

Chapter 1 BASICS OF INDUSTRIAL HYGIENE

I. Industrial Hygiene

Industrial Hygiene is the science and art of recognizing, evaluating, and controlling occupational health hazards. It uses scientific principles to evaluate the adverse effects of **chemical, physical and biological agents, and ergonomic stresses** on the body. That is, can these hazards injure or impair the health of miners?

II. Types of Health Hazards

- A. **Chemical Hazards** - Chemicals may enter the body and poison or otherwise injure the body's organs or tissues. (This chapter includes an overview of chemical hazards and potential health effects. More information about certain topics can be found in Chapter 19 – Chemical Storage and Use.)
- **Organic chemicals** - are chemicals that have at least one carbon atom bonded to a hydrogen atom. Such chemicals are called hydrocarbons. The name “organic” was derived from chemicals like petroleum that are the result of decomposed organisms. This term does not mean “all natural.” In fact, most known organic chemicals are man-made (plastics, solvents, pesticides, etc.). Organic chemicals may be very toxic. They are readily absorbed into the bloodstream through the skin and the eyes, and through the lungs and digestive system.
 - **Inorganic chemicals** - are any chemicals that are not organic. That is, they do not have any carbon atoms bonded to a hydrogen atom. Water and many minerals are inorganic.

The permissible exposure levels for many of these chemicals are listed in the *TLVs[®] Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*. This is an important document for compliance determinations. It was published by the American Conference of Governmental Industrial Hygienists and has been incorporated by reference into MSHA health standards for metal and nonmetal mines at 30 CFR Parts 56/57.5001. The hazard represented by these chemicals or hazardous materials depends on many factors (*e.g.*, concentration, type, and length of exposure).

The *NIOSH Pocket Guide to Chemical Hazards*¹ can be a helpful tool for MSHA inspectors in determining the toxicity of a substance. *Material Safety Data Sheets (MSDS)* are another resource for similar information.

1. **Asphyxiants** - suffocate by preventing the body from getting oxygen.
 - **Simple asphyxiants** - displace the oxygen in the environment
Examples are carbon dioxide, methane, nitrogen and nitrous oxide.
 - **Chemical asphyxiants** – combine with hemoglobin to reduce the blood's capacity to transport oxygen, thereby preventing oxygen uptake at the cellular level. An example is carbon monoxide.
2. **Corrosives** - chemicals (very strong acids or caustics/alkalies) that causes visible destruction or permanent changes in tissue at the point of contact. Acidity or alkalinity of chemicals is measured on the **pH scale**, which ranges from 0.0 to 14.0, with 7.0 being neutral.
 - a. **Acids** - pH lower than 7.0. The pH of corrosive acids is 0 to 2. Examples are battery and some laboratory acids.
 - b. **Pure water** - pH of 7.0
 - c. **Caustics or Alkalies** - pH higher than 7.0. The pH of corrosive caustics/alkalies is 12 to 14. Examples are drain cleaners and lye.
3. **Irritants** - a chemical that is non-corrosive, and causes reversible damage or inflammation in or on the body. An example is portland cement.
4. **Solvents** – substances that dissolve another material. Some solvents can damage fatty tissue and organs like the brain and central nervous system (CNS), liver, kidneys and bone marrow. Examples are water, acetone and paint thinners.
5. **Carcinogens** - cause cancer. Examples are asbestos, radon, some metals, and some solvents.

¹The *NIOSH Pocket Guide to Chemical Hazards* contains an index of synonyms for the most common chemicals in the workplace, information on the health effects of toxic chemicals, chemical incompatibilities, and required personal protective equipment (PPE).

6. **Organ toxins** – damage specific body organs (called **Target Organs**), including the liver (hepatotoxins), the kidneys (nephrotoxins) or the brain/central nervous system/nerve cells (neurotoxins). Examples are many solvents.
7. **Systemics** - substances that spread throughout the body, poisoning multiple body organs and systems. Examples include some solvents and heavy metals.
8. **Sensitizers** (also called “allergens”) – some chemicals are skin sensitizers (causing an inflammation called “dermatitis”), while others are lung sensitizers (which may cause an “asthma-like” reaction). Still other chemicals may affect both the skin and lungs. Persons may respond to a sensitizer during their initial exposure, with respiratory tract irritation or bronchoconstriction, or they may experience little or no reaction during first exposure, but a small amount or concentration of the chemical during a subsequent exposure may elicit a dramatic reaction. Cross-reactivity may occur in some individuals, *i.e.* a sensitized person may react to other chemicals. Complete avoidance of certain chemicals may be necessary (*i.e.*, no occupational or non-occupational exposure).
9. **Reproductive Toxins, Teratogens and Mutagens** - cause sterility, birth defects, or mutations of future generations.
10. **Contaminants** - In Mine Safety and Health Administration (MSHA) standards, chemical health hazards are frequently called **contaminants**. Contaminants found in mining facilities occur naturally, as part of an ore body (such as silica, lead, etc.), or are man-made (such as processing chemicals or solvents). These contaminants are released into the environment through various mining and processing activities. They may be found as various **States of Matter**:
 - a. **Aerosols** - are solid or liquid particles suspended in air or in another gas.
 1. **Dusts** are solid particles produced by drilling, crushing, grinding, chipping, or cutting.
 - **Respirable dusts** are particles suspended in the air with a size of less than 10 microns in diameter.

These dusts can penetrate to the deepest areas of the lungs. Examples are silica, coal, and metal ore dust.

- **Total dust** refers to airborne particles of any size that are suspended in air. Some total dusts can be toxic when inhaled. Examples are lead and uranium. Other total dusts are classified as “nuisance dusts.” These are defined as those dusts listed in Appendix E of the *TLVs[®] Threshold Limit Values for Chemical Substances in Workroom Air Adopted by the ACGIH for 1973*. They may cause toxic effects when inhaled in large quantities.
- b. **Fumes** are microscopic particles formed when metal is melted and vaporizes (such as during welding, torch cutting, or smelting). When the heated metal vapor condenses, it forms a chemical compound of the metal and oxygen, called an oxide. Metal oxide fumes can be inhaled and may cause damage to various internal organs.
 - c. **Mists** are microscopic liquid droplets formed by splashing, foaming, or spraying. They are easily breathed, and some can be absorbed by the skin and the eyes. Acid mists can damage the lungs and skin. Examples are paint sprays and oil mists.
2. **Gases** are formless at room temperature and fill the shape of the space they are in. Under very high pressure or low temperature they change to liquids or solids. Gases are easily breathed and some are readily absorbed by the eyes. Examples are carbon dioxide or oxygen.
 - a. **Vapors** are gases that under ordinary conditions are liquids or solids. They can be easily breathed and absorbed by the eyes. Some organic chemical vapors can dissolve skin oils, be absorbed by the skin and enter the blood stream.
- B. Physical Hazards** – sometimes referred to as environmental factors, and often resulting from mechanical sources. Physical hazards can cause acute or chronic physical injury or death.
1. **Noise** – excessive noise for an extended time can damage or destroy the hearing cells of the inner ear, causing Noise Induced Hearing Loss.

2. **Thermal hazards** – a miner’s health can be adversely affected if exposed to extremes of temperature or radiation, or if the body’s metabolism is not properly regulated.
 - a. **Heat stress** – occurs when the body’s ability to cool itself is exceeded. This can result from high ambient temperature and/or excessive body heat production due to one’s work load.
 - b. **Hypothermia** – occurs when the body’s core temperature falls due to exposure to cold and/or wet conditions. If not reversed, death can result.
 - c. **Frostbite** – occurs when fluids near the body’s surface freeze, creating ice crystals and damaging the skin. Areas most commonly affected are the hands and fingers, feet and toes, nose and ears.
 3. **Radiation**
 - a. **Ionizing** – gamma and X-rays can penetrate the skin and damage internal organs. Examples of sources are laboratory X-ray machines and storage level indicators.
 - b. **Non-ionizing** – excessive exposure can burn and damage the skin or eyes. Examples of sources are lasers, infrared sensors and ultraviolet light generated by welding.
 4. **Pressure extremes** – Rapid release of pressure can injure miners. Examples of extreme pressure containers are compressors and air receivers, compressed gas cylinders and aerosol cans.
- C. **Biological Hazards** - an animal, plant, microscopic organism, virus, or product of a living organism can cause disease, poisoning, or allergic reactions.
1. **Bioaerosols** – bacteria, molds and fungi can cause mild or serious effects on miners’ health. These small organisms can be found in the air, soil, water, solid surfaces and decaying matter.
 2. **Bloodborne pathogens** – exposure to some viruses can cause serious health effects. Examples of viruses that may be in body fluids are hepatitis B and human immunodeficiency (HIV).

3. **Zoonotic diseases** – are those spread by animals and birds. Some may be injurious to miners. Examples are Histoplasmosis, Lyme disease, tick fever and Hantavirus.

- D. **Ergonomic Hazards** - Improperly designed tools, equipment, and/or workplaces, or improper lifting techniques, repetitive motions, excessive force, extended periods of vibration and/or awkward or improper body positioning can damage muscles, tendons, spine, nerves or cardiovascular system.

III. Health Effects

Any chemical or physical agent when administered in sufficient quantities is capable of evoking adverse effects. The **dose**, or the amount of chemical or physical stress exposure over a given period of time, will elicit the degree of **response** of the miner. Defining or estimating the dose-response relationship is one important step in the risk assessment process.

Note: There is some variation in each miner's response to identical concentrations of chemicals or to exposure levels of physical agents. Exposure limits are designed to protect the "normal" person for a working lifetime from these health hazards. For persons with increased susceptibility, such as asthmatics, those with heart disease, or other pre-existing medical conditions, reactions may be more dramatic than for the general mining population. Adverse effects may occur at or even below the Permissible Exposure Level (PEL). Because estimates of risk may differ for such susceptible persons (miners), the measures taken to protect them from occupational hazards may need to be more carefully considered.

The effects of overexposure to health hazards can either be **acute** or **chronic**.

- A. **Acute** effects result from short term or a single exposure and have immediate or almost immediate symptoms. Examples are metal fume fever, heat stroke, carbon monoxide poisoning, or a chemical burn.
- B. **Chronic** effects result from long term exposure and often take years before the symptoms appear. They may cause a long-term illness or deterioration of health. Examples are silicosis, metal or solvent poisoning of the liver and brain, or noise induced hearing loss.

IV. Routes of Entry

Chemical or biological contaminants can enter the body by four different paths. These are called **routes of entry**:

- A. **Inhalation (breathing)** - for example, silica dust, welding fumes, or solvent vapors.
- B. **Ingestion (swallowing)** - for example, metal dusts, or solvents splashed in the mouth.
- C. **Absorption (through skin or eyes)** - for example, mercury, hydrogen cyanide, and many processing chemicals.
- D. **Injection (through a puncture or cut in the skin)** - allowing direct entry into the bloodstream.

V. Risk

Risk is the combination of the probability of sustaining bodily harm or impairment from exposure to a contaminant or a stressor and the severity of injury or illness should harm occur. Risk depends on the combined effects of the following factors:

- A. The nature of the contaminant itself; for example, its chemical toxicity;
- B. The amount or concentration of the material to which the miner is exposed;
- C. The proximity of the miner to the source of the material;
- D. The length of time of a miner's exposure;
- E. The route of entry into the miner (breathing, swallowing, absorbing, etc.);
- F. Temperature (especially when heat stress or toxic chemicals are involved);
- G. The individual miner's tolerance or sensitivity to the contaminant; and
- H. Other health hazards in the area that can damage the same part(s) of the body and have an *additive* or multiplicative effect, such as a combination of asbestos and smoking.

VI. Control Measures

The first step in controlling workplace hazards is to identify hazards and possible exposures. Consider where and how a substance is produced, handled, and stored, as well as its effects on miners' health. These factors influence how effectively the hazard(s) can be controlled and the type of the control(s) chosen.

- A. **Controls** are devices, equipment, substances or procedures that either prevent health hazards from being generated or reduce or limit exposure to the hazard. Controls can be applied at three points: source (the origin of the hazard), path (the environment between source and miner), or the miner. Because each workplace is unique, one **type of control** or set of controls may not satisfy all conditions.
- B. **Types of controls** are often grouped in what is termed a "hierarchy of controls." The types are listed in order of preference below except for the Noise and Diesel Particulate standards which do not place preference on the use of engineering controls over administrative controls:
 - 1. **Engineering controls** involve modifying, repairing, or controlling an existing condition to reduce the health hazard; for example, redesigning a loading spout to reduce the dust. An engineering control may also involve substitution. Substitution replaces the offending machine, process, or contaminant with something less hazardous. Examples are the use of a quieter fan to replace a noisy fan, or the use of mineral spirits to replace benzene in parts cleaning applications.
 - 2. **Administrative controls** limit the time a miner is exposed to a health hazard. Examples are establishing and enforcing policies, modifying job tasks, designating and avoiding high-risk areas, or rotating personnel so affected miners spend less time exposed to the health hazard. If not properly implemented, adhered to, or supervised, administrative controls have the potential to overexpose a greater number of miners.

VII. Personal Protective Equipment

Personal Protective Equipment (PPE) is worn by the miner to protect against health and safety hazards. When an overexposure has occurred, PPE must be used during the implementation of controls. PPE must also be worn when control measures have been exhausted and an overexposure still exists. Examples of PPE include ear plugs, respirators, goggles, protective outerwear, and gloves. Refer to Chapter 16.

VIII. Training

Training is important in industrial hygiene to communicate to miners the health hazards to which they may be exposed, how to recognize the hazards, the precautions needed to prevent or minimize exposure, and the importance of maintaining controls installed or implemented for the miners' protection.