Environmental Concerns in Buildings: What You Don't Know Can Hurt You

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Most buildings today are laden with hazardous building materials and/or potential environmental concerns. Asbestos, lead, mercury, polychlorinated biphenyl (PCBs) are just a few examples. Failure of building owners/managers to have a basic understanding of these risks and how to handle them appropriately may result in hundreds of thousands, if not millions of dollars in clean-up costs, governmental fines, and/or litigation costs. An excellent example of how things can go terribly wrong was the Interstate Brand Corporation, Hostess facility located in Schiller Park, Illinois. In 1998 this facility was a manufacturer of Hostess Twinkies, Ho-Ho's and other Hostess products. On January 11th, 1998 a couple of employees of the facility were instructed to remove some old insulation from equipment in the boiler room of the facility. The employees did as they were told and removed the insulation, carted it through the plant, and disposed of it in a dumpster. Shortly after the removal was completed, an employee of the facility complained about improper asbestos removal to the U.S. Environmental Protection Agency (USEPA). The USEPA informed the Illinois Department of Public Health (IDPH) and the Illinois Environmental Protection Agency (IEPA) about the complaint and an inspection of the facility ensued by the two agencies. Inspectors found asbestos debris in the boiler room and other areas of the plant. In response, the plant was shut down and the food products produced in the plant in and around the time of the incident were recalled, resulting in one of the largest food recalls in Illinois history. The plant was closed down for several weeks and over two hundred and fifty employees were laid off during the decontamination process. Decontamination of the facility cost the company millions of dollars. In addition, the plant was fined over one million dollars by various government agencies and had to defend itself against lawsuits filed by employees as well as a class action lawsuit filled by attorneys on behalf of consumers. The company could have saved millions of dollars, if the building's manger had a basic understanding of the hazards associated with the building's insulation and how to deal with it appropriately. Asbestos is just one of many environmental hazards that building owners/managers face, having a basic knowledge of the environmental hazards that exist in buildings and the actions that can or must be taken to deal with them is an essential skill for all building owner/mangers today. Most of the concerns associated with buildings can be broken down into three categories: toxic building material, biological hazards, and dangerous gases & vapors.

Toxic Building Materials

Asbestos, the "wonder mineral", is probably one of the most familiar hazardous building materials to building owners/managers. It is a naturally occurring rock mineral that is highly resistant to weather, heat, and chemicals. Due to its fibrous nature it is a superior insulator and can be easily woven into a variety of fabrics and other materials. The physical properties that made asbestos so attractive to building material manufactures also make it dangerous, as its fibers can break into smaller fibers, invisible to the naked eye. These fibers can become airborne easily and are readily inhaled and deposited in the lungs. Because the fibers are highly chemically resistant, the bodies' own defense mechanisms are limited in their abilities to remove these fibers once they have been deposited in the lungs. Diseases such as asbestosis, mesotheloma, and lung cancer may appear years after exposure has occurred. Asbestos was readily used in thousands of building materials

from the early 1900's until to the late 1970's. The height of its use generally occurred from the early 1940's to the early 1970's. Asbestos was banned from use in sprayed-on fire proofing in 1973. It was banned from other products in the mid to late 1970's; however, it has never been banned completely. An all out ban of asbestos was implemented in 1989 but the ban was overturned in the courts. Asbestos can still be used in non-friable (materials that do not release fibers readily) consumer products such as roofing tars, brake shoes, etc. However, most manufactures have phased it out voluntarily due to the general liability associated with it. Asbestos was commonly used in floor tiles, floor tile mastics, mechanical insulations, sprayed-on fire proofing, ceiling tiles, drywall seam compound, plaster, roofing felts, cement products, and caulks, just to name a few. Unfortunately, whether a material contains asbestos or not can only be determined through laboratory testing. However, knowing the dates of installation can help. For instance, a sprayed-on fireproofing installed after 1973 is not likely to contain asbestos. Some manufactures of sprayed-on fireproofing also added a light blue coloring to their products to indicate that they were asbestos-free. Building materials installed after the 1980's are most likely asbestos-free; however, as a precautionary measure, testing of suspect materials is always recommended for confirmation. Testing of building materials must occur prior to any disturbance such as renovation, demolition, etc. Analysis of suspect building materials is relatively inexpensive however most states require licensed building inspectors to collect the samples. Having a licensed inspector sample only one or two materials can get expensive when cost per material tested is considered. For this reason, it is recommended that a complete inspection of the building be performed. Although this can be expensive up front, it is often less expensive over the long-run and may be most beneficial to the building owner/manager. If the building has known or suspect asbestos materials, it is imperative to keep them in good condition as asbestos is only hazardous if it is airborne. Keeping the asbestos materials in good condition and informing the building's maintenance staff and occupants of its locations will assist in preventing disturbance of the asbestos materials and the potential accidental release of the hazardous fibers. It is also important to note, that currently there are no laws that require the removal of asbestos materials from buildings except for demolition. Prior to demolition, many if not all of the asbestos materials may need to be removed. Removal of asbestos is highly regulated by state, federal and/or local laws. In general, removal must be completed by trained and licensed asbestos abatement workers. Air monitoring of both the employees performing the removal and surrounding environment will need to be completed. Individuals performing this work may also have to be licensed. Asbestos is a building material that most building owners/managers will encounter in their career. Knowing where these materials are located, keeping them in good condition, and following all pertinent regulation is crucial in preventing incidents like that at Interstate Brands.

Lead is another common hazard identified in building materials. Lead was used in various building materials from the early 1900's up until recently. It was primarily used as a pigment in paints and older plumbing pipes and/or solders. Lead solder is also contained in many electronic devices such as computers, telephones, video displays, etc. Lead pigment has also been discovered in some window blinds. Lead pigments were used in paints and other building materials for their bright colors (i.e., whites, reds, yellows, etc.), superior durability, and microbial resistance. Lead was used in solders because it has a very low melting point that makes it relatively easy to work with and when cooled provides an excellent seal. Over time the lead paints weather and wear resulting in chalking (powdering of the paint or plastic), cracking and blistering. In plumbing products, the lead materials slowly leach into the water supply. Exposure to lead primarily occurs through ingestion. For example, children eating loose paint chips or getting the dust on their hands and then putting their hands into their mouth. Drinking water with lead solder and/or pipes can also lead to the ingestion of lead. Exposure may also occur through inhalation, for example, breathing lead dust disturbed by the wind. Although children are generally

most at risk, adults may be exposed to significant concentrations of lead during the removal of lead based paints and/or the drinking of contaminated water. High concentrations of lead in the body can result in learning disabilities, and a variety of adverse health effects on the blood, central nervous system, reproductive system, and digestive system. Extremely high exposures to lead can result in death. Due to its high toxicity, lead has been banned from most consumer products. It was banned from use in paints in 1978 and from plumbing solders in 1988. It has not been officially banned from electronic devices in the US but is in the process of being phased out of electronics in the European Union (EU). This has resulted in many electronic manufacturers voluntarily phasing lead out of their products and using lead-free solder instead. Lead is still present in many older buildings and electronic devices. Like asbestos materials, the removal and disposal of lead materials is highly regulated. It is important to know where these materials are in a building and to manage them in place. One of the easiest and must affordable ways to determine if a material contains lead is to use lead check swabs. These devices look like a cigarette. The swabs have chemicals, which are continued in small capsules within the device, when broken the chemicals saturate a white swab at the end of the tube. When the chemicals come into direct contact with lead the swab turns a red color. These swabs are available on line or at most home improvement stores. Of course, paint chips and other materials can also be sent into a laboratory for analysis. Laboratory analysis is generally the most accurate way to determine if a material contains lead. Water can also be tested for lead content by a laboratory. If lead is found in a building material, much like asbestos, it is not mandated that it be removed but must be managed in place. Keeping paints sealed and/or in good condition is an acceptable control. If the lead materials are to be removed and disposed of, someone familiar with the local, state, and federal laws regarding lead should be consulted. Several purification methods are available to remove lead from potable water. Older electronic equipment should be given to an electronics recycler, not disposed of and sent to a landfill.

Mercury, a naturally occurring heavy metal, is also a toxin commonly found in buildings. It may be located in some paints (usually marine paints), thermostats, switches, valves, fluorescent bulbs, medical equipment, LCD displays, rubberized flooring, and/or other materials. Mercury has been used in building materials and other products for many years and may still be found in trace amounts in products available today such as fluorescent light bulbs and computer displays. Mercury exposure can occur through ingestion, inhalation, and to a lesser extent skin absorption. Long-term exposure to excess concentrations of mercury can cause adverse health effects to the central nervous system. Some forms of mercury can be identified visually: such as the silver liquid used in switches and valves. Other forms are not easily identified visually, a good example is the mercury contained in rubberized flooring. While mercury is commonly known as a liquid, it releases airborne vapors at room temperature resulting in possible inhalation exposures even without direct contact. Usually the presence of mercury must be identified through laboratory analysis or by one of several hand-held electronic instruments. The use of mercury in building materials and other devices has not been banned but it is being phased out by many manufacturers due to increases in regulatory activities related to mercury. If large quantities of liquid mercury are present in a building, if possible, it should be removed. An example of a good removal strategy would be removing older thermostats that contain small ampoules of mercury and replacing them with electronic ones that are mercury-free. Care must be taken whenever any mercury materials are removed, spillage of mercury can result in expensive clean-up costs. Should a spill of mercury occur, it must be cleaned-up and disposed of immediately by properly trained personnel. Disposal of mercury materials must be in accordance with local and federal regulations. Due to the potential spill and disposal issues, it is best to leave larger projects to professional remediation contractors. Likewise if a spill is suspected, the area should be isolated immediately, the ventilation for the area shut down or isolated, and a remediation contractor

called to assess and clean-up the spill. Knowing where mercury is located in a building and how to handle it properly can prevent spills.

Formaldehyde is yet another hazardous material building owners/managers may encounter. It is still used in some building materials such as adhesives, varnishes, insulations, fabrics, etc. It can be found in liquids, resins, and off-gassing from many of the newer products produced with it. One of the largest concerns with formaldehyde is its use in the foam insulations used in trailers and mobile homes. This became apparent shortly after Hurricane Katrina when some occupants of the trailers and mobile homes provided by the federal government stated that they experienced breathing difficulties, nose bleeds, and headaches when in the trailers. Governmental tests suggested that the levels of formaldehyde were excessive. Formaldehyde is a strong irritant of the eyes, nose, and throat. Exposure most often occurs through inhalation. Long-term exposure to elevated concentrations has been linked to nasal cancer. Although the use of formaldehyde in insulations is well documented, it may also be found in other building materials such as press board furniture, laminates, and curtains. It is of most concern with new formaldehyde containing products as they readily off-gas the chemical. After a few months or years, the off-gassing diminishes gradually. To prevent formaldehyde from becoming a concern in buildings, it is recommended that formaldehyde be prohibited in use in new building materials or products. Much of the “green building” occurring today prohibits the use of formaldehyde in new building materials. If formaldehyde is suspected air monitoring can be used to determine if formaldehyde is present in significant quantities to cause a potential hazard to the occupants.

Polychlorinated biphenyls (PCBs) maybe located in many older buildings. PCBs are man-made oils. In buildings, they were primarily used in older fluorescent light ballast and transformers, mainly for cooling purposes. They have also been found in some paints and caulks. PCBs were largely used between 1930 and 1977. Exposure to PCBs typically occurs through ingestion. Although there have been very few cases of direct ingestion of PCB oils, they are extremely stable and entered the food chain resulting in bioaccumulation. Direct contact with the skin is also a concern. Although PCBs are not readily absorbed through the skin, prolonged contact can cause a condition know as chloracne, an acne-like rash. PCBs are also suspect carcinogens. If PCBs are present in a building they are most often found in the florescent light fixture ballast or in transformers associated with the buildings main electrical system. The use of PCBs was banned in 1977 but may be present in ballasts manufactured through 1979. If PCBs are suspected in a transformer, the building owner/manager should check with the local electrical company. Most PCBs have been removed from transforms and the local electrical company should have records. A blue “Non-PCB” label may also appear on transformers where the oils have been tested and found to be negative for PCBs or removed and replaced with PCB-free oil. Light ballasts manufactured after 1979 are required by law to be labeled as “NO PCB” so simply reading the label may be sufficient to determine if PCBs are present. If a “No-PCBs” label is not present on the ballast and the ballast is the older “black-box” type, it should be considered to be positive until proven otherwise. Laboratory testing may be needed to determine if PCBs are present in these cases. Most modern florescent light fixtures have electronic ballasts; these are normally much smaller than the older “black-box” ballast and will be labeled as “electronic ballast”. The newer electronic ballasts are PCB-free. If PCB ballasts are present and they will be removed, for example during renovation, they must be disposed of properly. Disposal of more than one pound of PCBs (approximately 12 to 16 ballasts) triggers special environmental reporting requirements. If PCB ballast will be disposed of, they should be removed and disposed of by a firm that specializes in this work. To prevent potential future liabilities, the preferred method of disposal is incineration, with the building owner/manager receiving a “Certificate of Destruction” at the end of the process. Landfilling PCBs may lead to future liabilities.

Biological Concerns

Mold growth in buildings is nothing new; however, within the last few years it has captured considerable media attention and resulted in several high profile court cases. Mold is ubiquitous in both the indoor and outdoor environments. Outdoor concentrations fluctuate considerably over the course of a year depending upon temperature, moisture, wind, and vegetation present. In nature, mold plays an important role in the breakdown of dead vegetation such as wood, leaves and grasses. Most molds reproduce by producing and releasing spores. Spores are microscopic seed-like structures that are released into the environment. They are invisible to the naked eye but easily seen with the aid of a microscope. The morphology of these spores can be used to identify the type of mold that produced it. If a spore lands on a suitable environment for growth, generally a wet cellulosic material (i.e., wood, paper, etc.), mold growth will occur. It is important to note that mold does not require sunlight to grow. In fact, most molds prefer to grow in darkness; this maybe one of the many reasons why mold growth is usually denser in wall cavities, attics, etc. Outdoor mold concentrations are usually highest in the fall when there is an ample supply of cellulose materials and moisture. Indoor mold spore concentrations are normally lower than that observed outside a building due to the filtering mechanisms of the ventilation system and fact that dry building materials do not support mold growth.

The main exposure route of entry for mold however it can also enter the body through open wounds or cause mucus membrane or eye infections. Because mold is so prevalent in the environment, most healthy individuals experience no adverse health effects. However, individuals with allergies to molds may experience symptoms such a stuffy noise, scratchy throat, itchy eyes, etc. These symptoms often dissipate when exposure is stopped. Allergy medication can also reduce the symptoms associated with seasonal allergies. Exposure to excess concentrations of mold spores can also initiate asthmatic reactions in sensitive individuals and cause serious infections in individuals with compromised immune systems (e.g., bone marrow transplant patients, individuals with HIV, individuals that have undergone organ transplants, etc.). Exposure to mold has also been cited to cause a whole host of other health effects such as hemorrhaging of the lungs, memory loss, fatigue but these effects have not been substantiated by scientific studies and are currently under debate. Some news stories have described mold as toxic or “toxic black mold”. The toxic effects of mold are from ingestion, primarily of animals eating grains contaminated with mold, not from airborne exposures.

Many building materials are comprised of cellulose. Examples include ceiling tiles, wall paper, and the paper covering on the outside of most drywall. Mold may grow on these materials if they are exposed to moisture. Dust and debris that can accumulate in carpets or on surfaces can also provide sufficient cellulose for mold growth to initiate. Roof leaks, window leaks, plumbing leaks, condensation, and a host of other moisture sources can lead to mold growth inside buildings. Mold growth is simply a symptom of the problem, moisture intrusion is the actual problem and underlying cause Regardless of the debate over health effects, mold growth inside a building should not be tolerated under any circumstance and is best controlled by identifying and eliminating sources of excess moisture, including elevated humidity. Indoor relative humidity levels should be kept to below sixty percent. Sometimes identifying the source of moisture is fairly straight forward, such as a plumbing or roof leak, other times it may take the help of a professional, such as an architect or engineer to identify the cause. If a leak, flood, or other moisture intrusion event occurs, it must be corrected immediately and drying procedures begun as soon as it is discovered. Professional remediation contractors may be needed to respond to large emergencies. If mold growth does occur, the affected material(s) often will need to be

removed and replaced. If the mold growth exceeds more than ten square feet of material, a professional mold remediation contractor should be involved in the clean-up procedure. Some states now require that current and past mold and moisture concerns be disclosed during real-estate transactions therefore, the building owner/manager will need documentation to show that the problem was corrected. Documentation may include professional inspections, information from the remediation contractor, and test results.

In 1976 another biological concern associated with buildings came to light at an American Legion convention held in Philadelphia. Shortly after the convention, hundreds of conventioneers' became sick with flu like symptoms, thirty four died. A previously unidentified bacterium, Legionella (named after the convention itself), was identified in the cooling tower of the building where the convention was held. Droplets of water from the cooling tower had entered the convention center's air handling system. Convention goers inhaled the droplets and were infected by the bacteria, resulting in the illness later observed. Legionella is a bacterium that thrives in hot water, temperatures from 95 to 115^{o} F. Although cooling towers are a potential source of this bacterium, it has also been isolated from hot potable water sources such as hot water tanks, sinks, showers, water pipes, and other hot water sources. The primary route of entry is inhalation of contaminated water droplets. Individuals with a compromised immune system and the elderly are most at risk of developing disease from Legionella. Therefore, it is of particular concern in hospitals and nursing homes. Legionella contamination may be controlled in buildings by first ensuring that all cooling towers are placed far away from the outside air intakes for the ventilation system. Another strategy for controlling Legionella is the use of biocides and/or disinfecting agents like chlorine, ozonation, silver ions, etc. Whichever method of control is selected, it should also include regular testing of the water to ensure that the method used is effective in reducing Legionella. Do-it yourself test kits are usually available from most laboratory or water treatment companies. Some states and/or municipalities have special regulations on Legionella testing; therefore, the building owner/manager should check with the local authorities before attempting this testing on their own. Private testing firms are available. Samples collected are very sensitive and must be submitted to a laboratory within a specific time frame, generally 24 hours. Careful treatment and monitoring of all hot water sources can prevent Legionella outbreak. Disinfection of systems after an outbreak occurs can be expensive and time consuming.

Birds or bats roosting in buildings can also present a hazard. The roosting of these animals may occur in attics or interstitial spaces. This concern is primarily seen in older buildings where access, due to poor maintenance has occurred; however, it can also occur in new buildings as well if the eves, vents and roofs are not maintained properly. Fecal waste from these animals will accumulate if not treated immediately. Over time the accumulated waste can provide and ideal environment for *Histoplama capuslatum*, a fungus and/or *Cryptococcus neoforms*, a yeast. These microbes do not present a hazard simply by being present; however, if inhaled, which usually occurs during the clean-up of the accumulated waste, infection of the lungs may occur. Infection is usually followed by a general ill feeling, fever, chest pain, and dry unproductive cough. Left untreated these diseases can result in death. Prevention includes, keeping animals out of the building by maintaining all eves, vents, roofs, etc. If excess fecal matter is found, it should be cleaned by a professional remediation company.

Toxic Gases & Vapors

Radon is perhaps the best known toxic gas that building owners/managers are aware of but most are not sure how it affects the buildings they manage. Radon is a colorless, odorless gas generated by the natural decay of radium deep within the earth's crust. Trace amounts of this gas

are constantly being released into the atmosphere through the soil. This gas also can seep into buildings depending upon a number of factors including the type of foundation, cracks or other openings in the foundation, exhaust and ventilation present in a building as well as other factors. Radon gas may accumulate and present a hazard to the building occupants. Since most homes have recirculating ventilation systems (not allowing fresh air into the ventilation cycle), radon is most often associated residential settings. Radon is a particular concern in crawlspaces or basement areas; however, left unremediated it can migrate into the upper floors. It is rarely found in commercial settings do to the fact that most commercial ventilation systems have some means of introducing fresh outside air into the ventilation cycle and exhausting air. This dilutes and reduces any radon present. However, in commercial buildings or particular rooms where ventilation is poor, radon may be a concern. Radon enters the body through inhalation; excess long-term exposure can lead to cancer of the lungs. The USEPA has stated that radon is the second leading cause of lung cancer in the US, next to cigarette smoking. The USEPA has also stated that it causes more deaths per year than drunk driving. The first step and only way to determining if radon is a concern in a building is to have the air in the building tested. Many firms are available to conduct this testing or it may be carried out through test kits that are available in most home improvement stores. Whatever testing method is selected, the laboratory performing the ultimate analysis should be approved by the USEPA. If a firm is chosen to conduct the test, the building owner/manager should check to make sure that the firm is qualified; some states require that radon testing firms be licensed. The initial test should be performed in low lying areas of the building such as crawl spaces, basements, or areas that are of a “slab on grade” construction. Samples can be taken for a short period of time, one to five days or for a longer period of time, such as six months. Long term test are generally more accurate, as radon level fluctuate naturally from day-to-day and season-to-season. Air monitoring results will be reported in picocuries per liter of air (pCi/L). Currently, the USEPA considers anything greater than 4 pCi/L an elevated risk that should be remediated. Remediation may consist of sealing all openings in the foundation and depressurizing the slab, a procedure where a small duct and fan system is used to pull the air underneath the slab and exhaust it outside the building.

A relatively new hazard identified in buildings is that of vapor intrusion. Vapor intrusion is similar to that of radon, except instead of a poisonous gas it is vapors from leaking underground storage tanks, chemicals spills or old dump sites that seep into the building. Like radon, the vapors seep in through small cracks or openings in the foundation of the building. In poorly ventilated spaces, these vapors can accumulate and present a risk to the occupants. The hazard to the occupants is usually through inhalation of the vapors. The health hazards associated with vapors depends upon the individual vapors present, some may have unknown or no effects, where as others maybe carcinogenic. Unlike radon, this is a highly technical rapidly expanding field with many unknowns and no do-it yourself test kits. The EPA has established some exposure guidelines. If testing indicates that vapor intrusion is a concern, a professional should be contacted to determine the best options.

Exhaust gasses entering a building through doors, windows, cracks, the ventilation system or other sources are not as common as radon and other gas/vapor concerns but they occasionally occur. Probably the most common source of exhaust gases is vehicular traffic in or around the building. Common examples include propane or gas fired fork truck used in an adjoining building or warehouse or truck(s) idling outside near the ventilation intake for the building. Other sources of exhaust gases inside a building include bringing combustion equipment into the building such as a gas fired generator or pump. Gas fired heaters, ovens, water heaters, etc. are also common sources of exhaust gases. There are a number of toxic chemicals within exhaust gases but the most important is carbon monoxide. Carbon monoxide is a highly toxic, colorless, odorless gas. In

poorly ventilated spaces, carbon monoxide can buildup to fatal levels. Carbon monoxide enters the body through inhalation and attaches to the oxygen carry molecule of the red blood cells, reducing or preventing them from carrying oxygen to the various organs of the body. At lower levels, carbon monoxide may cause nausea and headaches. At higher concentrations it can cause asphyxiation, leading to death. Prevention includes: using gas fired vehicles and other equipment only in well ventilated areas, keeping all vehicles and exhaust sources away from the buildings' outside air intakes, and maintaining all gas fired equipment, such as heaters, water heater, etc., in accordance the manufacturers recommendations. This usually includes an inspection of the internal heat exchanger and exhaust ducts.

Conclusion

The environmental hazards within a building are numerous. A few of the common, and not so common, concerns have been presented. Failure to identify and handle these concerns appropriately could result in occupant complaints, regulatory fines, lawsuits, short and/or long-term injuries to the occupants, and even death. Knowing how to recognize, evaluate, and control these concerns may prevent these adverse effects and perhaps, in some cases, even save a life.

The following web sites were used for reference and maybe used to obtain additional information on virtually all of the topics above:

- www.epa.gov
- www.cdc.gov
- www.osha.gov
- www.atsdr.cdc.gov/
- www.idph.state.il.us/