10.7: Atmospheric Particle Pollutants

Although gases that cause global warming are arguably the most serious air pollutants, other air pollutants can cause serious problems with the atmospheric environment. These are discussed in the remainder of this chapter.

Because of their ability to reduce visibility and light, atmospheric particles are the most visible form of air pollution. Commonly called **particulates** in air pollution parlance, atmospheric *aerosols* are solids or liquids less than 100 micrometers (millionths of a meter,μm) in diameter, and commonly in a size range of 0.001 to 20μm. They may be inorganic or organic materials and may belong to the two general classes of **dispersion aerosols** formed by grinding solids, dispersing dusts, or atomizing liquids, and **condensation aerosols** produced by the condensation of gases or vapors, often formed as the result of atmospheric chemical processes. Common dispersion aerosols include water droplets from sea spray, solid particles of NaCl left over when water evaporates from sea spray droplets, cement dust, soil dust dispersed by wind, foundry dust, and pulverized coal. Carbon black, metal fumes, and combustion nuclei form as condensation aerosols from combustion or partial combustion. Liquid particle **mists** include raindrops, fog, cloud droplets, and droplets of sulfuric acid produced when atmospheric SO_2 is oxidized. Organisms produce an abundance of particles. For those afflicted with allergies, the most annoying such particles are plant pollen. Other particles of biological origin include viruses, bacteria, and spores of bacteria and fungi.

In the past and even now in some areas of the world, one of the more troublesome sources of atmospheric particles was **fly ash**, a byproduct residue from combustion of liquids or very finely divided coal. Often the most abundant component of fly ash is elemental carbon left over from incompletely burned fuel. Fly ash commonly includes oxides of aluminum, calcium, iron, and silicon, as well as some magnesium, sulfur, titanium, phosphorus, potassium, and sodium. With properly operating emission control devices, fly ash emissions are now well controlled.

One health concern with particles, especially those from combustion sources, is their ability to carry toxic metals. Of these, lead is of the greatest concern because it usually comes closest to being at a toxic level. Problems with particulate lead in the atmosphere have been greatly reduced by the elimination of tetraethyllead as a gasoline additive, an application that used to spew tons of lead into the atmosphere every day. Another heavy metal that causes considerable concern is mercury, which can enter the atmosphere bound to particles or as vapor-phase atomic mercury. Airborne mercury from coal combustion can become a serious water pollution problem leading to unhealthy accumulations of this toxic element in some fish. Other metals that can cause problems in particulate matter are beryllium, cadmium, chromium, vanadium, nickel, and arsenic (a metalloid).

Some areas of the world, including parts of the United States, have problems with radioactive particles resulting from underground sources of radioactive **radon**, a noble gas product of radium decay. The two major radon isotopes, 222Rn (half-life 3.8 days) and 220Rn (half-life 54.5 seconds)are alpha particle emitters that decay to radioactive 218Po and 216Po, respectively. These radionuclides are nongaseous and adhere readily to atmospheric particulate matter, which, along with gaseous radon, can cause significant indoor air pollution and potential health problems.

Pollutant particles in the atmosphere have both direct and indirect effects. The most obvious direct effects are reduction and distortion of visibility. The light scattering effects of particles in a size range of 0.1μm–1μm are especially pronounced due to interference phenomena resulting from the particles being about the same size as the wavelengths of visible light. Particles also have direct health effects when inhaled. This is especially true of very small particles that can be carried into the innermost parts (alveoli) of lungs. An indirect effect of particles is their ability to serve as reaction sites for atmospheric chemical reactions. They also act as nucleation bodies upon which water vapor condenses.

Limiting Particulate Emissions

The first widespread measures to limit air pollution were directed at control of particle emissions. These measures have become very effective so that the “smoke” that one sees emanating from smokestacks usually consists of droplets of water formed by condensation of steam.

The simplest method of particle control from stack gas and other gases released to the atmosphere consists of **sedimentation** in which particles entrained in stack gas are allowed to settle by gravity in relatively large chambers. Sedimentation is most effective for larger particles. **Inertial mechanisms** operate by spinning a gas in a round chamber such that particles impinge upon the container walls by centrifugal force. **Fabric filters** contained in **baghouses** act to filter particles from air or stack gas (Figure 10.6). The mechanism employed provides for periodic shaking of the fabric filters to collect particles held on their walls, thus restoring gas flow through the fabric. Numerous factors including moisture levels, particle abrasion, particle size, and acidity or alkalinity of the gas and particles must be considered in choosing filter fabrics. **Scrubbers** that spray water or solutions into stack gas are employed to literally wash particles out of gas. In some cases these are operated with a minimal amount of water, which evaporates, so that a solid material is collected. One of the most effective means of particle control consists of **electrostatic precipitators**. These devices use a very high voltage to impart a negative charge onto particles from a central electrode, and the particles are attracted to, and collect on the positively charged walls of the precipitator.

In keeping with the practice of sustainability the particulate matter, such as that collected by a fabric filter in a baghouse, may be used for various purposes. Typically, particulate matter from lead or zinc smelting operations is recycled back into the metal recovery process. Lime kiln dust is often used as agricultural lime. Some kinds of coal fly ash could be used as a source of aluminum if aluminum ore (bauxite) becomes scarce.
