

Stray Carbon Dioxide in Homes

Introduction

While not a common occurrence, high concentrations of stray carbon dioxide (CO₂) gas have occasionally migrated from the ground into homes. The Department of Environmental Protection (DEP) is aware of instances where this has occurred at concentrations sufficient to be a health hazard. Where elevated CO₂ was a problem, property owners were able to take fairly simple corrective measures to reduce CO₂ levels to acceptable conditions. This fact sheet provides information on the chemical and physical properties of CO₂, exposure concerns (levels at which CO₂ can be a problem), the potential for CO₂ to migrate from the earth below the surface into buildings, and recommendations for fixing CO₂ problems.

Facts About CO₂

CO₂ is nonflammable, colorless and odorless as a gas and is approximately one and one-half times heavier than air. CO₂ composes about 0.035 percent of the air we breathe and makes up about three to four percent of the air we exhale. A concentration of 0.5 percent represents the level at which nearly all workers may be exposed day after day for a normal eight-hour workweek without adverse effect. The short-term exposure limit is 1.5 percent or 15,000 parts per million (ppm), which is the maximum exposure limit over a 15-minute timeframe. Symptoms of CO₂ exposure vary; however, CO₂ in excess of 1.5 percent may produce hyperventilation and headaches. Prolonged exposure to high concentrations may result in death from asphyxiation. Table 1 identifies the symptoms of exposure to respective concentrations of CO₂:

Table 1. CO₂ Concentrations and Symptoms:

CO ₂ Concentration:	Symptoms:
2%	50% increase in breathing rate, prolonged exposure can cause headaches
3-6%	Headaches, shortness of breath
6-10%	Headache, shortness of breath, tremors, visual impairment, unconsciousness
> 10%	Unconsciousness (potentially without warning)

CO₂ Sources

CO₂ occurs naturally and is produced as a by-product of a number of manufacturing processes. It is used in fire extinguishers, in refrigeration as dry ice (dry ice is the solid state of CO₂), in the carbonation of beverages (the fizz in soft drinks), and in the production of plastics, rubber and electronic components.

CO₂ is generated in shallow soils by the “breathing” of plants and microorganisms and is produced in landfill and underground coal mine atmospheres. The process of underground coal mining liberates CO₂ and other gases from the coal structure. This is the source of what miners call “black damp,” air that has high CO₂ and low levels of oxygen. CO₂ is also produced in reclaimed surface coal mines as the result of acidic water (acid mine drainage) reacting with rocks containing calcium carbonate such as limestone. Most CO₂ problems investigated by DEP have resulted from situations where basements have been built into or downslope from surface coal mine spoil material that contains both acid-producing and alkalinity-producing rocks. Situations of high CO₂ in houses have also been reported from areas that do not have coal, so the problem is not necessarily restricted to areas with coal and coal mining. The source of stray CO₂ in houses can often be determined through isotope geochemistry (an analysis of the type of carbon atoms) and other geochemical and geological tools.

How to Recognize CO₂ and How it Migrates

Often, occupants initially become aware of elevated CO₂ in a building because of labored breathing, and/or extinguishing furnace pilot lights and candles. These symptoms should be taken seriously and immediately followed-up with indoor air monitoring to determine the source of the problem. If the problem may be related to an industry regulated by DEP, contact the appropriate DEP office. Otherwise contact a professional with expertise in air sampling, including sampling for CO₂. Because a number of different compounds may produce symptoms similar to elevated CO₂, indoor air sampling is required. Portable meters properly calibrated and equipped with oxygen, carbon monoxide and carbon dioxide sensors are recommended for initial screening of indoor air quality.

If hydrocarbons are also suspected, a meter equipped with a flame ionization detector (FID) is also recommended. Air sampling by laboratory analysis should be conducted to accurately determine what is in the air. Stray CO₂ from a source below the surface of the ground will typically enter buildings through cracks in solid floors, construction joints, cracks in walls, gaps in suspended floors, and gaps around service lines. CO₂, like any other gas, will migrate from areas of high pressure to areas of low pressure. A basement, excavation, or water well represents a low-pressure area. Although CO₂ is heavier than air it will diffuse throughout the atmosphere (air) in a building.

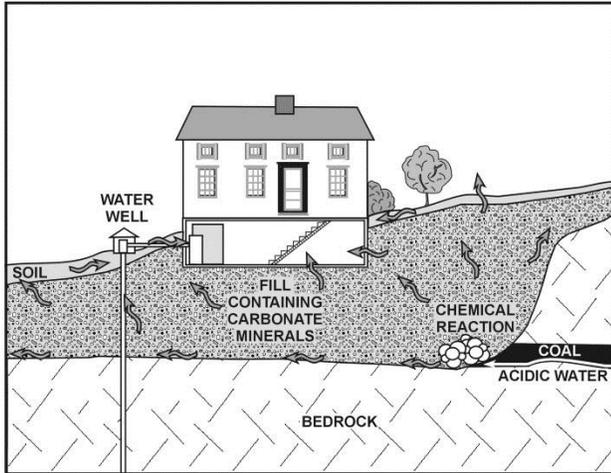


Figure 1. Schematic of how CO₂ enters basements of homes that are built in mine spoil.

Most buildings tend to maintain themselves at an air pressure lower than that of the surrounding soil (Figure 1, opposite side). This results mainly from weather-driven factors such as indoor/outdoor temperature differences and wind. The use of exhaust fans and combustion devices (such as furnaces) will also create a negative pressure within a home. This lower pressure in the house helps drive the migration of CO₂ and is also responsible for fluctuations in CO₂ concentration. During periods of falling barometric pressure, the pressure on the land surface (or basement) will be reduced relative to that in the ground. Under these conditions, CO₂ will flow from the ground into the basement, resulting in the potential for higher concentrations of CO₂ to migrate into buildings.

Fixing the Problem

If high CO₂ levels are a problem a variety of effective techniques exist to address the problem. Sealing floor cracks, construction joints, cracks in walls and gaps around service lines are recommended as initial remedial measures. Effective sealing materials include radon resistant caulk and hydraulic cement. Another technique is the construction of vapor barriers. These techniques are effective in helping to eliminate the migration of CO₂ into a building.

An effective long-term strategy is the use of “reverse” radon systems. Most radon systems draw air from under the basement slab and then vent the gas. These systems are effective to reduce concentrations in the parts per million range, such as is the case with radon. A typical radon system, however, may not effectively handle higher gas concentrations, such as CO₂. Conventional radon systems create a low-pressure area around the base of the building. This causes a low-pressure area that effectively draws the gas towards the structure. A reverse system, on the other hand, forces fresh air under the building; thus increasing the pressure of air around the foundation and creating a high-pressure area. This drives the CO₂-rich gas away from the building.

Reverse radon systems should be designed and installed by a qualified person. Appendix F of the International Building Code provides construction requirements for Radon Control Systems. These same principles can be applied to treat stray CO₂ from the subsurface with the recommendation that the ventilation is reversed. Continuous wall mounted CO₂ monitors are recommended to monitor CO₂ concentrations in the building. These will provide the comfort of knowing that levels are within acceptable limits and warn the occupants if a problem reoccurs.

If a CO₂ problem is suspected and may be caused by an industry regulated by DEP, DEP scientists are available to investigate and identify the source of these problems. If you suspect that the problem is mining related, contact the appropriate District Mining Office. If the problem is not mining related, contact the appropriate Regional Office.

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For more information, visit www.dep.pa.gov.