Course Learning Outcomes for Unit IV

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

5. Identify the hazard classes as outlined by the Department of Transportation (DOT) and the basic DOT hazardous material regulations related to the identification, classification, labeling, marking, transporting, and response to hazardous material incidents.
   5.1 Identify the hazard class, descriptions, labels, markings, and placards that DOT requires when transporting toxic substances.
   5.2 Identify the response actions that are applicable to incidents involving toxic substances.

6. Describe key chemical specific factors or properties that should be considered when managing or responding to incidents involving corrosive materials (acids and bases), water reactive substances, pyrophoric materials, toxic substances, oxidizers, organic compounds, and polymeric materials.
   6.1 Identify the chemical properties, uses, and ill effects associated with common toxic substances as related to the tasks and safety of an EHS & FS professional.
   6.2 Identify workplace exposure concentrations associated with common toxic substances.

Reading Assignment

Chapter 10:
Chemistry of Some Toxic Substances

CSU Online Library Article:


In order for the link above to function properly, you must first log into the myCSU Student Portal and access the Academic Search Complete database within the CSU Online Library.

You may also access the resource by visiting the Academic Search Complete database and performing a search for the title and/or author.

Unit Lesson

For Unit IV, we will study the chemistry of some toxic substances, which are covered in Chapter 10 of our textbook. You may notice that some of the hazardous materials that we just covered under the corrosive and water/air-reactive classification can also be classified as toxic since these substances can possess multiple hazardous characteristics. When these hazardous materials are transported, the Department of Transportation (DOT) description will indicate which hazard is primary.

Toxic substances (also known as toxicants or poisons) can cause injury, illness, or possibly death when the body is exposed to them, even in small quantities. As such, these substances require special attention when they are encountered during their manufacture, storage, transport, use, or in an emergency response incident. Other toxic substances are produced due to the interaction of hazardous/non-hazardous materials. An example of a toxic substance encountered at fire incidents is carbon monoxide (CO). CO is the result of
incomplete combustion (not enough oxygen/air to completely burn an organic material that is not necessarily hazardous).

Chapter 10 focuses on the following toxic substances that could be present as environmental health and safety (EHS) and (FS) professionals perform their duties: carbon monoxide (CO), hydrogen sulfide (H₂S), sulfur dioxide (SO₂), hydrogen cyanide (HCN), nitrogen dioxide (NO₂), ammonia (NH₃), asbestos, and pesticides. Warfare agents such as ricin are also briefly discussed. Just like in the previous units, workplace regulations, transport requirements, and recommended incident response actions are also covered.

The study of toxic substances is toxicology. Specifically, toxicology studies the symptoms, mechanisms, treatments, and detection of poisoning, especially the poisoning of people (News Medical, n.d.). Toxicology, which is a field on its own, investigates the manner by which toxic substances adversely affect a living organism, the diseases they may cause, the concentrations at which the onset of the adverse effects are noted, and ways to prevent or minimize them.

Epidemiology is the study of the adverse effects of these substances and diseases, specifically the how, when, and where they occur. In this course, we will cover only the very basic toxicology and epidemiology terms and concepts that are applicable to our study of hazardous materials interactions.

You should know that we can get exposed to toxic substances by inhalation, ingestion, and skin absorption. These exposure pathways are discussed with illustrations on pages 350-351.

We will also review the following common ways that toxic substances can adversely impact health. According to Meyers (2014),

- Exposure may cause immediate dysfunction, impairment or death.
- Exposure may affect only the site of contact.
- Exposure may affect the whole body so the ailment is not localized; this is called systemic effect.
- Exposure may target specific organs. There are specific terms used to describe these substances, such as the following:
  - Hemotoxicant, a substance that decreases the function of the blood’s hemoglobin and deprives the tissues of oxygen
  - Hepatotoxicant, a substance that causes liver damage
  - Nephrotoxicant, a substance that causes kidney damage
  - Neurotoxicant, a substance that adversely affects the central nervous system (the brain and spinal cord)
  - Respiratory toxicant, a substance that adversely affects the nasal passages, pharynx, trachea, bronchi, and lungs
  - Reproductive toxicant, a substance that adversely affects sexual function and fertility in adults, as well as development in their offspring. (Meyers, 2014, p. 352)

Toxic substances can also be classified as:

- Asphyxiant: "any gas or vapor that dilutes or displaces air and, when inhaled, causes unconsciousness or death" (Meyers, 2014, p. 352). An asphyxiant interferes with oxygenation of the tissues and the affected individual may literally suffocate. According to Plog (1988), these are generally divided into:
  - Simple asphyxiant: physiologically inert gases that dilute or displace atmospheric oxygen below that required to maintain blood levels sufficient for normal respiration. Examples: carbon dioxide, helium, hydrogen, methane, and nitrogen
  - Chemical asphyxiant: This prevents or interferes with the uptake or transport of oxygen through their chemical action. Examples: Carbon monoxide prevents oxygen transport by preferentially combining with hemoglobin. Hydrogen sulfide paralyzes the respiratory center of the brain and the olfactory nerve.
- Irritants: Any substance that on immediate, prolonged, or repeated contact with living tissue, induces a local inflammatory reaction (Meyer, 2014).

The harmful effects of toxic substances can be classified as chronic, acute, short term, and latent health effects (Meyer, 2014, p. 354).
There are several factors that affect the degree of toxicity. Since everybody is different, the effects of the toxic substances also vary to a certain degree based on several factors:

- amount of toxic substance that is inhaled, ingested, or absorbed;
- length of time of exposure;
- rate at which the toxic substance is absorbed in the bloodstream;
- age, sex, ethnicity, and general health of individuals (e.g., the elderly could be more sensitive);
- individual sensitivities—could be genetic; and
- adverse health impacts on a developing fetus. One example observed involved a pregnant woman ingesting a material with very high levels of lead, which impacted her baby. The baby had very high levels of lead when she was tested (only a few days old).

Measures of toxicity are classified as follows:

- Lethal Dose, 50% kill, or LD$_{50}$: dose when 50% of a test group die
- Lethal Concentration, 50% kill or LC$_{50}$: concentration of the substance that kills 50% of a test group
- Threshold Limit Value (TLV): This is a time-weighted average concentration under which most people can work consistently for eight hours a day, day after day, without harmful effects (Plog, 1988). A table of these values is published by the American Conference of Governmental Industrial Hygienists (ACGIH).

Read pages 365 through 391 of the textbook to determine the chemical properties, ill effects, workplace regulations, transportation requirements, and emergency response actions applicable to the common toxic substances that could be encountered by EHS and FS professionals in the course of performing their duties (Meyer, 2014).

References


**Suggested Reading**
