Course Learning Outcomes for Unit IV

Upon completion of this unit, students should be able to:

5. Explain key industrial hygiene concepts such as routes of entry and hierarchy of controls.
   5.1 Describe how chemical properties affect the different routes of exposure.
   5.2 Describe how chemicals can enter the body through the dermal route.

6. Examine different types of industrial hazards commonly addressed by the industrial hygienist.
   6.1 Identify chemical and biological hazards in occupational settings.

Reading Assignment

Chapter 6:
Gases and Vapors, pp. 113–119

Chapter 7:
Aerosols, pp. 137–144

Chapter 10:
Dermal Hazards, pp. 213–225

Chapter 15:
Biological Hazards, pp. 349–361

Click here to view a PowerPoint presentation to learn more information regarding chemical and biological hazards.

Click here to access the PDF version of the PowerPoint presentation.

Unit Lesson

An important part of the industrial hygienist’s job is to recognize hazards in the workplace. Occupational hazards can be divided into three basic categories: chemical, biological, and physical. We will be studying chemical and biological hazards during this unit. Recognizing chemical hazards requires the industrial hygienist to have at least a basic understanding of chemistry and biology, including the sub-science of microbiology.

Chemical hazards are typically divided into two categories based on their chemical state. The two categories are vapors/gases and aerosols. In the occupational setting, it is more common that the terms particle or particulate are used. It is fairly easy to understand the differences between gases/vapors and aerosols. What may be more difficult is to understand the difference between a gas and a vapor.

The difference between a gas and a vapor depends on the state of the chemical at normal (sometimes called standard) temperature and pressure (NTP or STP). A gas is in the gaseous state at NTP, while a vapor is in the liquid state at NTP with some vapors being produced. The concentration of the vapors being produced depends on the vapor pressure of the chemical. Gases have vapor pressures that are high enough that they do not exist as a liquid at NTP. The higher the vapor pressure is for a chemical, the more likely a vapor will be produced. One important thing to remember is that vapor pressure is temperature dependent. As the temperature increases, the vapor pressure of a chemical will also increase, increasing the volatility of the compound. This can be very important for an industrial hygienist in recognizing chemical hazards. Thus, if the
industrial hygienist knows that a certain chemical with a fairly low vapor pressure is being used in a process in which it will be heated up, there may be a significant increase in exposure levels that must be dealt with.

Another important chemical property that the industrial hygienist must consider is the vapor density. Chemicals with vapor densities greater than one (heavier than air) will settle to lower areas when there are no outside forces like wind or ventilation working on them. Chemicals with vapor densities lower than one tend to rise up. If a spill or gas release occurs at a facility, the industrial hygienist should consider the vapor density to account for concentrations of the chemical that may collect in low lying areas near the spill. Not taking this into account has resulted in exposure to individuals entering low lying areas, such as pits, after a spill cleanup and suffering harm or death due to the accumulation of vapors and gases.

Aerosols have chemical properties that make their recognition somewhat different than gases and vapors. There are several general categories of aerosols, dusts, mists, fogs, fibers, smokes, and fumes. The differences are based on the types of aerosols that are present in the air. Dusts and fumes are solid aerosols in the air. Mists and fogs are liquid particles in the air. Smokes are mixtures of solid and liquid aerosols in the air. Fibers are solid aerosols in the air with a specific length-to-width ratio.

Fumes are aerosols that are sometimes misunderstood by both health and safety personnel and the lay person. The term fume has come to be used synonymously with the terms vapor and gas. It is important for the industrial hygienist to understand the difference among these terms. A fume is generated when a solid material is vaporized. The vapor is not stable in the air at the temperatures that are present, so very small particles are produced. The most commonly encountered fumes in an occupational setting are welding fumes. Understanding the difference between a fume, a gas, and a vapor is very important when determining control methods, which we will explore in a later unit.

Another important difference between aerosols and vapors/gases is the concept we talked about involving vapor pressure and vapor density. Vapor pressure and vapor density are not typically the controlling factors regarding how aerosols react in the workplace. Particle size is very important in determining how an aerosol will interact with the human body and how long an aerosol may remain airborne. In general, smaller particles will be deposited in lower regions of the respiratory system than larger particles. This can have a great effect on the toxicity of the aerosol. An example of this is nasopharyngeal cancer caused by exposure to some hardwood dusts. The particles are typically too large to enter the lower regions of the lung and are deposited in the nasopharyngeal region where the harm occurs. Understanding aerosol size can also be important in determining control methods.

Passive diffusion can also be important for the deposition of particles if the particles are submicron in size. A random motion is imparted to the particles by the impact of gas molecules in the lungs. Also, diffusion is an important deposition mechanism in small airways and alveoli for particles below about 0.5 µm in size. The site of deposition affects the severity of tissue damage, the degree of absorption, the clearance mechanisms available, and thus, the ultimate removal of the particles. This is one factor in the toxicity of asbestos fibers, as smaller fibers are the most active.

Biological diseases are not typically as prevalent as chemical exposures in most industrial settings. However, in some occupational settings, biological exposures are extremely important. For example, in a hospital setting, the industrial hygienist needs to be able to identify several biological hazards, including bacteria like Mycobacterium tuberculosis and fungi like Aspergillus fumigatus. The industrial hygienist will also need to be able to identify viruses such as the human immunodeficiency virus (HIV), algae, and protozoa. Controlling biological exposures typically takes some specialty training beyond what the average industrial hygienist requires. A better understanding of microbiology, bacteriology, and mycology are examples of additional sciences that might be studied. The Occupational Safety and Health Administration (OSHA) has published the Bloodborne Pathogen standard specifically to control exposures to biological hazards.

Finally, industrial hygienists must also have a good understanding of routes of exposure for chemical and biological hazards. The dermal route of exposure presents a unique exposure that is sometimes overlooked. Understanding which compounds are more likely to cause harm through dermal exposure and understanding the conditions that may be present that could increase exposure through the dermal route can be very important. An example would be exposure to hydrogen fluoride (HF). HF will initially cause burns to the skin like other strong acids. However, HF can be absorbed through the skin. HF has a great affinity for calcium and will bind with calcium in the blood and bones, sometimes causing a severe condition called hypocalcemia. In places where dermal contact with HF may occur, the industrial hygienist will oftentimes
place containers of calcium gluconate gel, which can be applied immediately after dermal exposure to bond with the HF, preventing further harm to the individual.

**Suggested Reading**

The CSU Online Library contains many articles that relate to the reading assignment in this unit. The following are just a few of the related articles that can be found in the CSU Online Library:

*In order to access the resources below, you must first log into the myCSU Student Portal and access the Academic Search Complete database within the CSU Online Library.*

On some occupational sites, there are multiple chemical hazards present that may include gases, vapors, and aerosols. The article below shows the difficulties that can arise from trying to identify chemical hazards for a complex setting.


Some occupational settings may have chemical hazards that are not readily apparent because they come from secondary sources. The authors reported on the gas formaldehyde being found in school classrooms.


Dermal exposure can be a significant source of occupational exposures. This article looks at the potential for some vapors and gases to cross the dermal barrier directly from the air.


There are some settings where chemical and biological hazards may be present at the same time. The article “Evaluation of Microbiological and Chemicals Contaminants in Poultry Farms” describes one such setting and discusses the contributions each type of hazard might have for worker health. Click here to view the resource below.


In some instances, one chemical hazard can inadvertently impact an individual’s health by reducing the body’s ability to fight off infections. These researchers looked at the effect that exposures to welding fumes had on respiratory infections. The results were summarized in the article below, which can be found by entering the article’s title in a search engine of your choice.

Learning Activities (Non-Graded)

Non-graded Learning Activities are provided to aid students in their course of study. You do not have to submit them. If you have questions, contact your instructor for further guidance and information.

The National Institute for Occupational Safety and Health (NIOSH) publishes the NIOSH Pocket Guide to Chemical Hazards, which can be accessed at http://www.cdc.gov/niosh/npg/default.html. Access the NIOSH Pocket Guide to Chemical Hazards, and read the introduction section to see what properties of gases, vapors, and aerosols are included in the guide. Search the guide for several gases, several vapors, and several aerosols. Note the physical properties of each, including vapor pressure and vapor density. You can also find a conversion factor that makes it easier to convert from mg/m³ to ppm. Practice making conversions using the conversion factor and the formula provided in the textbook to see if you get the same answer.