Course Learning Outcomes for Unit VIII

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

4. Evaluate chemical interactions as they relate to control of potential hazards.
    4.1 Identify the explosive or radioactive material that could be involved in emergency response incidents.
    4.2 Describe the chemical interaction involving explosive or radioactive materials.

7. Analyze important standards related to hazardous substances.
    7.1 Identify the hazards, precautions, and regulations associated with the handling, storing, using, or transporting explosive or radioactive materials.
    7.2 Describe the immediate action that should be taken by EHS and FS responders take to protect human health and the environment in the event of an incident involving explosive or radioactive materials.

Course/Unit Learning Outcomes	Learning Activity
4.1	Unit VIII Lesson Chapter 15 Chapter 16 Unit VIII Assessment
4.2	Unit VIII Lesson Chapter 15 Chapter 16 Unit VIII Assessment
7.1	Unit VIII Lesson Chapter 15 Chapter 16 Unit VIII Assessment
7.2	Unit VIII Lesson Chapter 15 Chapter 16 Unit VIII Assessment

Reading Assignment

Chapter 15: Chemistry of Some Explosives, pp. 654-680

Chapter 16: Radioactive Materials, pp. 684-731

Unit Lesson

In this unit, we will study another more complex type of hydrocarbon—explosives (Chapter 15). Then to finish the course, we will study some radioactive materials (Chapter 16).

Chapter 15: Chemistry of Some Explosives

An *explosive* is a material or article, including a device, that can react and explode. For this chapter, we will focus on Department of Transportation (DOT) explosive materials, specifically chemical explosives such as TNT (trinitroglycerin) and ANFO (ammonium nitrate and fuel oil).

Chemical explosives have beneficial as well as detrimental uses. They can be used for sporting activities, coal mining, excavations for foundations, underwater channels, and pyrotechnics. However, explosives can also be used by terrorists, such as in the Oklahoma bombing in which ANFO was used, or in improvised explosive devices (IED) used by suicide bombers (Meyer, 2014).

Some terms to note regarding explosives include the following:

- *Detonation* is when the explosive material decomposes instantaneously. Large amounts of gases and vapors are produced with high heat and pressure shock waves.
- *Detonation velocity* is the speed of the energy wave, which determines how powerful the explosive material is.
- *Detonation temperature* approximates the explosive's melting point.
- *Brisance* is the potential shattering power of the explosive (Meyer, 2014).

Products of explosive decomposition are mainly carbon monoxide, carbon dioxide, nitrogen, oxygen, and/or water vapor (depending on the chemical constituents of the explosive). *Environmental health and safety (EHS) professionals, fire science (FS) professionals, and emergency responders should always acknowledge that explosives possess a high degree of hazard* (Meyer, 2014).

Storing explosives: Federal, state, and local regulations require that explosives be stored in magazines (any building, room, or vessel that is used for receiving, storing, and dispensing explosives).

Transporting explosives: DOT regulates the transportation of specific types of explosive articles *and* explosive substances listed in the Hazardous Materials Table. When the word *forbidden* appears in column 3 of the Hazardous Materials Table, the designation signifies a forbidden explosive, meaning the material is prohibited for any mode of transportation (Meyer, 2014).

Responding to incidents involving explosives: Under routine conditions, responding to an emergency incident involving explosives should be undertaken only by experts who are competent, experienced and have received special training in the handling of these materials (Meyer, 2014).

Chapter 16: Radioactive Materials

When people hear the term *radioactive,* some will probably think of the Fukushima Dai-Ichi nuclear power plant incident in Japan, and some may think of the atomic bomb dropped in Japan to end World War II (Meyer, 2014). In both events, there was a release of *radioactive materials*. We will discover in this chapter that both events are associated with the occurrence of one or more nuclear processes. We will also learn that there are serious health risks associated with exposure to radioactive materials (Meyer, 2014).

Modes of radioactive decay: Most of you are familiar with these modes so just review pages 689-692 in your textbook.

Radioactivity can be detected by radiation detection instruments which are commercially available. The picture shown in Figure 16.5 of the textbook is an example of a handheld radiation detector that is commonly used by first-on-scene responders to measure the intensity of radiation.

Historical Notes of Interest: Radioactivity was first discovered in 1896 by Henri Becquerel (Environmental Protection Agency, 2012). Many of the terms associated with radioactivity, as you will find out, come from the early pioneers in radiation physics such as Marie Curie and Wilhelm Conrad Roentgen. Roentgen discovered the basic properties of X-Rays, the properties of ionizing radiation, and the possibility of using radiation in medicine. These discoveries though did not come without a price. "Scientists learned that radiation was not only a source of energy and medicine, but it could also be a potential threat to human health if not handled properly" (EPA, 2014, para. 5).

Units of radiation dose: When human tissue is exposed to ionizing radiation, we are concerned with the quantity of radiation absorbed per unit of mass. The amount of radiation absorbed per body weight is called the dose. It is measured by using units like the *roentgen, rad, rem, gray,* and *sievert*.

Units of activity: The intensity of the radioisotope may be provided directly in disintegrations per second, or it may be converted into multiples or fractions of units called the *curie* and *Becquerel* (Meyer, 2014). Refer to the textbook about conversions and equivalents of these units.

Effects of radiation: Everyone is constantly exposed to cosmic radiation and other inescapable low-level ionizing radiation emitted from the naturally occurring radioisotopes. The combination of ionizing radiation from natural and artificial sources in and around the Earth is called background radiation, the sources of which are noted in Figure 16.7 of the textbook (Meyer, 2014).

The combination of acute adverse health effects resulting from exposure to different doses of radiation is called radiation sickness. See Table 16.3 of the textbook. In the workplace, OSHA regulates employee exposure to radiation for activities that are not addressed by the Nuclear Regulatory Commission (NRC) or Department of Energy (DOE).

Nuclear fission: One method of producing radioisotopes involves utilizing the nuclear reactions that occur within a *nuclear reactor*, the heart of a nuclear power plant. The reactor functions because of the phenomenon called nuclear fission (Meyer, 2014). Fission is a reaction when the nucleus of an atom splits into two or more nuclei, and releases a significant amount of energy as well as more neutrons in the process (International Energy Agency, 2014). These neutrons then go on to split more nuclei, and a chain reaction takes place. The fragments that are produced by individual fission events are called *fission products.*

Nuclear power plants: According to Meyer (2014), 435 nuclear power plants produce approximately 20% of the electrical energy worldwide. According to the World Nuclear Association (2014), sixteen countries depend on nuclear power for at least a quarter of their electricity. Notable nuclear power incidents include Three Mile Island in Pennsylvania, Chernobyl in Russia, and the recent Fukushima Dai-Ichi in Japan.

Transporting radioactive materials: Stringent regulations apply to the transportation of a radioactive material. For details on shipping descriptions, labeling, marking, etc. read pages 718- 726 of the textbook. It is also important to be aware of regulations when responding to radiation incidents**.** When radiation sources are located nearby, government regulations require the authorized regulatory body to warn individuals of their presence.

Radiological dispersal device (RDD): An RDD can also be referred to as a *dirty bomb*. In an RDD, the radioisotopes could diffuse through the air where currents could carry them and in time cause the radioactive material to become dispersed worldwide (Meyer, 2014). A *dirty bomb* is charged with a hazardous material that is dispersed into the environment as the explosive is detonated.

Radon is an indoor air pollutant that is colorless, odorless, tasteless, and inert gas that occurs naturally. Radon comes from the natural breakdown (radioactive decay) of uranium. It is found in igneous rock and soil and in some cases from well water. As radon decays, it releases radioactive byproducts that can be inhaled. Radon enters homes through cracks in walls, foundation floors, gaps in wall-to-wall joints, and other openings. According to the American Lung Association (2014), exposure to radon is the second leading cause of lung cancer in the United States, after smoking. The radon that enters the home is residential radon and consists primarily of radon-22- and radon-222, with half-lives of 54.5 seconds and 3.82 seconds, respectively (Meyer, 2014). There are now test kits that are used to check homes for radon. There is a lot of information available on mitigation measures if a house has high levels of radon.

References

American Lung Association. (2014). Radon. Retrieved from http://www.lung.org/healthy-air/home/resources/radon.html

Environmental Protection Agency. (2012). History of radiation protection. Retrieved from http://www.epa.gov/radiation/understand/history.htm l

International Energy Agency. (2014). Nuclear fission and fusion. Retrieved from http://www.iea.org/topics/nuclearfissionandfusion/

Meyer, E. (2014). *Chemistry of hazardous materials* (6th ed.). Upper Saddle River, NJ: Pearson.

World Nuclear Association. (2014). Nuclear power in the world today. Retrieved from http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World-Today/

Suggested Reading

The American Lung Association maintains this webpage and information related to radon gases and the danger to human health. This information is easy to understand and provides an introduction to this chemical hazard.

American Lung Association. (2014). Radon. Retrieved from http://www.lung.org/healthy-air/home/resources/radon.html

This link will take you to the US EPA Radiation Protection Document Library. There are links on this webpage to many resources the risk of radiation exposure on human health.

Environmental Protection Agency. (2012). History of radiation protection. Retrieved from http://www.epa.gov/radiation/understand/history.html

The World Nuclear Association maintains this website with information related to nuclear power in the world. This webpage is a good resource for information and facts related to nuclear energy.

World Nuclear Association. (2014). Nuclear power in the world today. Retrieved from http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World-Today/