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Industrial hygiene: Industrial hygiene is the science and art devoted to the anticipation, recognition, evaluation, and control of environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among citizens of the community. The industrial hygienist recognizes that environmental stresses may endanger life and health, accelerate the aging process, or cause significant discomfort. Working with management and medical, safety, and engineering personnel, the industrial hygienist can help to eliminate or safeguard against environmental conditions caused by chemical, physical, ergonomic, or biological stresses. This chapter covers the following topics:

Environmental Hazards: The various environmental factors or stresses that can cause sickness, impaired health, or significant discomfort in workers can generally be classified as chemical, physical, biological, or ergonomic in nature.

Chemical Hazards: Exposure to a variety of chemical substances occurs both on and off the job and most do not present a hazard under ordinary conditions, but all have the potential for being harmful at some concentration and level of exposure. Chemicals pose a wide range of potential health hazards (such as irritation, disease, sensitization, and carcinogenicity) and physical hazards (such as flammability, corrosion, and reactivity). Chemical hazards can be found in the following basic forms:1) dusts, generated from solid organic or inorganic materials by reducing their size through either mechanical or natural processes, 2) liquids, an aqueous substance that flows freely, like water, 3) fumes, formed when a volatilized solid, such as a metal, condenses in cool air, 4) mists, finely dispersed liquids suspended in the air,5) gases, formless fluids that can be changed to the liquid or solid state only by the combined effect of increased pressure and decreased temperature, 6) vapors, the gaseous form of substances that are normally in the solid or liquid state at standard temperature and pressure 7) smoke, carbon or soot particles produced from the incomplete breakdown of carbon-containing materials

When chemical stressors are encountered in the workplace, a hazard evaluation should be conducted to identify potential health hazards. The most effective worksite evaluation includes all pertinent operations and work activities. The industrial hygienist inspects, researches, or

analyzes how the particular chemical hazards at a worksite could affect the worker. As part of the evaluation, industrial hygienists may review material safety data sheets (MSDSs) and/or conduct environmental monitoring and use applicable analytical methods to determine the extent of potential worker exposure. Airborne concentration, type and length of exposure, regulatory and consensus exposure limits (both short- and long-term limits) may be some of the issues impacting the evaluation.

If the chemical exposure evaluation indicates potentially hazardous conditions affecting employee health, the industrial hygienist then recommends appropriate corrective actions. Substitution with less hazardous materials is one of the most effective ways of eliminating or reducing exposure to chemicals that are toxic or pose other hazards .If substitution is used, one should be careful not to generate a more hazardous scenario with the substitute .Engineering (ventilation, isolation, enclosure), work practice (procedures, good housekeeping), administrative controls (worker rotation), and other methods (personal protective equipment) can also be used to control potential health hazards.

Physical Hazards: Physical hazards include excessive levels of ionizing and nonionizing radiations, noise, vibration, and extremes of temperature.

Noise: Noise is one of the most commonly encountered occupational health hazards. If a noise problem is suspected, then a noise assessment or survey should be performed to determine source(s) of noise, amount, exposure population, and duration of exposure. With proper instrumentation, monitoring noise levels is a relatively straightforward operation for an experienced industrial hygienist. To prevent adverse outcomes from excessive noise exposure, noise levels should be reduced to acceptable levels. After evaluating the workplace, an industrial hygienist can help develop a hearing protection strategy by recommending engineering and administrative controls and the use of PPE where needed. There are a variety of control techniques documented in the literature to reduce the overall worker exposure to noise .

Vibration: Vibration exposure occurs in many occupations where a worker comes in contact with vibrating machinery or equipment. Significant exposure to vibration could occur from either stationary or portable equipment. The industrial hygiene evaluation should look at the following risk factors: intensity and frequency of the vibration, the duration (time) of exposure, and the

part(s) of the body receiving the vibration energy. The evaluation will typically be described in terms of frequency, amplitude, and acceleration.

• Frequency: The number of cycles that a vibrating object completes in one second. The unit of frequency is hertz (Hz).One hertz equals one cycle per second.
• Amplitude: The distance from the stationary position to the extreme position of oscillation. The intensity of vibration depends on amplitude
• Acceleration: Acceleration is a measure of how quickly the speed of a vibrating object changes with time.
Vibration exposure occurs through contact with a vibrating mechanism that transfers vibration energy to a person's body. The effect of vibration exposure also depends on the frequency of vibration. Each organ of the body has its own resonant frequency (tendency to vibrate at one particular frequency depending on the makeup, size, and structure of the organ). If exposure occurs at or near any of these resonant frequencies, the resulting effect is greatly increased.

Temperature: Both very cold and very hot temperatures can be encountered in numerous occupational settings and as such are frequently evaluated by industrial hygienists. Excessive exposure to heat is referred to as "heat stress" and excessive exposure to cold is referred to as "cold stress." An industrial hygienist would conduct temperature-stress evaluations on operations involving high and low-air temperatures, radiant-heat sources, high humidity, or direct physical contact with hot and cold objects. Strenuous physical activities or outdoor operations conducted in hot or cold weather extremes could also require evaluations.

Two types of exposure limits are often used as guidelines for an evaluation: occupational exposure and thermal comfort. Occupational exposure limits are designed to protect industrial workers from temperature-related illness. Thermal comfort limits are used to ensure productivity and quality of work for office workers. An industrial hygienist will use portable heat-stress meters or monitors to measure thermal conditions (temperature, humidity, air velocity). These measurements will be used to calculate the Wet Bulb Globe Temperature (WBGT) and Effective Temperature (ET) indexes, two common heat-stress indices. An evaluation of temperature extremes would include an examination of environmental conditions, worker behavior, medical records, and body indices.

Biological Hazards: Affecting workers from the health care industry to agricultural operations, illnesses caused by exposure to biological agents have been widely reported, but in many workplaces their presence and resultant impacts are not well recognized. Sources of biological hazards (biohazards) include bacteria, viruses, insects, plants, birds, animals, and humans. Exposure to these sources can cause a variety of health effects ranging from skin irritation and allergies to infections and life-threatening disease (influenza, Legionnaires' disease, Lyme disease, tuberculosis). Occupational exposures to blood borne pathogens (immunodeficiency virus (HIV) and hepatitis B virus) are regulated by federal regulations. Nearly one-third of the world's population is infected with tuberculosis (TB) and the resulting 3 million deaths a year make TB the leading cause of death due to an infectious agent in the world. Outbreaks have occurred in hospitals, correctional institutions, homeless shelters, nursing homes, and residential care facilities for AIDS patients. Nationwide, at least several hundred employees have become infected and have required medical treatment after workplace exposure to TB. The bacterium, *Chlamydia psittaci*, and the fungus, *Histoplasma capsulatum*, are two biological agents that use birds as a vector for transmitting disease to humans. Lyme disease results from exposure to ticks carrying the disease.

Routes of exposure: A chemical may exert a harmful effect if it comes into contact with a susceptible site in, or on the body. The basic modes of entry are inhalation, skin absorption and ingestion.

Inhalation: For industrial exposures to chemicals, the most important route of entry is usually inhalation. Nearly all materials that are airborne can be inhaled. The respiratory system is composed of two main areas: the upper respiratory tract airways (the nose, throat, trachea, and major bronchial tubes leading to the lobes of the lungs) and the alveoli, where the actual transfer of gases across thin cell walls takes place. Only particles smaller than about 5 μm in diameter are likely to enter the alveolar sac. The total amount of a toxic compound absorbed via the respiratory pathways depends on its concentration in the air, the duration of exposure, and the pulmonary ventilation volumes, which increase with higher workloads. If the toxic substance is present in the form of an aerosol, deposition and absorption occur in the respiratory tract. Gases and vapors of low water solubility but high fat solubility pass through the alveolar lining into the bloodstream and are distributed to organ sites for which they have special affinity. During

inhalation exposure at a uniform level, the absorption of the compound into the blood reaches an equilibrium with metabolism and elimination.

Skin absorption: Skin absorption an important route of entry is absorption through either intact or abraded skin. Contact of a substance with skin results in four possible actions: the skin can act as an effective barrier, the substance can react with the skin and cause local irritation or tissue destruction, the substance can produce skin sensitization, or the substance can penetrate to the blood vessels under the skin and enter the bloodstream. The cutaneous absorption rate of some organic compounds rises when temperature or perspiration increases. Therefore, absorption can be higher in warm climates or seasons. The absorption of liquid organic compounds may follow surface contamination of the skin or clothes; for other compounds, it may directly follow the vapor phase, in which case the rate of absorption is roughly proportional to the air concentration of the vapors. The process may be a combination of deposition of the substances on the skin surface followed by absorption through the skin.

Ingestion: Anything swallowed moves into the intestine and can be absorbed into the bloodstream and thereafter prove toxic. The problem of ingesting chemicals is not widespread in industry: most workers do not deliberately swallow materials they handle. Workers can ingest toxic materials as a result of eating in contaminated work areas; contaminated fingers and hands can lead to accidental oral intake when a worker eats or smokes on the job. They can also ingest materials when contaminants deposited in the respiratory tract are carried out to the throat by the action of the ciliated lining of the respiratory tract. These contaminants are then swallowed and significant absorption of the material may occur through the gastrointestinal tract.

Injection: Material can be injected into some part of the body. This can be done directly into the bloodstream, the peritoneal cavity, or the pleural cavity. The material can also be injected into the skin, muscle, or any other place a needle can be inserted. The effects produced vary with the location of administration. In industrial settings, injection is an infrequent route of worker chemical exposure.

Contaminants: Industrial contaminants are a very wide category that includes those compounds produced, manufactured and entitled by the industry.

Air Contaminants: These are commonly classified as either particulate or gas and vapor contaminants. The most common particulate contaminants include dusts, fumes, mists, aerosols, and fibers.

1) Dusts are solid particles generated by handling, crushing, grinding, colliding, exploding, and heating organic or inorganic materials such as rock, ore, metal, coal, wood, and grain

2) Fumes are formed when material from a volatilized solid condenses in cool air. In most cases, the solid particles resulting from the condensation react with air to form an oxide.

3) The mist is applied to liquid suspended in the atmosphere. Mists are generated by liquids condensing from a vapor back to a liquid or by a liquid being dispersed by splashing or atomizing.

4) Aerosols are also a form of a mist characterized by highly respirable, minute liquid particles.

5) Fibers are solid particles whose length is several times greater than their diameter, such as asbestos. 6) Gases are formless fluids that expand to occupy the space or enclosure in which they are confined. They are atomic, diatomic, or molecular in nature as opposed to droplets or particles which are made up of millions of atoms or molecules. Through evaporation, liquids change into vapors and mix with the surrounding atmosphere. Vapors are the volatile form of substances that are normally in a solid or liquid state at room temperature and pressure. Vapors are gases in that true vapors are atomic or molecular in nature.

TOXICITY OF HAZARDOUS CHEMICALS IN THE WORKPLACE The toxicity or hazardous properties of a chemical refer to its capacity to affect or injure the human body. The toxic effects of a chemical depend on the following:

- Nature of the chemical
- Type/form of the chemical
- Concentration of the chemical
- Exposure period
- Personal susceptibility
- Mode of entry

- Environment
- Nutritional status
- Diet
- Sex
- Age
- Threshold limit value

Chemicals Affecting Lungs and Respiratory System: The acute effects of chemicals are irritation and burns. Chemical irritation of the Tracheobronchial tree is called bronchitis and when the irritation extends to the lungs, it is called pneumonitis.

Pulmonary Irritants : There are different types of pulmonary irritants such as Ammonia, Antimony, Beryllium, Boron trifluoride, Bromine, Cadmium dust/fumes, Chlorine, Chlorine trifluoride, Chromic acid , Diaxomethane, Dichloroethyl ether, Dimethyl sulphate, Hydrogen fluoride, Maleic anhydride, Methyl bromide, Methyl iodide, Nickel carbonyl, Nitro ethane, 2-Nitropropane, Ozone, Paraquat, Phosgene, Ethylene oxide etc.

The chemical burns inside the lungs may lead to Pulmonary Oedema. The more fluid there is in the lungs, the less space is available for air, resulting in laboured breathing or dysponea.

Chemicals Affecting Liver (Hepato-billiary system): The liver is particularly vulnerable to chemical attack because it is not only the organ in the body where a great deal of metabolic activity takes place, but also because it is well supplied with blood, particularly from the gut. Chemicals which damage the liver are called Hepatotoxins.

The some Hepatotoxins such as Acetylene tetrabromide, Carbon disulphide, Carbon tetrachloride, Chloro diphenyl, Chloroform, Dichlorobenzene, Dimethyl acetamide, Dimethyl formamide, Diamino-diphenyl-methane, Dioxane, DDT, Dinitrophenol, Ethylene chlorohydrins,Trichloroethylene, Toluene, Trinitrotoluene etc.

Chemicals Affecting the Blood (Hematological system): Another area of the body that is sensitive to the effects of chemicals is the bone marrow, where blood cells are produced. Benzene is very hazardous for the bone marrow, causing a severe form of anaemia called Aplastic anaemia, and cancer of the blood or Leukaemia. The chemicals, which destroy red

blood cells circulating in the blood, causing another form of anaemia, are called haemolytic agents. They include: Arsine, Betyl cellusolve, Naphthalene, Phenyl hydrazine, Stibine.

Chemicals Affecting the Nervous System: Neurotoxins are those chemicals which affect the brain and nervous system. Some chemicals have immediate effect on the brain. Loss of brain function is called narcosis, and so these materials are known are narcotics. The chemicals of these categories include: Acetaldehyde, Acetone, Amyl acetate, Benzene, Butyl acetate, Carbon disulphide, Chlorobenzene, Cyclohexane, Diglycidyl ether, Ethyl acetate, Ethyl bromide, Ethylene oxide, N-heptane, Methyl acetate , Methyl ethyl ketone, Methyl iso-butyl ketone, Octane, Pentane, Propyl alcohol, Styrene, Tetra chloro ethane, Tetrachloro ethylene, Toluene