Chapter 6. Evaluating Exposures

by
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The human health risk associated with a chemical is dependent on the rate at which the chemical is released, the fate of the chemical in the environment, human exposure to the chemical, and human health re sponse resulting from exposure to the chemical. In simpler terms, as described in Chapter 2, risk is a function of hazard (or toxicity) and exposure. Chapter 5 discusses methods of predicting physical-chemical properties from chemical structure to infer the fate of a chemical in the environment. Chapter 7 discusses green chemistry techniques to select chemical that are less toxic. Chapters 5 and 7 are useful in designing chemical structures with low hazard, on of the two components of the risk equation. This chapter, Chapter 6, addresses the e*xposure* component of the risk equation. Ideally, exposure is quantified by monitoring the work area or environmental setting where a chemical will be used or released; however, when monitoring data are not available to measure exposures, exposures can be estimated using methods described in this chapter.

The methods for estimating exposure will be separated into two sections—occupational and community. Occupational exposure occurs in the workplace. Workers in ch emical production facilities may be exposed to toxins used or produced in the chemical process. Exposure to chemicals may occur from the inhalation of workplace air, ingestion of dust or contaminated food, or from contact of the chemical substance with th e skin or eyes. In addition, chemical engineers must be aware of community exposures resulting from releases into the air and water, and from solid and hazardous waste disposal. Chemical releases to rivers, lakes, and streams may accumulate in fish and oher marine life, which are subsequently used as a source of food, or may be ingested by persons using the downstream reaches of rivers as a supply of potable water. Persons living downwind of a chemical manufacturing facility may be exposed to fugitive and point source releases of chemical toxins to the atmosphere. Disposal of solid and hazardous wastes on the land, either in repositories such as landfills or into the subterranean strata by injection into wells may result in contamination of potable grou ndwater if the waste is not isolated form the water supplies.

The intent of Chapter 6 is to introduce students to some methods for predicting potential exposure, in particular, occupational exposure and community exposure. During process design, it may b e useful to predict potential exposures to nearby residents from chemical emissions or releases from the plant (i.e., “occupational exposure”), or potential exposures to nearby residents from chemical emission or releases from the plant (i.e., “community p r general population exposure”). There are other exposure areas, such as consumer exposure, which are not discussed in this chapter. The chemical engineer, in addition to selecting chemical with low toxicity, also needs to select solvent chemicals and design unit operations to minimize potential exposure as well.

There are many good references on exposure assessment. Interested students are encouraged to consult references on other types of exposure not covered in this chapter. EPA has a website specifically for exposure which contains computerized tools for all exposure areas (http://www.epa.gov/oppt/exposure). This information can be useful in selecting and designing unit operations. Many of these references are listed in Appendix F.

Chapter 6 Example Problem

Example 6.2-1

A cleaning bath for electronic parts emits 0.5 g/sec of CFC -12 into a small work room of dimensions 3 m x 3 m x 2.45 m high. Calculate the concentration in the room under average and poor ventilation conditions if the air velocity in the room is 0.3 m/s and compare the results to the OSHA PEL.

Solution

When the air speed is 0.3 m/s, the volume of air flowing through the room will be:

Q = 0.3 m/s x 3 m x 2.45 m = 2.21 m3/s,

and the concentration of CFC-12 in the air will be:

average ventilation C = 0.5 g/sec / (0.5 x 2.21 m3/s) = 0.45 g/m3,

poor ventilation C = 0.5 g/sec / (0.1 x 2.21 m3/s) = 2.27 g/m3.

A comparison with the permissible exposure limits given in Table 6.2 -1 indicates that even under poor ventilation conditions, the OSHA PEL will not be exceeded and respiratory protection will not be needed to safe-guard the health of a person working in this room.

Chapter 6 Sample Homework Problem

A liquid transfer pump is leaking at the seals releasing 1 milliliter per minute (about two ounces per hour) of an aqueous solution containing 4 percent acrolein (2-butenal). Nearby, a process tank has a leaking seam from which is weeping an aqueous solution containing 5 percent methyl ethyl ketone (2-butanone) at a rate of 30 milliliters per minute (about 2 quarts per hour). The ventilation rate in the process building where the leaking pump and weeping tank are located is 200 cubic meters per hour. Is either of these releases a potential health hazard to workers in the process building?

Solution:

Because both of these materials are volatile, it can be assumed that the liquids vaporize rapidly. The density of the dilute solutions will be close to that of water, 1000 mg/ml. The average concentration in the process building will be equal to the rate of release of contaminant divided by the ventilation rate. Thus,

For acrolein: $C = (1\ ml/min)(60\ min/hr)(0.04)(1000\ mg/ml)/(200\ m^3/hr) = 12\ mg/m^3$

For MEK: $C = (30\ ml/min)(60\ min/hr)(0.05)(1000\ mg/ml)/(200\ m^3/hr) = 450\ mg/m^3$

Recommendations for short-term exposure limits to environmental contaminants are give in the NIOSH Pocket Guide, available online at www.cdc.gov/niosh/npg/pdgstart.html. For the chemicals in this example, the recommended limits for short-term exposure are 0.8 mg/m for acrolein and 885 mg/m for MEK. Although the exposure to MEK for short periods of time may be acceptable until the weeping tank is repaired, the hazard resulting from short-term exposure to acrolein is unacceptable.