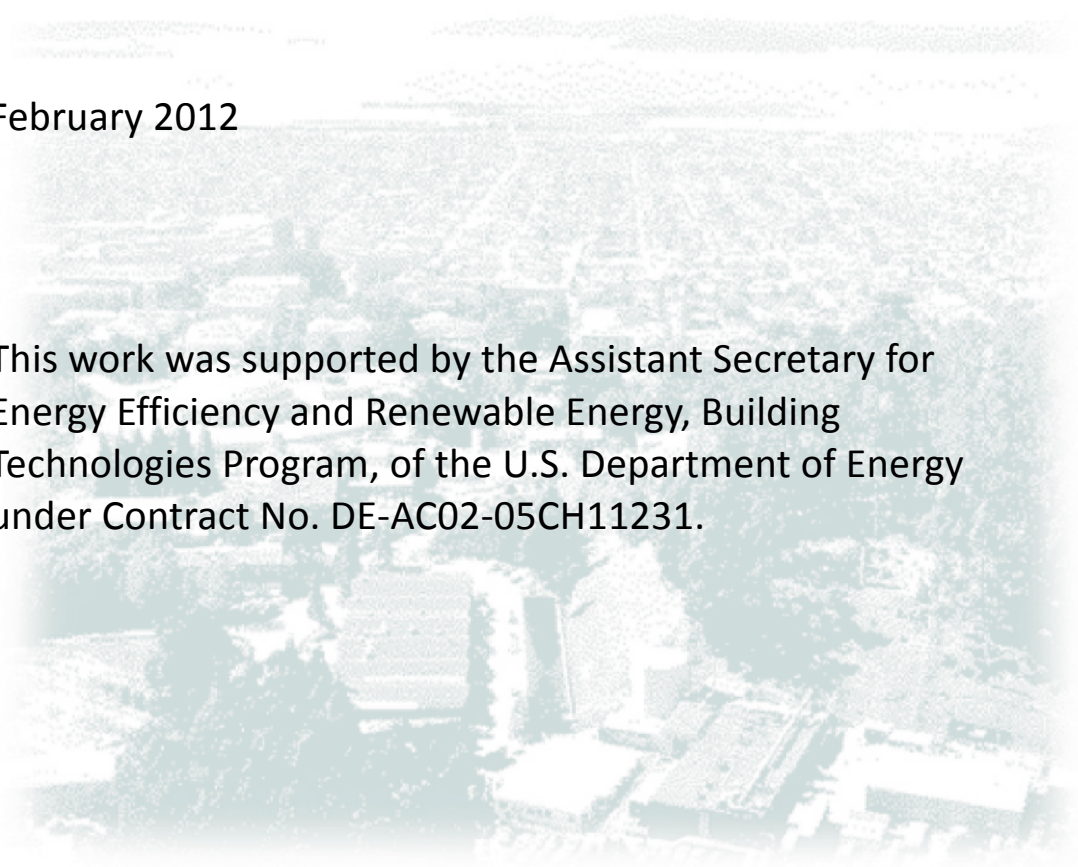
## Health and Safety Guide for Home Performance Contractors

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## INTRODUCTION:

This report is intended to provide home performance contractor trainers with a resource to keep both their workers and home residents safe and healthy. This document is an attempt to describe what we currently believe is safe, what we believe is unsafe, and what we're unsure about. It is intended to identify health and safety issues and provide historical context and current understanding of both risks and mitigation strategies. In addition, it provides links to more in-depth resources for each issue.

When we tighten the thermal envelope of a house to improve comfort and reduce energy use, we have to be sure that we are not compromising the indoor air quality of the home. This means identifying and mitigating or eliminating pollution sources before and after you make changes to the home. These sources can include materials and finishes in the home, exhaust gasses from combustion appliances, soil gasses such as radon, and moisture from a bathroom, kitchen, or unvented clothes dryer.

Our first responsibility is to do no harm – this applies both to our clients and to our employees. Currently, there are many new products that are widely used but whose health effects are not well understood. Our inability to have perfect information means the directive to do no harm can be difficult to obey. Each home is a little bit different, and in the face of a situation you've never encountered, it's important to have a solid grasp of the fundamental concepts of building science when the hard and fast rules don't apply.

The home performance industry is gaining momentum, and has the potential to expand greatly as energy costs continue to rise. It is imperative that we remain vigilant about protecting the health and safety of our workers and our customers. It only takes a few news stories about a family that got sick after their home was tightened by a home performance contractor to scare off potential customers and taint the reputation of the entire industry. Good reputations take time to build, but can be quickly damaged.

## ORGANIZATION OF THIS GUIDE

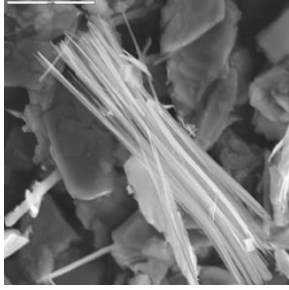
Hazards are listed alphabetically within two overarching categories: Indoor Environmental Hazards and Shock and Fire Hazards.

Alternatively, the table below lists common home performance tasks with links to associated hazards:

Home performance task	Associated hazards (with links to each section)
Attic - insulating, air sealing	Aluminum Wiring - Asbestos - <b>Faulty Wiring</b> - Fiberglass - Formaldehyde - Heat Tape - Knob and Tube Wiring - Moisture Problems - Pests - Polychlorinated Biphenals (PCBs) - Recessed Lighting - Spray Polyurethane Foam (SPF) - Volatile Organic Compounds (VOCs)
Blower door test	Asbestos - Below-ground contamination sources (radon, sewer gases, chemicals) - Combustion Safety - Indoor Particulate Matter (PM) and Dust - Moisture Problems - Pests
Crawlspace/basement - insulating, air sealing, vapor barrier	Aluminum Wiring - Asbestos - Below-ground contamination sources (radon, sewer gases, chemicals) - Combustion Safety - Faulty Wiring - Fiberglass - Formaldehyde - Heat Tape - Indoor Particulate Matter (PM) and Dust - Knob and Tube Wiring - Lead - Moisture Problems - Pests - Polychlorinated Biphenals (PCBs) - Polyvinyl Chloride (PVC) - Spray Polyurethane Foam (SPF) - Volatile Organic Compounds (VOCs)
HVACR repair, replacement	Asbestos - Below-ground contamination sources (radon, sewer gases, chemicals) - Combustion Safety - Indoor Particulate Matter (PM) and Dust - Moisture Problems - Pests - Polyvinyl Chloride (PVC)
Lighting replacement	Aluminum Wiring - <b>Faulty Wiring</b> - Knob and Tube Wiring - Recessed Lighting
Ventilation installation	Aluminum Wiring - Below-ground contamination sources (radon, sewer gases, chemicals) - Combustion Safety - Environmental Tobacco Smoke (ETS) - <b>Faulty Wiring</b> - Formaldehyde - Indoor Particulate Matter (PM) and Dust - Knob and Tube Wiring - Moisture Problems - Pests - Polyvinyl Chloride (PVC) - Recessed Lighting - Volatile Organic Compounds (VOCs)
Walls/interior cavities - Insulating, air sealing	Aluminum Wiring - Asbestos - Below-ground contamination sources (radon, sewer gases, chemicals) - Combustion Safety - <b>Faulty Wiring</b> - Fiberglass - Formaldehyde - Indoor Particulate Matter (PM) and Dust - Knob and Tube Wiring - Lead - Moisture Problems - Pests - Polychlorinated Biphenals (PCBs) - Polyvinyl Chloride (PVC) - Spray Polyurethane Foam (SPF) - Volatile Organic Compounds (VOCs)
Water heater repair/replacement	Asbestos - Combustion Safety - Lead - Polyvinyl Chloride (PVC)

## INDOOR ENVIRONMENTAL HAZARDS

## Asbestos



MAGNIFIED DETAIL OF ASBESTOS FIBERS (IMAGE VIA EPA)

Asbestos is a set of six naturally occurring silicate materials commonly used in building components. It is especially common in many US building materials produced before 1985. Raw asbestos is refined into fibers to be used in building materials. Asbestos has multiple desirable characteristics; it is a flame retardant and an insulator and has high tensile strength, flexibility, and resistance to chemicals. Because of these characteristics, asbestos has been used in numerous building materials.

### WHY IT IS PROBLEMATIC:

In addition to its versatility, asbestos also has some very undesirable characteristics. The World Health Organization International Agency for Research on Cancer (IARC) has determined that asbestos is carcinogenic to humans [1].<sup>1</sup> The EPA states that “when asbestos-containing materials are damaged or disturbed by repair, remodeling or demolition activities, microscopic fibers become airborne and can be inhaled into the lungs, where they can cause significant health problems.”[2]

These health problems include an increased risk of:

- lung cancer, especially when combined with exposure to smoke and/or radon
- mesothelioma – a cancer of the lining of the chest and abdominal cavity
- asbestosis, in which the lungs become scarred with fibrous tissue

The symptoms of these diseases do not usually appear until about 20 to 30 years after the first exposure to asbestos, and are almost always found in individuals that have had significant, long-term exposure to asbestos dust [2]. The EPA’s personal exposure limit (PEL) for asbestos is 0.2 fibers per cubic centimeter of air over an 8-hour time-weighted average [3]. Asbestos-containing materials are only problematic if they are damaged such that the asbestos fibers can easily be disturbed and made airborne (i.e. they’ve become *friable*).

### WHERE YOU FIND IT:

Most asbestos-containing products were banned in the United States in 1989 [4], but the ban was overturned by the New Orleans U.S. Fifth Circuit Court of Appeals in 1991 [5]. Since 1991, only certain asbestos-containing material (ACM) products are still banned [6].

Banned products include:

- Most spray-applied surfacing ACM
- Wet-applied and pre-formed asbestos pipe insulation, and pre-formed asbestos block insulation on boilers and hot water tanks
- Corrugated paper, rollboard, commercial paper, specialty paper, flooring felt, and any new (post-1991) uses of asbestos.

Besides the products listed above, the EPA has no existing bans on asbestos-containing products or uses [6]. That said, most products made today do not contain asbestos. Those few products made which still

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<sup>1</sup> Asbestos belongs to Group 1. For more information on the IARC groupings, please see Appendix 5: World Health Organization (WHO) International Agency for Research on Cancer (IARC) classification groups and descriptions.



contain asbestos that could be inhaled are required to be labeled as such.<sup>2</sup> Through the 1980s, many types of building products and insulation materials used in homes contained asbestos. These products include:

- Vermiculite insulation
- Roofing felt
- Shingles
- Artificial ashes in gas-fired fireplaces
- Pipe insulation
- Water heater insulation
- Asbestos insulating board
- Loose asbestos insulation

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<sup>2</sup> The 2001 Mineral Commodity Summary for Asbestos from the U. S. Geological Survey (USGS) reported 61% of the asbestos used in the United States (in 2000) was in roofing compounds, 19% in friction products, 13% in gaskets, and 7% classified as “other.”



Asbestos loose-fill insulation  
(rare in residential buildings)



Friable asbestos pipe insulation



Detail of asbestos roofing felt



Detail of asbestos vinyl floor tile



Detail of asbestos cement wall board



Detail of asbestos textured  
("popcorn") ceiling



Detail of friable asbestos duct insulation



Asbestos-containing vermiculite attic insulation

### WHAT TO DO ABOUT IT:

If you suspect or discover *friable* asbestos-containing material (ACM) in a home, stop work immediately and explain the situation to the homeowner. Isolate and evacuate the contaminated area. Do not dust, sweep, or vacuum debris that may contain asbestos. Instruct the homeowner to have the material in question sampled and analyzed by a qualified professional. If the material is determined to be a friable ACM, any repairs will need to be performed by trained asbestos professionals.

If you discover ACM in the home and it is not damaged and is not friable, in most cases the home performance audit and retrofit work may proceed. This includes undisturbed vermiculite insulation in the attic or walls.

Caution should be taken when performing a blower door test in a home containing any potentially harmful indoor air pollutant such as asbestos. In most cases homes with *non-friable* ACM can safely undergo a blower door test.

### RESOURCES:

EPA Publication – *Asbestos in Your Home* ([www.epa.gov/asbestos/pubs/ashome.html](http://www.epa.gov/asbestos/pubs/ashome.html))

Environmental Working Group – Asbestos ([www.ewg.org/sites/asbestos/](http://www.ewg.org/sites/asbestos/))

## **Below-ground contamination sources (radon, sewer gases, chemicals)**

### Radon

Radon is a radioactive, naturally-occurring, colorless, odorless gas that is emitted from the Earth's crust.

#### **WHY IT IS PROBLEMATIC:**

According to the US EPA, epidemiological studies have shown a clear link between breathing high concentrations of radon and incidences of lung cancer. Radon is the second most frequent cause of lung cancer, after cigarette smoking.

#### **WHERE YOU FIND IT:**

If unmitigated, radon can accumulate in buildings – especially in unvented basements and attics. Radon concentrations vary greatly by geography (See

Appendix 6: United States Radon Map). However, homes with elevated levels of radon have been found in all risk zones.

**WHAT TO DO ABOUT IT:**

Ask the homeowner if their home has ever been checked for radon. If not, inform the homeowner about the risks of radon and recommend that they have their home tested for radon per EPA guidelines, ideally both before and after any work is performed on the home. As with other indoor air contaminants, reducing infiltration through a building’s envelope can introduce a radon problem where there wasn’t one before.

The EPA’s action threshold for radon is 4 pCi/L (picocuries per liter) or greater. If radon concentration above this threshold is found, an active soil depressurization system should be installed in the home by a radon mitigation professional. The [National Environmental Health Association – National Radon Proficiency Program](#) provides listings of qualified radon mitigation professionals in your area.

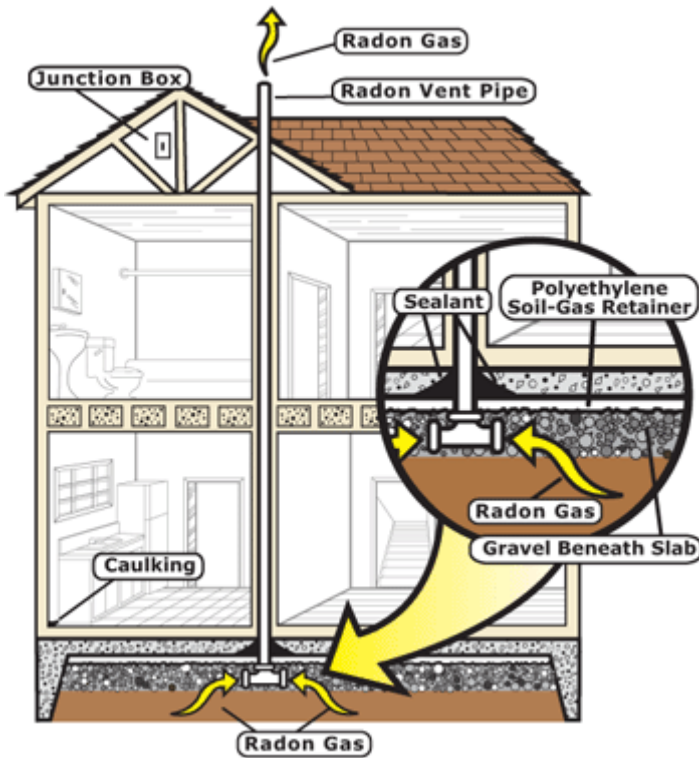


DIAGRAM OF A RADON-VENTED HOME. IMAGE VIA EPA

**RESOURCES:**

EPA guide to radon:

- [www.epa.gov/radon/index.html](http://www.epa.gov/radon/index.html)

National Environmental Health Association – National Radon Proficiency Program (NEHA – NRPP)

- [www.radongas.org/](http://www.radongas.org/)

## Appendix 6: United States Radon Map

### Combustion Safety

#### Nitric Oxide (NO) and Nitrogen Dioxide (NO<sub>2</sub>)

“NO<sub>x</sub>” is a term that refers to both NO (nitric oxide) and NO<sub>2</sub> (nitrogen dioxide).

#### **WHERE YOU FIND IT:**

Like carbon monoxide, NO<sub>x</sub> is a product of combustion, but whereas CO is formed when the combustion temperature is too low, NO<sub>x</sub> is formed when the temperature is too high.

#### **WHY IT IS PROBLEMATIC:**

NO<sub>x</sub> contributes to the formation of ground-level ozone and smog. It also reacts with indoor water vapor and air pollutants, including volatile organic compounds (VOCs), to form small particles that can cause breathing difficulties, especially in people with asthma.

#### **WHAT TO DO ABOUT IT:**

If combustion appliances are being used in the house, there is no easy way to prevent the formation of NO<sub>x</sub>.<sup>3</sup> The best way to deal with NO<sub>x</sub> is reduce exposure through ventilation. The most common source of NO<sub>x</sub> exposure in homes comes from gas ranges. Any time a gas range is used, a range hood vented to the outside should be operated to remove NO<sub>x</sub> (as well as particulates, carbon monoxide, and acrolein) from the living space. The range hood flow should be tested and should match the flow recommended by the [Home Ventilating Institute \(HVI\)](#) for the home’s cooktop size and location.

#### **RESOURCES:**

HVI range hood sizing guidelines

- [www.hvi.org/publications/pdfs/HVIRangeHood\\_4Feb08.pdf](http://www.hvi.org/publications/pdfs/HVIRangeHood_4Feb08.pdf)

EPA guide to NO<sub>x</sub>

- [www.epa.gov/oaqps001/nitrogenoxides/health.html](http://www.epa.gov/oaqps001/nitrogenoxides/health.html)

#### Carbon Monoxide

When we burn hydrocarbon fuels (natural gas, heating oil, etc.) in our homes, if there is not enough oxygen available (from air) or the combustion temperature is too low due to impingement, the combustion may be incomplete and produce Carbon Monoxide (CO) instead of Carbon Dioxide (CO<sub>2</sub>).

#### **WHY IT IS PROBLEMATIC:**

CO is an odorless, colorless, tasteless gas that is poisonous to humans and animals. It reacts with the hemoglobin in our blood, impeding our blood’s ability to carry oxygen to our body.

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<sup>3</sup> The combustion appliance can be “tuned” so that the flame burns at an ideal temperature range that reduces both NO<sub>x</sub> and CO production, but this task is beyond the work scope of the typical home performance contractor.

Carbon Monoxide (CO) Levels	
9 parts per million (ppm)	EPA exposure limit: 8 hours
35 ppm	EPA exposure limit: 1 hour <b>NOTE: At this level, the home inspection should be discontinued and, subject the inspector's discretion, the home should be evacuated until the problem is remedied.</b>
200 ppm	NIOSH ceiling: 15 minutes; headache within 2-3 hours
400 ppm	Headache within 1-2 hours
800 ppm	Sickness and twitching of limbs within 1-2 hours; unconsciousness within 2 hours
1600 ppm	Headache within 20 minutes; death within 2 hours
3200 ppm	Death within 30 minutes
6400 ppm	Death within 10-15 minutes
12800 ppm	Death within 1-3 minutes

A 2002 study by the US Centers for Disease Control and Prevention reported an average of 1,100 accidental CO deaths per year from 1968 to 1998[7]. A 2007 study estimated US incidence of emergency department visits due to CO poisoning to be approximately 50,000 per year[8].

**WHERE YOU FIND IT:**

Any home that has combustion equipment may have problems with CO. Common combustion equipment in homes includes:

- furnaces
- water heaters
- vehicles
- boilers
- ranges
- fireplaces
- woodstoves
- clothes dryers
- electrical generators

Evaluating a combustion appliance

Three questions to ask about any combustion appliance:

- **How is it turned on/off?**

Does the appliance turn on/off automatically, or is it user-controlled? If there is a problem, is the appliance able to turn itself off? For example, newer furnaces have temperature sensors that shut the unit off if the operating temperature falls outside an optimal combustion range.<sup>4</sup> The combustion appliances of most concern are those that turn on automatically and have no check to

<sup>4</sup> If the temperatures are too hot, it can indicate a fire hazard and/or NOx emissions. If they are too cold, it can indicate incomplete combustion and CO emissions.

be turned off if there is a problem. These include older furnaces and boilers as well as naturally drafted gas-fired water heaters.

- **How does it get combustion air?**

If the appliance is not getting enough air (oxygen), its combustion may be incomplete and it may produce carbon *monoxide* (CO) instead of carbon *dioxide* (CO<sub>2</sub>) as a combustion product. Some appliances get combustion air from the surrounding area inside the home – this area is commonly referred to as the Combustion Appliance Zone (CAZ).

“Sealed combustion” appliances have a dedicated inlet duct to provide combustion air directly from outside, ensuring that the appliance always has adequate combustion air.

- **How do its combustion gases get exhausted?**

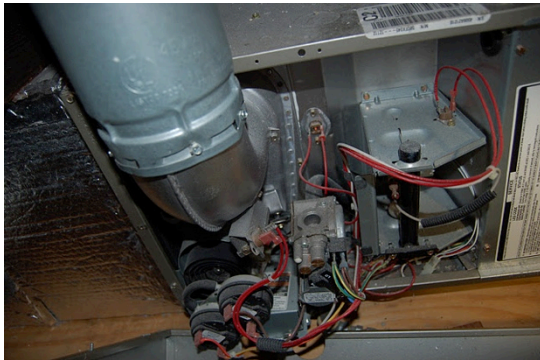
Combustion appliances have to get their poisonous exhaust gasses out of the house. Below are the main categories of venting types, listed in order of least to most combustion-efficient:



#### Atmospheric “Natural” Draft

- Relies on the stack effect to vent exhaust gases
- Uses surrounding air for combustion
- Prone to back drafting and spillage of exhaust gases into living space

NATURAL DRAFT, TANK STORAGE GAS-FIRED WATER HEATER



#### Atmospheric Induced Draft

- Uses a powered fan to induce stack effect to vent exhaust gases
- Uses surrounding air for combustion
- Less prone to back drafting and spillage

INDUCED DRAFT GAS-FIRED, FORCED AIR FURNACE





### Sealed Combustion

- Uses a powered fan to directly exhaust cooled combustion gases through a dedicated, sealed outlet
- Sealed, dedicated inlet supplies combustion air from outside
- Because the system is sealed, back drafting and spillage are not a concern with these devices

SEALED-COMBUSTION, GAS-FIRED ON-DEMAND WATER HEATER

### Combustion air and venting

If a house is receiving air sealing and insulation as part of a home performance retrofit, the reduced air leakage will have an effect on the operation of the home's combustion appliances. Devices that were not a CO hazard before the retrofit may have become a hazard afterward. For this reason, the home should be tested thoroughly for combustion safety both before and after the retrofit.

**“Natural” draft** appliances use the surrounding air to create combustion and then exhaust combustion flue gasses passively through the stack effect. If the flue is not exhausting properly (i.e. spilling or back drafting) and/or the equipment is not receiving enough combustion air, these devices may continue to operate, potentially releasing poisonous CO into the living space.

**Induced draft** appliances have a powered fan that assists the stack effect draft. They also typically include a pressurization sensor that turns the device off if the combustion gases are not being exhausted properly. However, this safety feature can be ineffective if the furnace is commonly vented with a natural draft water heater, because the exhaust gases could still be coming out the draft diverter (and into the living space!) instead of out the flue.

**Sealed combustion** appliances have a dedicated inlet to supply combustion air from outside and a dedicated outlet to exhaust combustion gases outside. Because the exhaust is sealed, depressurization-induced back drafting of exhaust gases is not a concern with these devices.

Sealed combustion devices are often condensing, meaning that they are very efficient at capturing heat from combustion.<sup>5</sup> Because the temperature of their exhaust air is so low, plastic piping can be (and almost always is) used with sealed combustion appliances. Because they are pressurized, a hole should never be drilled in the exhaust pipe of a sealed combustion appliance. If you wish to insert a probe in the exhaust gases of a sealed combustion appliance to measure combustion efficiency, do so at the exhaust outlet on the exterior of the house.

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<sup>5</sup> They capture so much of the heat, in fact, that the temperature of the combustion air falls below its dew point, causing water vapor to condense into (acidified) liquid water. This water must be captured and drained away from the appliance to avoid corrosion.



### Evaluating CO risks

To get specific values, CO levels should be tested with a properly calibrated CO meter. However, it is important to be able to recognize evidence of CO and other combustion safety issues while visually inspecting a home. These indicators include:

- Natural gas appliances that burn with a yellow flame (instead of a blue flame) – indicates incomplete combustion and potential CO production
- Soot around/on combustion appliances – indicates incomplete combustion and is itself a harmful particulate
- Charring on the surface of appliances – indicates flame rollout and constitutes a fire hazard
- Evidence of fuel leaks – explosion/fire hazard
- Disconnected or misaligned flue pipe – indicates that poisonous exhaust gasses may be spilling into the living space
- Flue pipe conditions that prevent exhaust gasses from leaving the home (may include exhaust pipes that are horizontal or slope downward *from* the device being vented and/or damaged pipes) – indicates that poisonous exhaust gasses may be spilling into the living space
- An “orphaned” atmospherically-vented water heaters that previously shared a chimney with another appliance but doesn’t any longer – pressure differences may be spilling poisonous exhaust gasses into the living space

Even if none of these indicators is present, the home may still have dangerous levels of CO under certain conditions. In order to more definitively determine the combustion safety of a home, its appliances must be tested under the conditions most likely to produce unhealthy levels of CO within the living space. One common test for evaluating a home’s tendency to release combustion gases into the living space is known as a Worst-case Combustion Appliance Zone (CAZ) Depressurization test. The test entails turning on every mechanical exhaust device and configuring the openings within the home to depressurize the CAZ as much as possible in an attempt to suck the combustion appliance exhaust gasses away from the flue and into the living space.

The Building Performance Institute (BPI), RESNET, the National Fire Protection Association (NFPA)<sup>6</sup>, and other institutions have developed detailed protocols for testing worst-case conditions, draft pressure, and CO concentrations within a home. Please refer to the Resources at the end of this section for links to detailed home performance standards and protocols publications.

#### **WHAT TO DO ABOUT IT:**

If CO levels in the home are too high under worst-case conditions, they should be tested again under natural conditions. If a test fails before the house is air sealed or insulated, follow procedure to remedy the problem before the retrofit proceeds. After the retrofit work has been completed, the same tests should be performed again. If a test fails after the house is air sealed or insulated, the problem must be identified and fixed before the house can be occupied.

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<sup>6</sup> NFPA 54 – Natural Fuel Gas Code, Annex G

## Homeowner Education

### *Residential Carbon Monoxide detectors*

Increasingly, US states and local jurisdictions are requiring homes to have functional CO detectors installed.<sup>7</sup> A 2002 study conducted by the Gas Research Institute found most commercially available CO detectors to be faulty[9]. The primary CO detector standard used in the US is Underwriters Laboratories Standard 2034 (UL 2034)[10]. This standard has been criticized because its alarm thresholds do not correlate to the CO concentration limits required by US National Ambient Air Quality Standards (NAAQS). For example, UL 2034 requires that detectors *not* sound an alarm if CO concentrations are below 30 ppm. This could conceivably allow a home to maintain an average CO concentration of 29 ppm indefinitely, even though that value is more than 3 times higher than the 9 ppm 8-hour maximum exposure level required by NAAQS[11]. Moreover, UL 2034 requires that alarms sound only when CO concentrations are 30-70 ppm for more than 30 days, even though the EPA states that exposure to levels above 35 ppm should not last more than one hour[11]. The GRI study also critiques UL 2034 for not requiring CO detector manufacturers to perform quality assurance testing as recommended by the US Consumer Product Safety Committee[9].

### **Carbon Monoxide (CO) Exposure Standards**

	EPA	UL 2034
Short term	35 ppm / 1 hour	70 ppm / 1 hour
Longer term	9 ppm / 8 hours	30 ppm / 720 hours (30 days)

In short, encourage your customers to do their research when choosing a CO detector for their homes, and encourage them to not let cost be the primary factor in their decision. You may want to recommend that they look for a Low Level CO detector that monitors and displays CO concentrations continuously. If they just choose the least expensive option, they may end up with an ineffective unit that provides a false sense of security – a situation which may in fact be more dangerous than having no CO detector at all.

### **RESOURCES:**

CO Testing standards and guidelines:

- [Building Performance Institute \(BPI\) – Building Analyst Technical Standards](#)
- [Residential Network \(RESNET\) – Interim Guidelines for Combustion Appliance Testing](#)
- ASTM E1998 – Standard Guide for Assessing Depressurization-Induced Backdrafting and Spillage from Vented Combustion Appliances[12]
- NFPA 54 – National Fuel Gas Code

### **Environmental Tobacco Smoke (ETS)**

Environmental tobacco smoke is a mixture of the smoke given off by the burning end of a cigarette, pipe, or cigar, and the smoke exhaled by smokers.

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<sup>7</sup> For example, California senate bill 183 - [info.sen.ca.gov/pub/09-10/bill/sen/sb\\_0151-0200/sb\\_183\\_cfa\\_20090526\\_141751\\_sen\\_floor.html](http://info.sen.ca.gov/pub/09-10/bill/sen/sb_0151-0200/sb_183_cfa_20090526_141751_sen_floor.html)

**WHY IT IS PROBLEMATIC:**

According to the EPA, ETS is a human lung carcinogen, responsible for approximately 3000 cancer deaths per year in nonsmokers. Tobacco smoke contains more than 3800 chemicals, including carbon monoxide, formaldehyde, and ammonia.

**WHAT TO DO ABOUT IT:**

The best solution is to eliminate tobacco smoke. In the absence of eliminating the source, ventilation in living spaces should be increased substantially to limit second and third-hand smoke exposure. “Smoke eater” filters can also reduce risks to non-smokers, but again, the only real solution to tobacco smoke exposure is to eliminate the source.

**RESOURCES:**

Overviews of the risks of environmental tobacco smoke:

- [www.cancer.gov/newscenter/pressreleases/1999/ets](http://www.cancer.gov/newscenter/pressreleases/1999/ets)
- [EPA – Health Effects of Environmental Tobacco Smoke](http://EPA – Health Effects of Environmental Tobacco Smoke)

**Fiberglass**

Fiberglass is created by spinning molten glass into a thin fiber. Its primary use as a building material is as an insulator in walls, floors, and attics. Fiberglass insulation comes in two primary forms: batt and blown-in.

**WHY IT IS PROBLEMATIC:**

When used as batt insulation, strands of fiberglass are impregnated with a binding agent. Typically this binding agent contains formaldehyde<sup>8</sup>, a substance that IARC has determined to be carcinogenic to humans[13]. The off-gassing of formaldehyde represents an indoor air quality hazard for both installation workers and homeowners[14]. Multiple manufacturers currently offer formaldehyde-free fiberglass insulation.<sup>9</sup>

IARC has determined that there is inadequate evidence that fiberglass itself is carcinogenic to humans. (Group 3) OSHA recommends that people working with fiberglass cover their skin with gloves, long sleeves, pants, and a cap to prevent skin irritation.<sup>10</sup> In addition, they recommend wearing unvented goggles and a cartridge respirator to prevent eye and respiratory irritation while working with fiberglass. Clothes worn while working with fiberglass should be laundered separately from other clothes to prevent contamination.

**RESOURCES:**

OSHA guide for synthetic mineral fibers, including fiberglass:

- [www.osha.gov/SLTC/syntheticmineralfibers/index.html](http://www.osha.gov/SLTC/syntheticmineralfibers/index.html)

**Formaldehyde**

Formaldehyde is a type of volatile organic compound (VOC). Its chemical formula is CH<sub>2</sub>O; at room temperature, it is a colorless gas with a characteristic pungent odor.

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<sup>8</sup> For more information about formaldehyde, see next section.

<sup>9</sup> Pharos is a database of building materials comprehensively rated for multiple categories, including health and environmental impact, available at [www.pharosproject.net/](http://www.pharosproject.net/)

<sup>10</sup> Detailed instructions available at [www.osha.gov/SLTC/syntheticmineralfibers/index.html](http://www.osha.gov/SLTC/syntheticmineralfibers/index.html)

**WHY IT IS PROBLEMATIC:**

Formaldehyde is a human carcinogen according to the World Health Organization (WHO) and the National Institute of Health’s National Toxicology Program (NTP)[15]. It can cause eye, nose, and respiratory irritation and can be an asthma trigger in sensitive individuals[16].

California Office of Environmental Health Hazard Assessment (OEHHA) Formaldehyde Reference Exposure Level (REL)		
	parts per billion (ppb)	micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ )
Acute	44	55
8-hour	7	9

Multiple studies have concluded that formaldehyde concentrations in homes commonly exceed the OEHHA 8-hour limit (refer to table above), and many new homes regularly exceed even the acute limit [17-19]. A 2011 study found that formaldehyde was among the most hazardous – and least recognized – prevalent indoor air pollutants [20].

**WHERE YOU FIND IT:**

There are two primary types of formaldehyde used in building materials: urea-formaldehyde (UF) and phenol-formaldehyde (PF). Urea formaldehyde continues to outgas formaldehyde for years after manufacture and has been a target of green building programs and regulatory action [20]. Products containing phenol formaldehyde also outgas formaldehyde during use, however at a far lower rate than urea formaldehyde-based products.

Uses of formaldehyde:

- Glues and adhesives
- Permanent press clothing
- Preservative in paints and coatings

Common sources:

Small amounts of formaldehyde are produced in the case of incomplete combustion of methane gas. Formaldehyde is present in many building materials and household products, especially pressed wood products, such as:

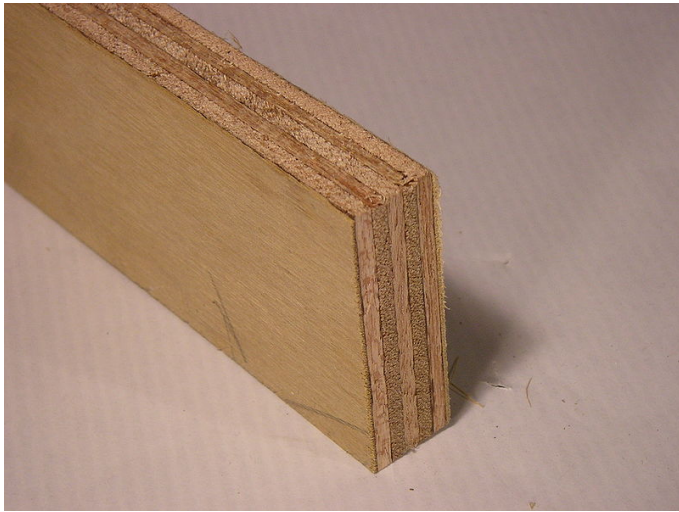
- Particleboard (subflooring and shelving in cabinetry and furniture)
- Hardwood plywood paneling (decorative wall coverings, cabinets and furniture)
- Medium density fiberboard (MDF) (used in drawer fronts, cabinets, and furniture tops)<sup>11</sup>

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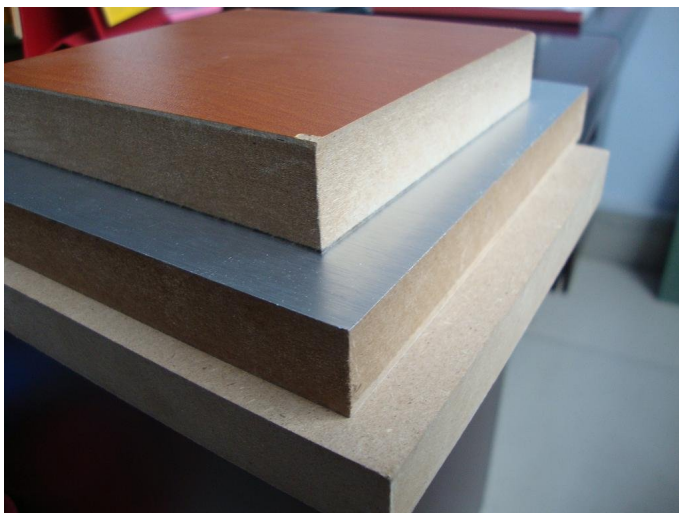
<sup>11</sup> Medium density fiberboard contains a higher resin-to-wood ratio than any other UF pressed wood product and is generally recognized as being the highest formaldehyde-emitting pressed wood product.



**PARTICLE BOARD**



**PLYWOOD**



**MEDIUM DENSITY FIBERBOARD (MDF)**

From EPA:

“Other composite wood products, such as softwood plywood and flake or oriented strandboard (OSB), are produced for exterior construction use and contain the dark, or red/black-colored phenol-formaldehyde (PF) resin. As the name implies, formaldehyde is present in this type of resin also, but composite woods that contain PF resin generally emit formaldehyde at considerably lower rates than those containing UF resin.”<sup>12</sup>

#### WHAT TO DO ABOUT IT:

The first step to reduce exposure to formaldehyde is to identify and eliminate the sources of formaldehyde.<sup>13</sup> Where source reduction/elimination is impossible or impractical, residents' and workers' formaldehyde exposure can be limited through increased ventilation. Increasing ventilation always carries with it energy and financial costs, but those costs should be realistically weighed against the health costs of formaldehyde exposure.

#### Alternatives to formaldehyde-based adhesives

According to the EPA, the most widely used completely formaldehyde-free alternative resins are MDI (methylene diphenyl isocyanate) and PVA (polyvinyl acetate).<sup>14</sup>

In addition, at least one manufacturer offers composite wood products that use formaldehyde-free, soy-based adhesive that they claim to be equivalent in cost and performance to formaldehyde-based adhesives.<sup>15</sup>

#### RESOURCES:

Formaldehyde overview

- [www.healthybuilding.net/healthcare/2008-05\\_formaldehyde\\_fact\\_sheet\\_updated.pdf](http://www.healthybuilding.net/healthcare/2008-05_formaldehyde_fact_sheet_updated.pdf)
- [www.epa.gov/iaq/formalde.html](http://www.epa.gov/iaq/formalde.html)
- [www.healthybuilding.net/formaldehyde/](http://www.healthybuilding.net/formaldehyde/)

Formaldehyde exposure levels

- [oehha.ca.gov/air/hot\\_spots/pdf/FormaldehydePR.pdf](http://oehha.ca.gov/air/hot_spots/pdf/FormaldehydePR.pdf)
- [www.cdc.gov/nceh/ehhe/trailerstudy/compendium.htm](http://www.cdc.gov/nceh/ehhe/trailerstudy/compendium.htm)

Guide to formaldehyde alternatives

- [www.healthybuilding.net/healthcare/2008-04-10\\_alt\\_resin\\_binders\\_particleboard.pdf](http://www.healthybuilding.net/healthcare/2008-04-10_alt_resin_binders_particleboard.pdf)

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<sup>12</sup> Despite its name, PVA is not closely related to PVC. Without chlorine in its molecule it avoids many of the worst problems that PVC has in its lifecycle

<sup>13</sup> In 2007, the California Air Resources Board (CARB) approved an Airborne Toxic Control Measure (ATCM) to control formaldehyde emissions in composite wood products. ([www.arb.ca.gov/regact/2007/compwood07/fro-final.pdf](http://www.arb.ca.gov/regact/2007/compwood07/fro-final.pdf)) The resulting emission standards were incorporated into the state building code in 2009. In 2010, President Obama signed the Formaldehyde Standards for Composite Wood Products Act ([www.epa.gov/oppt/chemtest/formaldehyde/](http://www.epa.gov/oppt/chemtest/formaldehyde/)) into law. The legislation adds new requirements to the Toxic Substances Control Act that will be implemented in 2013.

<sup>14</sup> Despite its name, PVA is not closely related to PVC. Without chlorine in its molecule it avoids many of the worst problems that PVC has in its lifecycle.

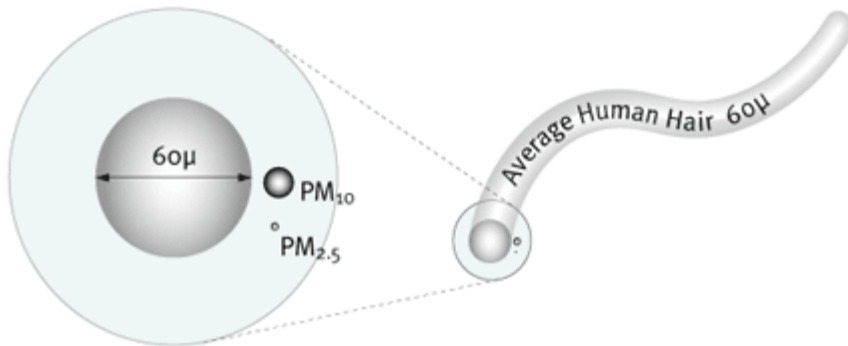
<sup>15</sup> [columbiaforestproducts.com/PureBond.aspx](http://columbiaforestproducts.com/PureBond.aspx)

## Indoor Particulate Matter (PM) and Dust

Particulate matter (PM) pollution is estimated to cause 22,000-52,000 deaths per year in the United States. PM is usually classified as have a diameter smaller than 10 microns ( $\mu$ ) – called PM<sub>10</sub>, or a diameter smaller than 2.5 microns – called PM<sub>2.5</sub>.

### WHY IT IS PROBLEMATIC:

The finer particles pose the greatest threat to human health because they can travel deepest into the lungs.



### COMPARATIVE PARTICLE SIZE (IMAGE VIA HEALTH CANADA)

In a recently published report about ventilation and indoor air quality[21], PM<sub>2.5</sub> was the most detrimental to human health among all pollutants considered. Combustion – whether in the home or from an outdoor source -- is the primary source of indoor particulate matter.

Dust is made up of particles in the air that settle on surfaces. Many sources can produce dust including: soil, fleecy surfaces, pollen, lead-based paint, and burning of wood, oil or coal. Dust, dust mites, and dust mite droppings are a major cause of asthma.

### WHERE YOU FIND IT:

Particulate matter from indoor sources:

- Cooking, even using electric resistance heat
- Improperly vented or non-vented combustion appliances
- Cleaning agents and air fresheners reacting with ozone[22]

Particulate from outdoor ventilation air:

- Mobile emissions from vehicles
- Point source emissions from industrial buildings
- Biogenic emissions – plants emit compounds that react with molecules in the air, forming particles that then enter the home[23]

### WHAT TO DO ABOUT IT:

- Filter incoming ventilation air
- Always use a range hood when cooking (even with electric cooktops) – especially when frying or sautéing
- Damp dust interior surfaces regularly and use a high efficiency vacuum cleaner



- Maintain adequate levels of ventilation, based on ASHRAE 62.2
- Use cartridge respirators when performing work that will create dust or particulate
- Keep work areas sectioned off from living areas

**RESOURCES:**

[www.epa.gov/iaq/schools/tfs/guidee.html](http://www.epa.gov/iaq/schools/tfs/guidee.html)

**Lead**

Lead is a poisonous substance to animals (including people); it is a potent neurotoxin that accumulates in both soft tissue and bones.

**WHY IT IS PROBLEMATIC:**

It damages the nervous system and causes brain disorders, among other health problems.

**WHERE YOU FIND IT:**

Historically, lead has been used extensively in building materials because of its abundance, malleability, and corrosion resistance. Currently, the primary sources of lead in homes are lead paint and soldering. Lead paint was banned in the United States in 1977 and amendments to the Safe Drinking Water Act banned lead-content plumbing materials (including solder) for drinking water systems in 1986[24]. If a house was built before 1978, you should assume that all the paint in the house is lead-based unless you have tested it and confirmed that it is lead-free.

**WHAT TO DO ABOUT IT:**

As of April 22, 2010, federal law requires that contractors performing renovation, repair, or painting projects that disturb more than 6 square feet of interior paint (or 20 square feet of exterior paint) in homes built before 1978 must be certified under EPA's Renovation, Repair, and Painting Rule.

Read about how to become an EPA Lead-Safe Certified Firm:

- [www.epa.gov/lead/pubs/lscp-renovation\\_firm.htm](http://www.epa.gov/lead/pubs/lscp-renovation_firm.htm)

Contractors who perform renovation, repairs, and painting jobs in pre-1978 housing must, before beginning work, provide owners and tenants with a copy of EPA's lead hazard information pamphlet:

*Renovate Right: Important Lead Hazard Information for Families, Child Care Providers, and Schools*

- [www.epa.gov/lead/pubs/renovaterightbrochure.pdf](http://www.epa.gov/lead/pubs/renovaterightbrochure.pdf)

Contractors must document compliance with this requirement; EPA's pre-renovation disclosure form may be used for this purpose:

- [www.epa.gov/lead/pubs/pre-renovationform.pdf](http://www.epa.gov/lead/pubs/pre-renovationform.pdf)

**RESOURCES:**

EPA Enforcement Alert: *Compliance with New Federal Lead-Based Paint Requirements*

- [www.epa.gov/compliance/resources/newsletters/civil/enfalert/leadpaint.pdf](http://www.epa.gov/compliance/resources/newsletters/civil/enfalert/leadpaint.pdf)



## Moisture Problems

Moisture in buildings creates problems, not only from the moisture directly, but from the results of the presence of moisture: mold growth, structural (wood warping and rotting) and finish damage (peeling paint). Moisture sources can be external (rain or melting snow/ice, ground water) or internal (from cooking, showering, and human bioeffluents). We should always be on the lookout for ways to reduce excess moisture sources in buildings. However, people often need to work on or live in buildings already suffering from the results of excess moisture. Given a minimum structural safety, the key health issue is from mold.

### Mold

Molds (a category of fungi) derive energy from breaking down organic matter. Mold spores are common in both outdoor and indoor air, but will only begin to grow when they land on a wet surface. Typically, mold spores need water to break down organic matter and turn it into food. Areas of persistent humidity in a home facilitate mold growth.

#### **WHY IT IS PROBLEMATIC:**

Mold growth in home has the potential to cause health problems. Molds may produce allergens, irritants, and in some cases, potentially toxic substances called mycotoxins.

Mold is especially a concern for home performance contractors because sealing up the thermal envelope of a leaky home can turn a small (undetected) moisture problem into a big one a few months later. This may lead the homeowner to conclude that the home performance contractor *caused* the mold problem -- and they would be right. To anticipate and avoid this undesirable outcome, the home performance contractor should investigate sources of moisture infiltration and humidity in the home (even ones that are not a problem currently) that will be worsened when the home's air sealing is improved.

Increased indoor humidity can also cause building materials to decay, releasing chemicals into the air and causing structural damage.

#### **WHERE DO YOU FIND IT:**

Areas of the home that have consistently high levels of humidity or moisture are susceptible to mold growth[25].<sup>16</sup>

Such areas include: Bathrooms, kitchens, laundry rooms, crawlspaces/basements, condensation in/on exterior walls, air conditioners, uninsulated duct/pipe, windows/window framing, flooded areas, leaky plumbing, window/door sills.

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<sup>16</sup> In 2006, the GREENGUARD Environmental Institute ranked US states for mold-related losses and property insurance claims as follows: Texas, Florida, Oklahoma, South Carolina, Nevada, Arizona, California, South Dakota, Tennessee, and Kansas.



**WHAT TO DO ABOUT IT:**

Mold spores are impossible to remove from indoor environments. The way to control mold is to control the moisture that allows the mold to grow. Mold growth is a symptom of a moisture problem in the home.

To retard mold growth, indoor relative humidity should have a weekly average between 30 – 60%. Exhaust fans or other forms of ventilation should be used in bathrooms, kitchens, and laundry rooms (and any other moisture-generating room/activity) to control humidity levels. ASHRAE standard 62.2 describes minimum requirements for local ventilation for these wet rooms.

If a mold problem is encountered, the first step is to identify and remediate the source of moisture that is causing the mold. After the source of moisture has been identified and eliminated, materials that have suffered mold damage should be thoroughly cleaned with a detergent and dried or replaced altogether. Absorbent materials such as carpet or ceiling tiles that have become moldy should be removed from the home and replaced.

Some species of mold produce mycotoxins that are dangerous to humans and animals. One of the most common of such “toxic molds” is black mold (*Stachybotrys chartarum*). Any mold growth in a home can cause health problems, especially for the young, the old, the infirm, and people with existing respiratory conditions. Only very minor mold problems can be safely handled by a home performance contractor.

Proceed only if you are confident that you can identify the source of the moisture problem, fix it, and clean or replace all affected materials in the home. If at any point you have any doubt about the severity of the problem, stop work and inform the homeowner that they need to contact a trained mold remediation contractor to remedy the problem before you can proceed[26].

Exercise caution when performing a blower door test on a house with a moisture problem. Depressurizing a house with a moisture problem has the potential to distribute mold spores throughout the living space. An alternative is to pressurize the house instead, but this should only be done when the moisture problem is minor and pressurization will not distribute the air from the affected area to other parts of the home. Again, if in doubt, stop work and advise the homeowner to contact a mold professional and have the problem remediated before performing a blower door test or air sealing.

### RESOURCES:

Guides for mold assessment and remediation:

- *Mold Remediation in Schools and Commercial Buildings* - U.S. EPA, Washington, D.C. [www.epa.gov/mold/pdfs/moldremediation.pdf](http://www.epa.gov/mold/pdfs/moldremediation.pdf)
- *A Brief Guide to Mold, Moisture, and Your Home* - U.S. EPA, Washington, D.C. [www.epa.gov/mold/pdfs/moldguide.pdf](http://www.epa.gov/mold/pdfs/moldguide.pdf)
- *Assessment & Remediation of Fungi in Indoor Environments* - New York City Department of Health. [www.nyc.gov/html/doh/downloads/pdf/epi/epi-mold-guidelines.pdf](http://www.nyc.gov/html/doh/downloads/pdf/epi/epi-mold-guidelines.pdf)
- *Bioaerosols: Assessment and Control* - American Conference of Governmental Industrial Hygienists (ACGIH®), Cincinnati, OH.
- *Standard and Reference Guide for Professional Mold Remediation S520* - Institute of Inspection, Cleaning, and Restoration Certification (IICRC), Vancouver, WA.
- *Assessment, Cleaning, & Restoration for HVAC Systems/ACHR 2005* - National Air Duct Cleaners Association (NADCA), Washington, D.C. [www.nadca.com/download/ACR%202006%20-%20March%202006.pdf](http://www.nadca.com/download/ACR%202006%20-%20March%202006.pdf)

Proposed Federal Legislation:

- (HR 1268) *The United States Toxic Mold Safety and Protection Act* [www.theorator.com/bills108/hr1268.html](http://www.theorator.com/bills108/hr1268.html)
- (HR 1269) (Proposal to amend the Toxic Substances Control Act to include toxic mold) [www.theorator.com/bills109/hr1269.html](http://www.theorator.com/bills109/hr1269.html)

### Pests

“Pests” are unwanted non-human animals that reside some place where we don’t want them – such as in our homes. Pests often cause damage, present health risks, and compete with humans for resources. Different species of pests predominate in each geographical region of the US. However, the most successful house pests are generalist species who have adapted to live in multiple environments and in close proximity to humans.<sup>17</sup>

### WHY IT IS PROBLEMATIC:

Pests in homes damage materials and equipment, reducing their performance or even making them unsafe to operate (e.g. a mouse that has chewed through electrical wiring insulation, creating a shock or fire hazard). Their wastes produce odors and may introduce pathogens into the human living space. In homes with forced air heating and/or cooling, pests often inhabit the same space as the furnace and

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<sup>17</sup> Humans themselves are perhaps the most successful generalist species.

ducts. If these ducts have leaks and are depressurized (e.g. return ducts), they can distribute pest-borne pathogens throughout the house via the HVAC system. Some pests – such as termites – feed on organic materials such as wood, degrading the building’s performance or making it structurally unsafe.

**WHERE YOU FIND IT:**

Common pest locations:

- *Dust and bedding:* Dust mites (for more information see Particulate Matter and Dust section)
- *Foundation, structure:* Termites, carpenter ants, wood-boring beetles
- *Crawlspace, attic, chimneys, and flues:* bats, birds, mice, opossum, raccoons



**BATS IN AN ATTIC**



**TERMITE DAMAGE**

**WHAT TO DO ABOUT IT:**

If you see evidence of significant past or current pest habitation, it will need to be remediated. If you are unsure or uncomfortable dealing with the situation, stop work and inform the homeowner and instruct them to contact a pest management professional (PMP) who practices integrated pest management (IPM) to remedy the problem. IPM does not use biocides, which can introduce their own health and safety

problems into the home. Qualified PMPs can be found via the QualityPro ([www.npmaqualitypro.org](http://www.npmaqualitypro.org)) or GreenShield ([www.greenshieldcertified.org](http://www.greenshieldcertified.org))

websites. Only continue work in that area after the pest problem has been remediated.

If you opt to remedy the pest problem yourself, first determine whether or not the pests are still present. If they are, take the necessary precautions and remove them. Next, determine how the pests are/were entering the space. Seal up or modify any openings as necessary in order to prevent the pests from returning to the area. If the attic or crawlspace is vented, make sure that adequate ventilation is maintained and that you do not seal up vents in the course of “pest-proofing” the space. This may entail modifying an existing vent with a finer-mesh material with smaller openings. Finally, taking the necessary personal protective equipment precautions, clean and repair any damage caused by the pests, verifying that you have eliminated any lingering air quality and/or health concerns.

#### **RESOURCES:**

National Pest Management Association, Inc.

- [www.pestworld.org](http://www.pestworld.org)

QualityPro

- [www.npmaqualitypro.org](http://www.npmaqualitypro.org)

GreenShield

- [www.greenshieldcertified.org](http://www.greenshieldcertified.org)

## **Polychlorinated Biphenals (PCBs)**

Polychlorinated biphenals (PCBs) are odorless, tasteless, synthesized compounds that are a clear to pale-yellow viscous liquid at room temperature.

They were first manufactured commercially in 1927 as a cooling and insulating fluid for electrical transformers and capacitors. PCBs are valued for their chemical stability as well as their insulating and electrical properties. The production of PCBs and most uses of PCBs were banned by the EPA in 1979[27].

#### **WHY IT IS PROBLEMATIC:**

PCBs have been demonstrated to cause a variety of adverse health effects in humans, including damage to the immune, reproductive, nervous, and endocrine systems, as well as cancer. Chemically, they are very stable and build up in our fat cells when ingested (that is, they are bio-accumulative). Because of past exposure, everyone’s body now contains some level of PCBs. PCBs readily penetrate skin and latex.

#### **WHERE YOU FIND IT:**

PCB-containing materials relevant to home performance contractors include pre-1979 magnetic fluorescent lamp ballasts, plasticizers in paints and cements, PVC coatings of electrical wiring, sealants, thermal insulation (wool felt, foam rubber, and fiberglass), adhesives, and wood floor finishes[28].

Caulk in homes built or renovated from 1950 – 1978 may contain PCBs. A report published in 1999 by the EPA stated that “the use of PCB-contaminated fiberglass insulation may be widespread throughout the United States.”[28]



Most uses of PCBs were banned in the United States in 1979. There is no easy way to visually identify PCB-containing materials. If you encounter any of the materials listed above manufactured between 1950 -1979, you should assume they contain PCBs.

**WHAT TO DO ABOUT IT:**

If you are going to be doing work that exposes you to potentially PCB-containing material (materials listed above manufactured 1950 - 1979), wear PCB-impervious coveralls and a cartridge respirator. Thoroughly clean up any potentially PCB-contaminated debris and collect it separately from other debris. To find out where to dispose of PCB-contaminated materials in your area, call the Toxic Substances Control Act (TSCA) information hotline at (202) 554-1404 or your regional PCB coordinator at (888) 835-5372.

**RESOURCES:**

*Preventing Exposure to PCBs in Caulking Material* [29]

Regional EPA PCB Contacts:

- [www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/coordin.htm](http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/coordin.htm)

## **Polyvinyl Chloride (PVC)**

Polyvinyl chloride (PVC) is a kind of plastic used in multiple building materials as well as many everyday products. In its rigid form it is used extensively in our buildings as PVC piping, window frames, doors, gutters, and vinyl siding. In its flexible form it is used in cements, electrical wire insulation, carpet backing, roofing membranes and flashing, and flooring. PVC is widely used because it is both highly versatile and inexpensive.

**WHY IT IS PROBLEMATIC:**

Metal stabilizers are used in PVC to prevent degradation from heat during processing and from exposure to ultraviolet light during the useful life of a product [30]. They include lead, cadmium, and newer substances called organotins. These metals will leach out of PVC products. Lead migrates out of PVC window blinds [31] and into water carried in PVC pipes [32]. Lead is a known cause of neurodevelopmental problems and cadmium causes cancer and kidney damage.

Organotin stabilizers were introduced to replace toxic metal stabilizers, but they have also been found to leach from PVC products [33, 34]. Like lead and cadmium, organotins are toxic. They affect the central nervous system, skin, liver, immune system, and reproductive system [30, 35].

In the event of a house fire, the chlorine contained in PVC materials may be released. Burning PVC releases multiple toxic gasses distinct to PVC, including hydrogen chloride gas, dioxins, and furans. Hydrogen chloride gas is highly combustible and can cause chemical burns to skin, lungs, and mucous membranes.<sup>18</sup> Dioxins and furans have been found to be bio-accumulative, carcinogenic, and endocrine-disrupting.<sup>19</sup>

### Flexible PVC “Off gassing”

During the course of making flexible PVC, substances called plasticizers that make the PVC more pliable and durable are added. These plasticizers often contain phthalates, which have been shown to cause

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<sup>18</sup> When hydrogen chloride gas comes in contact with the mucous lining of the lungs, it is converted to hydrochloric acid that can cause severe and permanent respiratory damage.

<sup>19</sup> Though their full discussion is beyond the scope of this document, there are many health, safety, and environmental concerns associated with the production and disposal lifecycle phases of PVC products. For more information, see Appendix 3: Overview of hazards with PVC production, use, and disposal.

developmental [36] and reproductive damage [37], altered liver [38] and kidney function [39], and have been linked to the development of respiratory problems in children [40] [41].

The plasticizers are mixed in with PVC, but not chemically bound to it. In new plasticized PVC materials, often the phthalates will evaporate (“off gas”) into the surrounding air, where they reduce indoor air quality and expose inhabitants to ingestion. This is one component of the “new car smell” people associate with many new products. Phthalates may also leach into water or other liquids contacting the flexible PVC [42].<sup>20</sup>

### Leaching from Rigid PVC

Components of PVC have also been found to leach from PVC pipes. In a study of rigid PVC pipe, vinyl chloride was detected in water after 30 days at 2.5 parts per billion (ppb), a level that exceeds the USEPA drinking water standard of 1 ppb [43]. Smaller pipe size, longer line length, and warm temperatures all increase the likelihood of vinyl chloride leaching from PVC pipes[42].

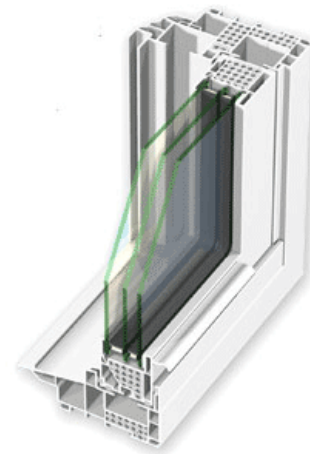
### WHERE YOU FIND IT:



VINYL SIDING



RIGID PVC PIPE



VINYL WINDOW FRAME



PVC FLASHING

### WHAT TO DO ABOUT IT:

More healthy and safe alternatives exist for every application of PVC. Resources for finding alternatives for some PVC materials most likely to be encountered by home performance contractors are listed below.

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<sup>20</sup> European REACH legislation banning some phthalates: [pubs.acs.org/cen/news/89/i08/8908news2.html](https://pubs.acs.org/cen/news/89/i08/8908news2.html)  
[www.healthybuilding.net/news/110222-european-chemical-ban-will-reach-us-building-materials.html](http://www.healthybuilding.net/news/110222-european-chemical-ban-will-reach-us-building-materials.html)

### PVC pipe

There are viable PVC-free alternatives for every application of PVC piping. Depending on the application, these alternative piping materials may include: cast iron, concrete, copper, ductile iron, steel, high-density polyurethane (HDPE), PEX (a type of HDPE), or vitrified clay.

Healthy Building Network's PVC-Free Pipe Purchaser's Report:

- [www.healthybuilding.net/pvc/pipes\\_report.pdf](http://www.healthybuilding.net/pvc/pipes_report.pdf)

### Vinyl siding<sup>21</sup>

Depending on your climate and local conditions, viable PVC-free cladding materials may include: stucco, stone veneer, cement fiber, wood, brick/brick veneer, and engineered wood.

### Vinyl windows

Vinyl has been a desirable material for window frames because of its low thermal conductivity and low maintenance compared to wood.

Viable PVC-free window frame materials that offer comparable thermal performance to vinyl windows include fiberglass and wood.

### PVC flashing and roofing membranes

Viable material alternatives to PVC flashing and roofing membranes include: Thermoplastic polyolefins (TPOs) membranes, EPDM (ethylene propylene diene monomer) membranes

### Vinyl Flooring

Vinyl-free durable flooring options include:

Wood, bamboo, linoleum, cork, terrazzo, concrete, and rubber

Alternatives to vinyl flooring:

- [www.healthybuilding.net/pvc/PVCFreeResilient.html](http://www.healthybuilding.net/pvc/PVCFreeResilient.html)
- [www.healthybuilding.net/docs/HBN-ResilientFlooring&ChemicalHazards-Report.pdf](http://www.healthybuilding.net/docs/HBN-ResilientFlooring&ChemicalHazards-Report.pdf)

### **RESOURCES:**

General information about PVC risks:

- [www.healthybuilding.net/pvc/Thornton\\_Enviro\\_Impacts\\_of\\_PVC.pdf](http://www.healthybuilding.net/pvc/Thornton_Enviro_Impacts_of_PVC.pdf)
- [www.besafenet.com/pvc/documents/PVC-Guide-1.pdf](http://www.besafenet.com/pvc/documents/PVC-Guide-1.pdf)

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<sup>21</sup> Unless it is being burned, vinyl siding does not itself represent a direct health risk to workers or homeowners. However, the creation of harmful substances – such as dioxins – is inherent in the product's manufacture and eventual disposal. (for more information, see Appendix 3: Overview of hazards with PVC production, use, and disposal)



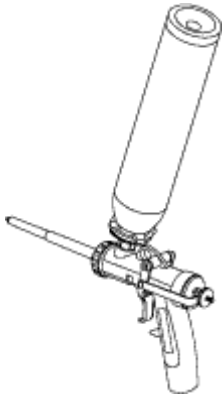
- [www.besafenet.com/pvc/documents/bad\\_news\\_comes\\_in\\_threes.pdf](http://www.besafenet.com/pvc/documents/bad_news_comes_in_threes.pdf)
- [www.abag.ca.gov/bayarea/dioxin/pilot\\_projs/PVC\\_FAQ.pdf](http://www.abag.ca.gov/bayarea/dioxin/pilot_projs/PVC_FAQ.pdf)

## Spray Polyurethane Foam (SPF)

Spray polyurethane foam (SPF) is a widely used and highly effective insulator and sealant. It is sprayed as a liquid and then expands significantly and hardens, filling even hard-to-reach gaps in the home's thermal envelope. Closed cell SPF is both an air and moisture barrier and an effective insulator.<sup>2223</sup>

### WHAT IT LOOKS LIKE:

#### One-part canned SPF



#### **ONE-PART CANNED SPF WITH APPLICATOR GUN**

Canned SPF is used for filling small areas such as gaps between framing members or around utility penetrations. The components in one-part SPF are pre-reacted, but they undergo further reaction with ambient moisture at the time of application.

#### Two-part SPF

Two-part SPF can be low pressure or high pressure, and it can be open cell or closed cell. "Open cell" SPF is lower density, lower R-value (3.5 per inch), softer, and typically uses water as a blowing agent. "Closed Cell" SPF is higher density, higher R-value (6.0 per inch), and typically uses hydrofluorocarbon (HFC) blowing agents[44].

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<sup>22</sup> [www.polyurethane.org/s\\_api/bin.asp?CID=885&DID=3853&DOC=FILE.PDF](http://www.polyurethane.org/s_api/bin.asp?CID=885&DID=3853&DOC=FILE.PDF)

<sup>23</sup> [www.epa.gov/dfe/pubs/projects/spf/spray\\_polyurethane\\_foam.html](http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html)



**A TWO-PART LOW PRESSURE SYSTEM THAT  
MAY BE USED BY PROFESSIONALS OR EVEN  
INTREPID HOMEOWNERS**



**TWO-PART, HIGH PRESSURE, CLOSED CELL FOAM BEING APPLIED TO A CATHEDRAL CEILING**



**TWO-PART, HIGH PRESSURE, CLOSED CELL FOAM BEING APPLIED TO ALTERNATING WALL STUD BAYS**

**WHY IT IS PROBLEMATIC:**

In combining parts A and B on-site, foam insulation installers follow the same basic steps that occur in industrial polyurethane factories, but in a far more confined space. Two-part closed cell SPF is composed of 1) a synthesized substance called isocyanate and 2) a mix containing substances called polyols (which

react with isocyanate to form the cells), catalysts (which trigger the two-part reaction), and flame retardants.

Isocyanates are powerful irritants to skin and the mucous membranes. Skin and/or respiratory exposure to isocyanates can cause severe asthma attacks. Allergic reactions to exposure may be delayed several hours and include: itchy and watery eyes, skin rashes, asthma, and other breathing difficulties.

People who may not experience respiratory symptoms the first time they are exposed to isocyanates may be “sensitized” (become allergic) to the substance. Some workers who become sensitized to isocyanates are subject to severe asthma if they are exposed again. The National Institute of Occupational Safety and Health (NIOSH) has documented multiple instances in which workers have developed chronic, sometimes fatal respiratory problems as a result of occupational isocyanate exposure[45].

A common catalyst in SPF is lead naphthenate[46]. As discussed elsewhere in this document, lead is a potent neurotoxin.

A common flame retardant in SPF is Tris (1-Chloro-2-Propyl) Phosphate or “TCPP.” The Healthy Building Network has listed TCPP as a probable carcinogen[46]. Like PVC, TCPP contains chlorine and will release chlorine gas if burned.

There are significant health and safety concerns regarding potential structural fires in homes insulated with SPF. SPF is treated with flame retardants to prevent it from staying alight, but if exposed to temperatures above approximately 700° F (371° C), SPF will burn uncontrolled[47]. Burning SPF releases isocyanates and hydrogen cyanide[48]. The effects of isocyanate exposure are discussed above. Hydrogen cyanide gas is both explosive and extremely poisonous[49]. In the case of a house fire, these gases (in addition, obviously, to the fire itself) may pose a grave threat to both the home’s residents and to emergency response personnel.

Until the SPF has hardened or “cured”, it still contains unreacted chemicals that can be ingested. The EPA states that following an SPF application “it is not clear how much time is needed before it is safe for unprotected workers or building occupants to re-enter”, but that “some manufacturers recommend 23 to 72 hours for two-component applications.”[48]

#### **WHAT TO DO ABOUT IT:**

If SPF insulation is being installed, precautions should be taken to reduce the health and safety risks to both workers and the home’s residents. These precautions should include educating workers about the risks associated with SPF and the personal protective equipment (PPE) they will need to help minimize these risks. PPE should include protection for the workers’ eyes, skin, and respiratory system, both during and after installation. See resources section for SPF PPE guide.

Thoroughly review the label of the product(s) you are using for ingredients, hazards, directions, safe work practices, and precautions. Maintain high levels of outdoor-air ventilation in the spaces undergoing the SPF work and keep them isolated from other habitable areas of the home if possible. Establish a prudent, safe re-entry “cure” time for unprotected workers and occupants to return to the affected space. The minimum re-entry time should be that required by the manufacturer.

#### **RESOURCES:**

Preventing Asthma and Death from Diisocyanate Exposure DHHS

- [www.cdc.gov/niosh/docs/96-111/](http://www.cdc.gov/niosh/docs/96-111/)

EPA overview of isocyanates

- [www.epa.gov/dfe/pubs/projects/spf/isocyanates\\_background\\_information.html#ov](http://www.epa.gov/dfe/pubs/projects/spf/isocyanates_background_information.html#ov)

[erview](#))

EPA Guide to SPF

- [www.epa.gov/dfe/pubs/projects/spf/spf\\_basic\\_information.html#longterm](http://www.epa.gov/dfe/pubs/projects/spf/spf_basic_information.html#longterm)

A visual PPE guide for SPF installation is available at:

- [209.190.222.88/ppe\\_sheet](http://209.190.222.88/ppe_sheet)

## **Volatile Organic Compounds (VOCs)**

What are VOCs and where can they be found, according to the EPA:

“Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials, furnishings, glues and adhesives.

Studies have found that levels of several organics average 2 to 5 times higher indoors than outdoors. During and for several hours immediately after certain activities, such as paint stripping, levels may be 1,000 times background outdoor levels.”

### **WHY IT IS PROBLEMATIC:**

Health risks of VOCs, according to the EPA

“Eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, dizziness.

The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those with no known health effect. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed. Eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics. At present, not much is known about what health effects occur from the levels of organics usually found in homes. Many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans.”

### **WHERE YOU FIND IT:**

Some of the most common VOCs include:

- Formaldehyde (multiple sources - see Formaldehyde section)
- Acetaldehyde (combustion, plastics, cleaning products)
- Benzene (from fuels, paint supplies, auto emissions)
- Methylene chloride (paint strippers, adhesive removers, spray paints)

- Acetone (nail polisher remover, other household products)
- Perchloroethylene (dry cleaning)

**WHAT TO DO ABOUT IT:**

- Identify and remove/reduce the sources of VOCs
- Increase ventilation and/or use cartridge respirators when using VOC-containing materials
- Do not store VOC-containing materials inside the living area or in locations (such as the crawlspace, attic, or garage) where VOC fumes can enter the home through the HVAC system or via infiltration
- Eliminate the need for pesticides using integrated pest management (IPM) – see Pests section for more information

**RESOURCES:**

Healthy Building Network guide to Low-VOC paints

- [www.healthybuilding.net/healthcare/Low-VOC-Paint-Listing.pdf](http://www.healthybuilding.net/healthcare/Low-VOC-Paint-Listing.pdf)

EPA guide to VOCs

- [www.epa.gov/iaq/voc.html](http://www.epa.gov/iaq/voc.html)

## ELECTRICAL SHOCK AND FIRE HAZARDS

*Electrical wiring that was improperly designed, improperly installed, or has become damaged both worsens the performance of the home's electrical system and may represent a fire hazard. Installing insulation over faulty wiring can both increase the fire hazard and make it harder to identify and repair the problems in the future. Knob and tube wiring is discussed in its own section.*

## Aluminum Wiring



Some homes wired between 1965-1973 contain electrical wiring made out of aluminum instead of copper. The wire connecting the electrical meter to the home's service panel (the "service entrance") is aluminum in most homes, but this topic is concerning aluminum electrical wiring originating at the service panel and coming *into* the home.

### WHY IT IS PROBLEMATIC:

Copper is 50% more electrically conductive than aluminum[50]; therefore, aluminum wires must be a larger gauge to carry the same current as a smaller gauge copper wire. This difference in conductivity was not always accounted for in homes containing both copper and aluminum wiring, resulting in under-sized aluminum wiring.

In addition to differences in conductivity, aluminum has a higher coefficient of thermal expansion than copper. [51] Connections between copper and aluminum wiring are subject to galvanic corrosion, oxidation, and loosened mechanical connections. All of these factors make residences containing both aluminum and copper wiring prone to fire hazard via overheating (overcurrent) and arc flashing.<sup>24</sup>[52] Putting thermal insulation over aluminum wiring exacerbates the fire hazard and makes it more difficult to identify, repair, or replace the wiring later.

### WHERE YOU FIND IT:

Homes built, rooms added, and circuits rewired or added between 1965 and 1973 may contain aluminum wiring. The United States Consumer Products Safety Commission (CPSC) estimates that approximately 2 million homes were built with aluminum wiring between 1965 and 1973[53]. This number of homes represents roughly 12% of homes built during that time period<sup>25</sup> and would presumably represent approximately 1.5% of all existing US homes as of 2009[54].

Look for the word "Aluminum" printed or embossed on the plastic wire jacket where wiring is visible. At connections, look for bare wire that is silver in color.

### WHAT TO DO ABOUT IT:

According to the CPSC, aluminum wiring should be repaired one of two ways:

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<sup>24</sup> In 1974, the US Consumer Product Safety Commission determined that homes wired with aluminum wire manufactured before 1972 are 55 times more likely to have one or more connections reach "Fire Hazard Conditions" than is a home wired with copper alone.

<sup>25</sup> This number was approximated by examining the number of homes built between 1960-1974, the most closely-aligning range of dates available in the survey.

- 1) hiring a COPALUM-certified<sup>26</sup> electrician to re-connect every copper-to-aluminum wiring connection **or**
- 2) replacing all aluminum wiring with copper wiring

If you see aluminum wiring in a home, *do not* insulate over it. Explain to the homeowner that the wiring needs to be inspected and repaired or replaced before the affected component of the home performance retrofit can proceed.

**RESOURCES:**

CPSC guide to Repairing Aluminum Wiring

- [www.cpsc.gov/cpscpub/pubs/516.pdf](http://www.cpsc.gov/cpscpub/pubs/516.pdf)

**Faulty Wiring**

No matter what kind of electrical wiring is installed in the home, you should check its condition before insulating over it. Infrared thermography can be used to identify electrical hot spots.

**WHERE YOU FIND IT:**

Especially examine wiring in any location where you plan to insulate. Look for:

- Connections that are loose or corroded
- Exposed wires where the insulation has come off
- Open splices not contained within a junction box
- Wire whose gauge is undersized for its load
- Lighting fixtures that are being supported by electrical wires
- Staples or straps that may have punctured wire insulation

In addition to visual inspection, it's good to check the voltage drop of the longest branch circuit with a circuit analyzer. The National Electric Code (NEC) suggests that the voltage drop from the main panel to the farthest branch circuit in the house should be no more than 5%<sup>[55]</sup>. The voltage drop of a circuit indicates the inefficiency of the transmission of electricity from the main panel to the outlet.<sup>27</sup> Electricity that doesn't reach the outlet is encountering resistance and being lost as heat somewhere along the circuit. This loss means wasted energy in the form of heat. If the electrical resistance is too great (generally a voltage drop >8%<sup>28</sup>), it can constitute a fire hazard, especially under large current loads. Placing thermal insulation over a circuit with a high voltage drop both exacerbates the fire hazard and makes it more difficult to repair the wiring.

**WHAT TO DO ABOUT IT:**

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<sup>26</sup> COPALUM is a proprietary crimping system designed for repairing aluminum wiring. It is owned by Tyco Electronics and is the only method of repair (short of rewiring) approved by the US Consumer Product Safety Commission.

<sup>27</sup> This is the electrical equivalent of performing a duct leakage test.

<sup>28</sup> An 8% voltage drop limit is a conservative estimate based on typical residential circuit loads. Local inspectors or governing bodies may use their own judgment on an acceptable level of voltage drop for the electrical system. For example, the Philadelphia Housing Development Corporation requires that circuits with voltage drops of 10% or greater be repaired or replaced before they are insulated over.



If you encounter faulty wiring, do not insulate over it. Stop any affected component of the retrofit and inform the homeowner that the wiring must be repaired by an electrician before the retrofit work can proceed.

**RESOURCES:**

Kinney, L. (1995). "Assessing the Integrity of Electrical Wiring." *Home Energy*: 5,6.

- [www.homeenergy.org/show/article/nav/roofandattic/page/5/id/1148](http://www.homeenergy.org/show/article/nav/roofandattic/page/5/id/1148)

**Heat Tape**

Heat tape is a flexible electrical resistance element that is wrapped around water pipes to keep them from freezing during the winter months in colder climates. The element has a built-in thermostat that is designed to heat the pipe only when the surrounding temperature is approaching freezing.

**WHERE YOU FIND IT:**

On water pipes:

- running through attics
- in unheated crawl spaces and sub-structures of mobile homes
- in unheated garages
- running under porches

**WHY IT IS PROBLEMATIC:**

If improperly installed and maintained, heat tape can pose both a shock hazard and a fire hazard. Because it is located in areas that are hard to access and rarely frequented, heat tape can degrade and cause damage without being noticed.



© 2011 InspectAPedia.com  
HEAT TAPE AROUND PIPE (CHARRING LIKELY CAUSED BY BRAZING)

(IMAGE VIA INSPECTAPEDIA.COM)

**WHAT TO DO ABOUT IT:**

If at all possible, the best solution for heat tape is to eliminate the need for it by insulating the pipes and/or expanding the home's thermal boundary to include the water pipes. If the plumbing is not going to be used for an extended period of time (e.g. if the occupants are on vacation or only use the house during the summer) then the water supply line should be turned off and all the pipes drained.

If heat tape *must* be used, make sure it's designed for your type of water line. Before insulating over heat tape, verify that it can be safely insulated over. Do not wrap heat tape over itself unless

specifically permitted in the manufacturer's instructions. Always plug heat tape into a GFCI (ground-fault circuit-interrupter) outlet. Please consult the CPSC's heat tape safety alert linked below.

**RESOURCES:**

New Electric Heat Tapes Help Prevent Fires: Safety Alert

- [www.cpsc.gov/cpscpub/pubs/5045.html](http://www.cpsc.gov/cpscpub/pubs/5045.html)

**Knob and Tube Wiring**

Knob and Tube electrical wiring was installed in homes until the 1940s. It consists of copper wires insulated by a flexible fabric sleeve. Ceramic "tubes" allow the wires to pass through joists and studs; ceramic "knobs" hold the wire in place, protect it, and give it structure. Knob and Tube wiring differs from contemporary wiring in (at least) three important ways:

1. The hot and neutral wires are run separately, coming together only at outlets.
2. The wires were sized assuming that heat can dissipate into the surrounding air
3. Knob and Tube wiring is not grounded



**KNOB AND TUBE WIRING IN A WALL AND CEILING**



**KNOB AND TUBE WIRING IN AN ATTIC**

**WHY IT IS PROBLEMATIC:**

**If properly installed and maintained, knob and tube wiring can be as safe as contemporary nonmetallic sheathed cable wiring. Any time you are insulating over existing electrical wiring, the wiring system should be checked for integrity and safety to identify potential fire and/or shock hazards. (See Faulty Wiring section for more details)** Checking the integrity and safety of knob and tube wiring requires particular attention. If a home has knob and tube wiring, you know that the wiring is *at least* 70 years old (as of 2011). Even if it was initially designed and installed properly, old wiring has had time to degrade and to have undergone modifications by untrained personnel. Moreover, electrical demand of appliances in contemporary homes is significantly higher than that of homes of the 1940s, meaning that much knob and tube wiring is now undersized.

The National Electric Code requires that attics and walls with knob and tube wiring *not* be insulated in such a manner that the insulation envelops the wire. However, based on their own findings, multiple state and local codes have amended the NEC to allow for insulation that envelops knob and tube wiring, given that certain conditions (including inspection and certification by a licensed electrical contractor) are met. States that currently provide conditional allowances for installing thermal insulation over knob and tube wiring include: Nebraska, Washington, Oregon, and California.

**WHAT TO DO ABOUT IT:**

Because of its age, knob and tube wiring should be inspected regularly for safety and integrity. If retrofitting a home with knob and tube, determine whether or not your area allows the installation of insulation over knob and tube wiring. Some professional institutions require the removal of knob and tube wiring, irrespective of what local code allows.

If the electrical code in your area does not permit insulation over knob and tube wiring (i.e. they follow NEC 324-4, unaltered), then you must inform the homeowner that you cannot install insulation until an electrician replaces knob and tube wiring with nonmetallic sheathed wiring.<sup>29</sup>

If your area *does* allow insulation over knob and tube wiring, consult the pre-conditions that must be met for it to be permitted. Typically, the requirements include an inspection of the condition of the wiring by a licensed electrician and installed over-current protection provided by a properly-sized Type S fuse or circuit breaker. [56, 57]

Keep in mind that in choosing to insulate over knob and tube wiring, you're effectively committing the homeowner to that wiring for the life of the insulation. Any insulation installed over knob and tube must be non-combustible and non-conductive. Spray foam insulation should *never* be used to cover knob and tube wiring[58].

**RESOURCES:**

Overview of retrofit issues with knob and tube wiring:

- [www.creia.org/files/public/knob\\_tube\\_locked.pdf](http://www.creia.org/files/public/knob_tube_locked.pdf)

State codes conditionally allowing thermal insulation over knob and tube wiring:

California

- [cbpcapublicutilities.org/wp-content/uploads/2010/12/title24\\_part03\\_page0280.pdf](http://cbpcapublicutilities.org/wp-content/uploads/2010/12/title24_part03_page0280.pdf)

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<sup>29</sup> Current (2011) cost estimates of rewiring an entire house start around \$3000 and can exceed \$10000, depending heavily on multiple factors including location, condition, age, and size of the home.

Nebraska

- [www.neo.ne.gov/wx/2010%20Work%20Measures%20\(Final\)-booklet.pdf](http://www.neo.ne.gov/wx/2010%20Work%20Measures%20(Final)-booklet.pdf)

Washington

- [apps.leg.wa.gov/wac/default.aspx?cite=296-46B-394](http://apps.leg.wa.gov/wac/default.aspx?cite=296-46B-394)

Oregon

- [www.ohcs.oregon.gov/OHCS/CRD/energyWX/pdfs/5-Section1\\_Attic.pdf?ga=t](http://www.ohcs.oregon.gov/OHCS/CRD/energyWX/pdfs/5-Section1_Attic.pdf?ga=t)

### **Recessed Lighting**

A recessed or “can” light is a light fixture that is inserted into a hollow opening in the ceiling. Recessed lights are most effectively (and efficiently) used to illuminate a specific area for a specific task, but they have also been used to provide general ambient lighting. Recessed lighting fixtures are rated as either “insulation contact” (IC) or “non-insulation-contact” (Non-IC).

Insulation can be installed in direct contact with the housing of IC fixtures. Insulation must typically be kept at least three inches from the housing of non-IC fixtures. The main function of the housing is to ensure that no flammable materials (such as thermal insulation) come into contact with the hot lighting fixture. Some IC fixtures are designed to be air tight.

#### **WHAT THEY LOOK LIKE:**

IC fixtures have two metal housings with a gap in between to dissipate heat. Whereas non-IC fixtures just have a single housing. Consult the manufacturer and model number to determine whether or not a specific fixture is IC or non-IC.



**INSULATION CONTACT (IC) RECESSED FIXTURE**

**NON-INSULATION-CONTACT (NON-IC) RECESSED FIXTURE**

#### **WHY IT IS PROBLEMATIC:**

Installing insulation over non-IC recessed lighting introduces a fire hazard into the home. Even IC rated fixtures have a safe maximum wattage rating for their lamps.

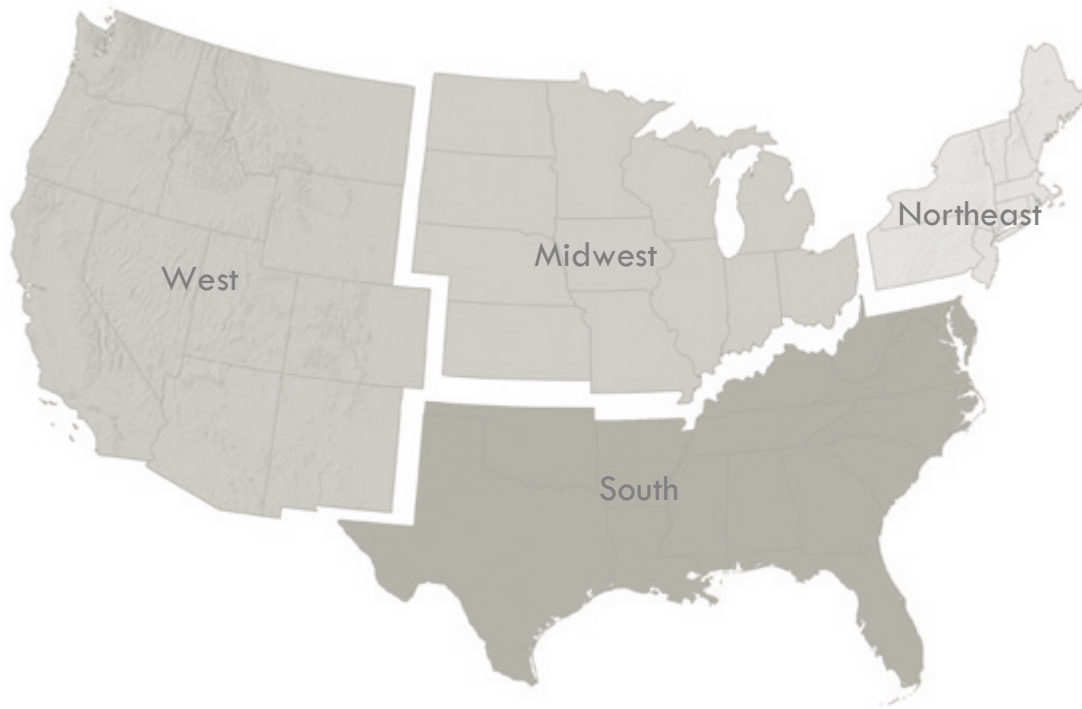
#### **WHAT TO DO ABOUT IT:**

Before installing insulation over a ceiling containing recessed light fixtures, determine beforehand whether they are IC or non-IC fixtures. If they are non-IC fixtures, baffles must be installed to provide the required separation between the insulation and the fixture. These baffles must be constructed and will reduce the efficacy of the insulation significantly. It often more cost effective (especially over the long term) to replace the non-IC fixtures with IC fixtures or – even better -- surface mounted lighting and insulate the attic space completely.

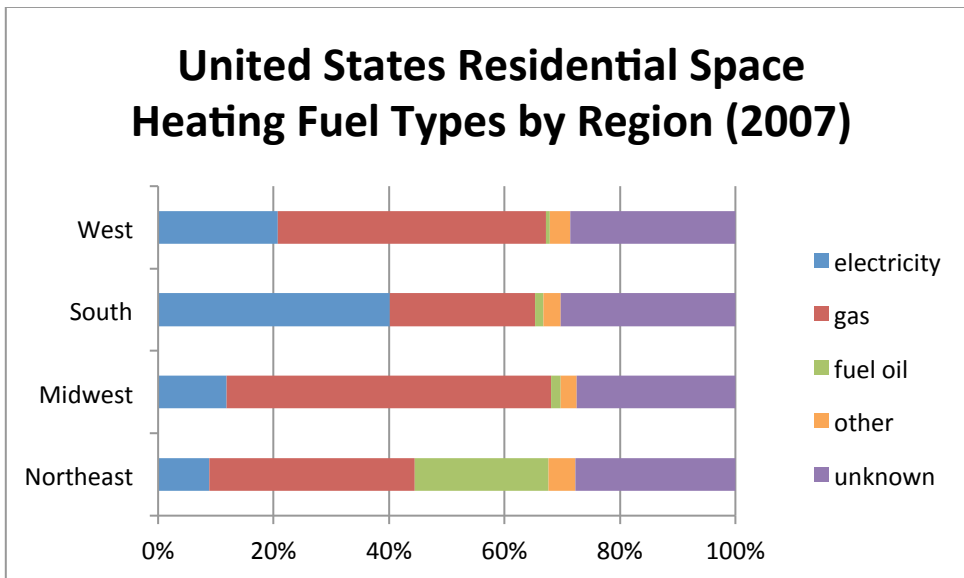


## APPENDICES

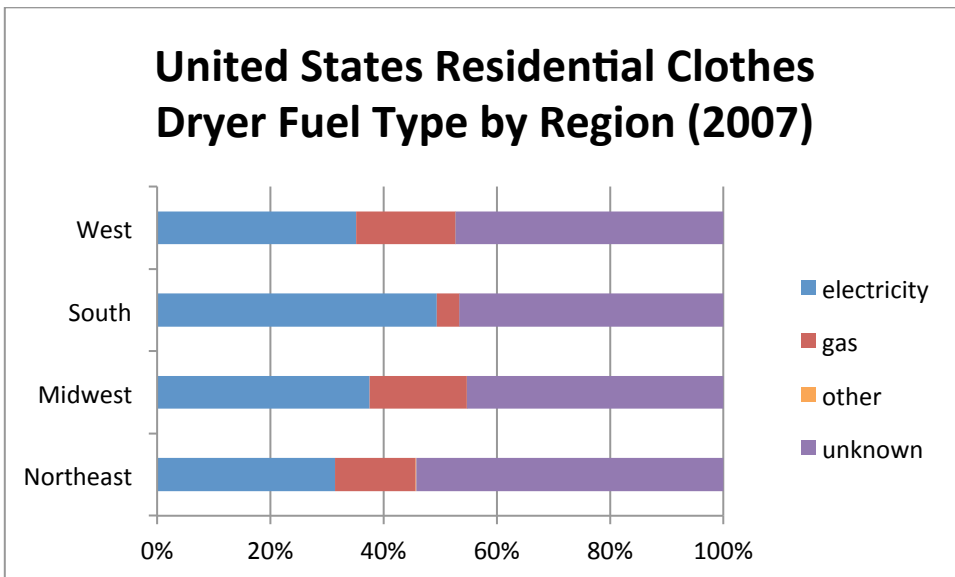
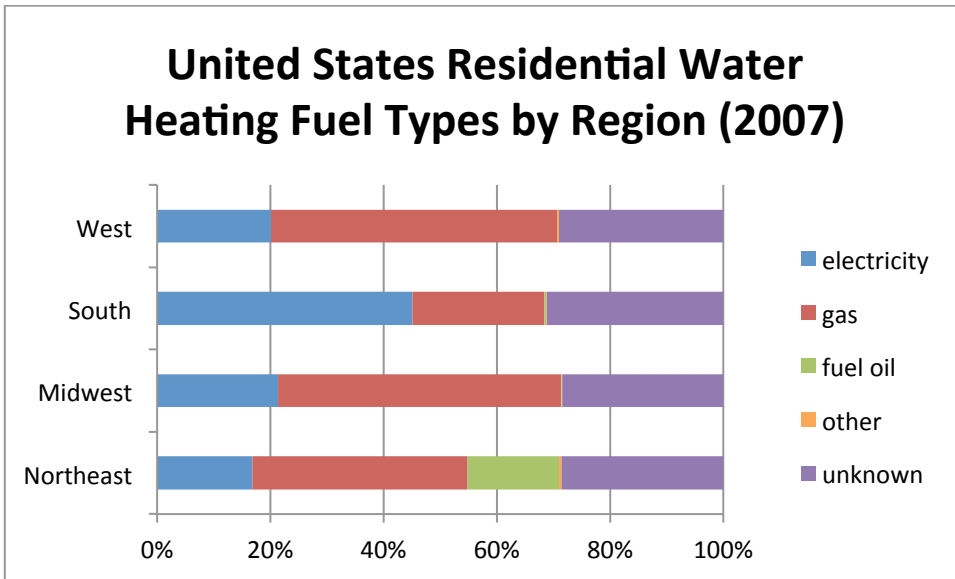
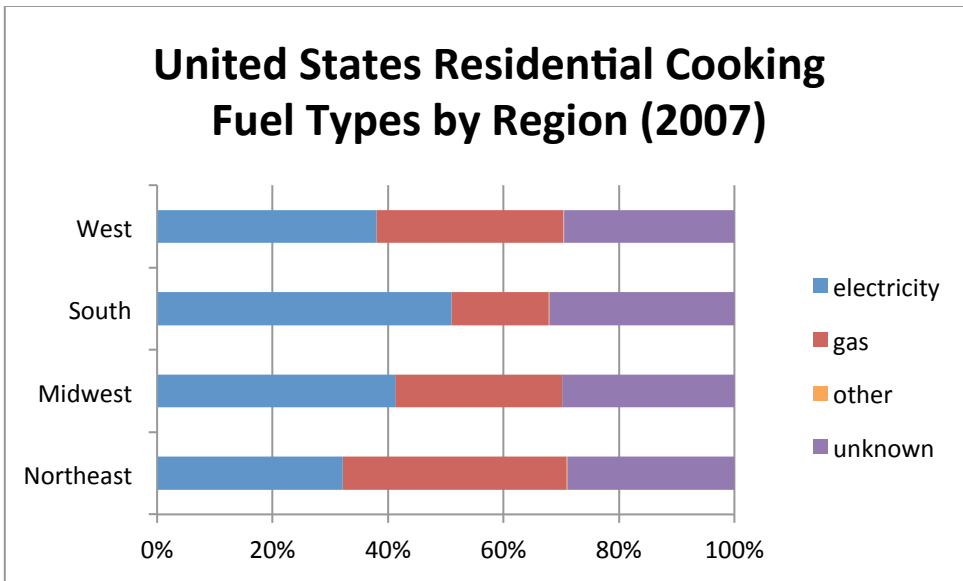
## Appendix 1: United States Residential Fuel Type Distributions



Charts constructed by the author using data from the 2007 American Housing Survey conducted by the U.S. Census Bureau[59]

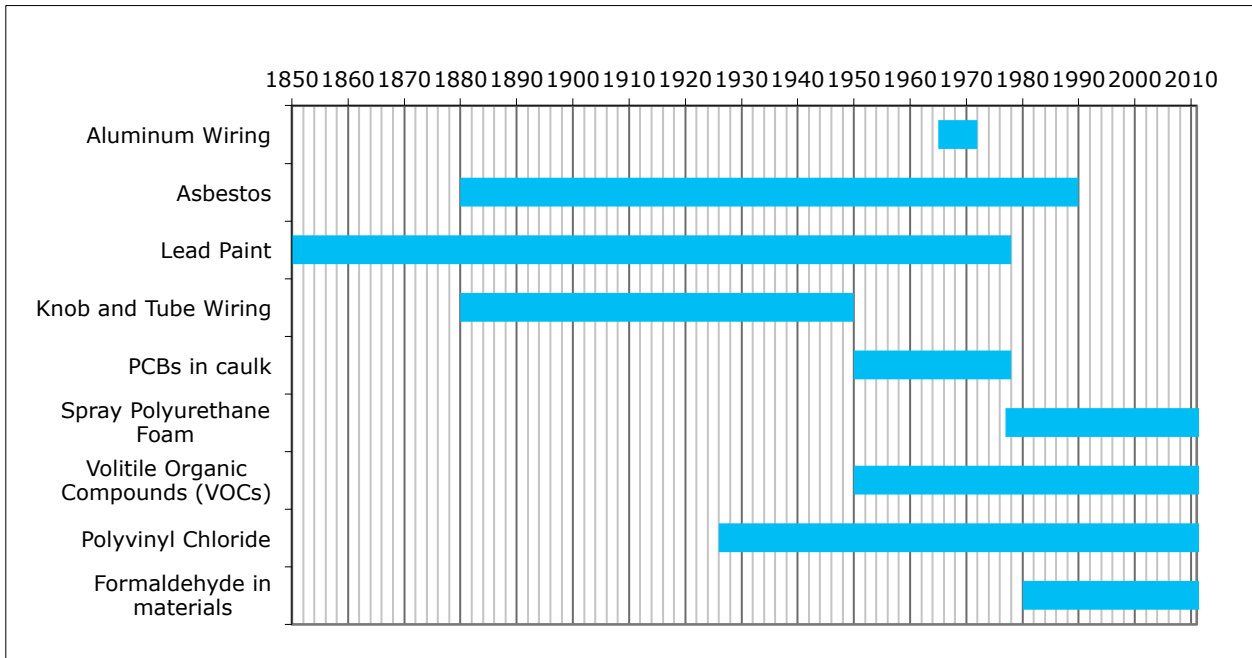








## Appendix 2: Timeline of Residential Retrofit Health and Safety Issues



**Appendix 3: Overview of hazards with PVC production, use, and disposal**  
(this table is an excerpt from a 2004 report from the Center for Health, Environment and Justice and the Environmental Health Strategy Center)

● ● ● ● ● Table 4 ● ● ● ● ●

**Overview of Hazards Associated with PVC Production, Use and Disposal**

**Production**

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- Dioxin and mercury emissions and asbestos waste from chlorine production.
- Air emissions and wastewater releases from Ethylene Dichloride/Vinyl Chloride Monomer (VCM) production facilities.
- Dioxins and other organochlorines released as by-products of Ethylene Dichloride/Vinyl Chloride Monomer (VCM) production.
- Worker exposures to VCM.
- Incineration of production wastes.

**Use**

---

- Additives leach and otherwise migrate from PVC products (plasticizers/metal stabilizers).
- Accidental structure and vehicle fires release dioxins.

**Disposal**

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*Landfill*

- Accidental landfill fires release dioxins.
- Additives, heavy metals and dioxins leach into groundwater.
- Gaseous emissions from additives.

*Incineration*

- Dioxins form when PVC is burned.
- Hydrochloric acid, toxic metals and dioxins are emitted to air.
- Ash, later stored in landfills, contains high levels of heavy metals and dioxins.

*Recycling*

- Diversity of additives prevents effective recycling of mixed PVC products and materials resulting in poor quality products (downcycling).
  - Low recycling rates (currently <1%).
  - Contaminates other plastics during recycling as well as other valuable commodities that are targeted for recycling.
  - Does not reduce the overall demand for raw materials to make plastics (virgin resin) and has no effect on the amount of vinyl produced each year.
-

**Appendix 4: Defining acronyms and terms**

ACM – Asbestos-containing material

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

BPI – Building Performance Institute

CDC – United States Centers for Disease Control and Prevention

CO – Carbon monoxide

CO<sub>2</sub> – Carbon dioxide

CPSC – Consumer Product Safety Commission

EPA – United States Environmental Protection Agency

ETS – Environmental tobacco smoke

GFCI – Ground fault circuit interrupter

HVAC – Heating, ventilation, and air conditioning

HVACr – Heating, ventilation, air conditioning, and refrigeration

IARC – International Agency for Research on Cancer

NAAQS – National ambient air quality standards

NEC – National Electric Code

NIOSH – National Institute for Occupational Safety and Health

NO<sub>x</sub> – Generic term for nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>)

PCBs – Polychlorinated biphenyls

PM – Particulate matter

PPB – Parts per billion

PPE – Personal protective equipment

PPM – Parts per million

O<sub>3</sub> – Ozone

OSHA – Occupational Health and Safety Administration

RESNET – Residential Energy Services Network

SPF – Spray polyurethane foam

TSCA – Toxic Substances Control Act

UL – Underwriters' Laboratories

VOCs – Volatile organic compounds

WHO – World Health Organization

## **Appendix 5: World Health Organization (WHO) International Agency for Research on Cancer (IARC) classification groups and descriptions:**

(from: [monographs.iarc.fr/ENG/Preamble/currentb6evalrationale0706.php](http://monographs.iarc.fr/ENG/Preamble/currentb6evalrationale0706.php))

### **Group 1: The agent is *carcinogenic to humans*.**

This category is used when there is *sufficient evidence of carcinogenicity* in humans. Exceptionally, an agent may be placed in this category when evidence of carcinogenicity in humans is less than *sufficient* but there is *sufficient evidence of carcinogenicity* in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity.

### **Group 2.**

This category includes agents for which, at one extreme, the degree of evidence of carcinogenicity in humans is almost *sufficient*, as well as those for which, at the other extreme, there are no human data but for which there is evidence of carcinogenicity in experimental animals. Agents are assigned to either Group 2A (*probably carcinogenic to humans*) or Group 2B (*possibly carcinogenic to humans*) on the basis of epidemiological and experimental evidence of carcinogenicity and mechanistic and other relevant data. The terms *probably carcinogenic* and *possibly carcinogenic* have no quantitative significance and are used simply as descriptors of different levels of evidence of human carcinogenicity, with *probably carcinogenic* signifying a higher level of evidence than *possibly carcinogenic*.

### **Group 2A: The agent is *probably carcinogenic to humans*.**

This category is used when there is *limited evidence of carcinogenicity* in humans and *sufficient evidence of carcinogenicity* in experimental animals. In some cases, an agent may be classified in this category when there is *inadequate evidence of carcinogenicity* in humans and *sufficient evidence of carcinogenicity* in experimental animals and strong evidence that the carcinogenesis is mediated by a mechanism that also operates in humans. Exceptionally, an agent may be classified in this category solely on the basis of *limited evidence of carcinogenicity* in humans. An agent may be assigned to this category if it clearly belongs, based on mechanistic considerations, to a class of agents for which one or more members have been classified in Group 1 or Group 2A.

### **Group 2B: The agent is *possibly carcinogenic to humans*.**

This category is used for agents for which there is *limited evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals. It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances, an agent for which there is *inadequate evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data.

### **Group 3: The agent is *not classifiable as to its carcinogenicity to humans*.**

This category is used most commonly for agents for which the evidence of carcinogenicity is *inadequate* in humans and *inadequate* or *limited* in experimental animals.

Exceptionally, agents for which the evidence of carcinogenicity is *inadequate* in humans but *sufficient* in experimental animals may be placed in this category when there is strong evidence that the mechanism of carcinogenicity in experimental animals does not operate in humans.

Agents that do not fall into any other group are also placed in this category.

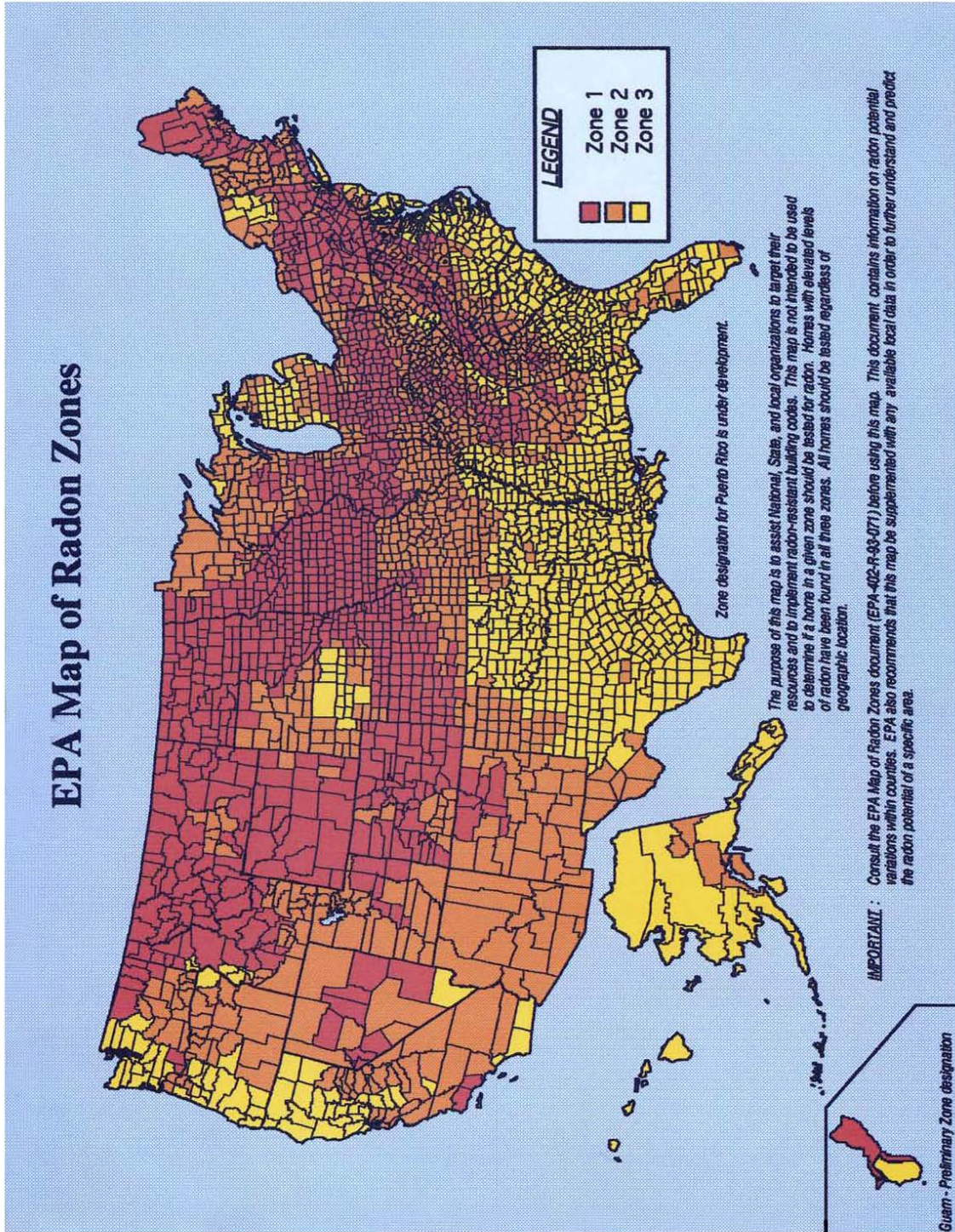
An evaluation in Group 3 is not a determination of non-carcinogenicity or overall safety. It often means that further research is needed, especially when exposures are widespread or the cancer data are consistent with differing interpretations.

### **Group 4: The agent is *probably not carcinogenic to humans*.**



This category is used for agents for which there is *evidence suggesting lack of carcinogenicity* in humans and in experimental animals. In some instances, agents for which there is *inadequate evidence of carcinogenicity* in humans but *evidence suggesting lack of carcinogenicity* in experimental animals, consistently and strongly supported by a broad range of mechanistic and other relevant data, may be classified in this group.

## Appendix 6: United States Radon Map





## Appendix 7: VOC Classification

Classification of Inorganic Organic Pollutants (adapted from WHO <sup>8</sup> )			
Description	Abbreviation	Boiling Point Range (°C)	Example Compounds
Very volatile (gaseous) organic compounds	VVOC	<0 to 50-100	Propane, butane, methyl chloride
Volatile organic compounds	VOC	50-100 to 240-260	Formaldehyde, d-Limonene, toluene, acetone, toluene, ethanol (ethyl alcohol) 2-propanol (isopropyl alcohol), hexanal
Semi volatile organic compounds	SVOC	240-260 to 380-400	Pesticides (DDT, chlordane, plasticizers (phthalates), fire retardants (PCBs, PBB))

From: [www.epa.gov/iaq/voc2.html#8](http://www.epa.gov/iaq/voc2.html#8)

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