INDUSTRIAL HYGIENE

8.1 industrial toxicology: Chemical Toxicity

Toxicology is the study of the nature and action of chemical substances on living systems. *Toxicity* is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body. *Hazard* is the *probability or likelihood* that injury will occur considering the manner in which the substance is used.

Dose-Response Relationships

The potential toxicity (harmful action) inherent in a substance is manifest only when that substance comes in contact with a susceptible living biological system. A chemical normally thought of as "harmless" will evoke a toxic response if added to a biological system in sufficient amount. The toxic potency of a chemical is defined by the relationship between the dose (the amount) of the chemical and the response that is produced in a biological system.

Routes of Entry into the Body

There are three main routes by which hazardous chemicals enter the body:

- absorption through the ***respiratory tract*** through inhalation.
- absorption or injection through the ***skin or eyes***.
- absorption through the ***digestive tract***. This can occur through eating or smoking with contaminatedhands or in contaminated work areas.

Most ***exposure standards***, Threshold Limit Values (TLVs) and Permissible Exposure Limits (PELs), are based on the ***inhalation*** route of exposure. They are normally expressed in terms of either parts per million (ppm) or milligrams per cubic meter (mg/m^3) concentration in air.

If a significant route of exposure for a substance is through skin contact, the MSDS will have a "skin" notation associated with the listed exposure limit. Examples include: some pesticides, carbon disulfide, phenol, carbon tetrachloride, dioxane, mercury, thallium compounds, ethylene, hydrogen cyanide.

Health Effects

Acute poisoning is characterized by rapid absorption of the substance and the exposure is sudden and severe. Normally, a single large exposure is involved. Examples: carbon monoxide or cyanide poisoning.

Chronic poisoning is characterized by prolonged or repeated exposures of a duration measured in days, months or years. Symptoms may not be immediately apparent. Examples: lead or mercury poisoning or pesticide exposure.

"Local" refers to the site of action of an agent and means the action takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples: some strong acids or alkalis.

"Systemic" refers to a site of action other than the point of contact and presupposes absorption has taken place. For example, an inhaled material may act on the liver. Example: arsenic affects the blood, nervous system, liver, kidneys and skin.

Cumulative poisons are characterized by materials that tend to build up in the body as a result of chronic exposure. The effects are not seen until a critical body burden is reached. Example: heavy metals (such as Lead).

Synergistic responses: When two or more hazardous material exposures occur, the resulting effect can begreater than the effect of the individual exposures. Example: exposure to ***both*** asbestos and tobacco smoke, producing lung cancer or mesothelioma.

Other Factors Affecting Toxicity

Rate of entry and route of exposure (how fast the toxic dose is delivered and by what means) are important factors. A person's ***age*** can affect the capacity to repair tissue damage. ***Previous exposures*** can lead to tolerance or increased sensitivity. General state of health, physical condition, and life style, can affect the toxic response. Preexisting disease can result in increased sensitivity.

Roles of the Industrial Hygienist and Toxicologist

Industrial hygienists and toxicologists are specialists who most commonly provide support through the on-site incident command structure during active response situations. They are also involved in addressing exposure and health related issues after the initial active emergency response phase ends, as well as in emergency response planning.

The following provides **examples** of what industrial hygienists and toxicologists do **related to chemical-related emergency planning, preparedness, and response**:

Industrial hygienists

Industrial hygienists in the American Industrial Hygiene Association's Incident Preparedness and Response Working Group have developed a "White Paper" on "Industrial Hygienists' Role and Responsibilities In Emergency Preparedness and Response." This white paper contains the following summary and notes the following initiatives:

Summary: Industrial Hygienists play a significant role in protecting the lives of our nation's response personnel, its support staff, and the surrounding community. Industrial Hygienists' technical expertise in occupational and environmental health and safety issues are applicable to a variety of natural disasters, hazardous chemical, biological or radiological releases, and terrorism events. Industrial Hygienists can effectively identify and control risks during Pre-Planning, Emergency Response, and Consequence Management Phases of an incident.

Initiatives: Through the appointed Emergency Preparedness and Response (EPR) Task Force, AIHA will focus the on the following objectives:

- Identify educational and training opportunities, through its Professional Development Courses, Symposiums, and Distance Learning venues, involving critical EPR tasks related to IH functions.
- Advise and develop alliances with organizations related to Emergency Planning and Response (e.g., local AIHA Sections, Local Emergency Planning Committees, National Fire Protection Association).
- Recommend EPR tasks, critical to the development of health and safety guidelines for both its members and outside response organizations, to the appropriate AIHA Technical Committees.

Toxicologists

Toxicologists working at the Centers for Disease Control and Prevention (CDC), Division of Toxicology and Environmental Medicine do the following:

- Provide technical expertise and site-specific support in addressing the health issues presented by emergency or acute release events and threatened releases of hazardous materials.

- Coordinate agency toxicology and environmental medicine activities with the U.S. Environmental Protection Agency (EPA), National Toxicology Program (NTP), and other appropriate Federal, State, local, or public programs
- Establish minimal risk levels (MRLs) for hazardous substances. An MRL is a scientific estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancerous health effects over a specified duration of exposure
- Provide substance-specific consultations (toxicological expertise) to state and federal agencies as well as to the general public;
- Develop and apply a program of computational toxicology research to enhance traditional approaches

8.2 industrial health risks: Although safety hazards related to the physical characteristics of a chemical can be objectively defined in terms of testing requirements (e.g. flammability), health hazard definitions are less precise and more subjective. Health hazards may cause measurable changes in the body - such as decreased pulmonary function. These changes are generally indicated by the occurrence of signs and symptoms in the exposed employees - such as shortness of breath, a non-measurable, subjective feeling. Employees exposed to such hazards must be apprised of both the change in body function and the signs and symptoms that may occur to signal that change.

The determination of occupational health hazards is complicated by the fact that many of the effects or signs and symptoms occur commonly in non-occupationally exposed populations, so that effects of exposure are difficult to separate from normally occurring illnesses. Occasionally, a substance causes an effect that is rarely seen in the population at large, such as angiosarcomas caused by vinyl chloride exposure, thus making it easier to ascertain that the occupational exposure was the primary causative factor. More often, however, the effects are common, such as lung cancer. The situation is further complicated by the fact that most chemicals have not been adequately tested to determine their health hazard potential, and data do not exist to substantiate these effects.

There have been many attempts to categorize effects and to define them in various ways. Generally, the terms "acute" and "chronic" are used to delineate between effects on the basis of severity or duration. "Acute" effects usually occur rapidly as a result of short-term exposures, and are of short duration. "Chronic" effects generally occur as a result of long-term exposure, and are of long duration.

The acute effects referred to most frequently are those defined by the American National Standards Institute (ANSI) standard for Precautionary Labeling of Hazardous Industrial Chemicals (Z129.1-1988) - irritation, corrosivity, sensitization and lethal dose. Although these are important health effects, they do not adequately cover the considerable range of acute effects which may occur as a result of occupational exposure, such as, for example, narcosis.

Similarly, the term chronic effect is often used to cover only carcinogenicity, teratogenicity, and mutagenicity. These effects are obviously a concern in the workplace, but again, do not adequately cover the area of chronic effects, excluding, for example, blood dyscrasias (such as anemia), chronic bronchitis and liver atrophy.

The goal of defining precisely, in measurable terms, every possible health effect that may occur in the workplace as a result of chemical exposures cannot realistically be accomplished. This does not negate the need for employees to be informed of such effects and protected from them. Appendix B, which is also mandatory, outlines the principles and procedures of hazard assessment.

For purposes of this section, any chemicals which meet any of the following definitions, as determined by the criteria set forth in Appendix B are health hazards. However, this is not intended to be an exclusive categorization scheme. If there are available scientific data that involve other animal species or test methods, they must also be evaluated to determine the applicability of the HCS.

1. "Carcinogen:" A chemical is considered to be a carcinogen if:

(a) It has been evaluated by the International Agency for Research on Cancer (IARC), and found to be a carcinogen or potential carcinogen; or

(b) It is listed as a carcinogen or potential carcinogen in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or,

(c) It is regulated by OSHA as a carcinogen.

2. "Corrosive:" A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact. For example, a chemical is considered to be corrosive if, when tested on the intact skin of albino rabbits by the method described by the U.S. Department of Transportation in appendix A to 49 CFR part 173, it destroys or changes irreversibly the structure of the tissue at the site of contact following an exposure period of four hours. This term shall not refer to action on inanimate surfaces.

3. "Highly toxic:" A chemical falling within any of the following categories:

(a) A chemical that has a median lethal dose (LD(50)) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

(b) A chemical that has a median lethal dose (LD(50)) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC(50)) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

4. "Irritant:" A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR 1500.41 for four hours exposure or by other appropriate techniques, it results in an empirical score of five or more. A chemical is an eye irritant if so determined under the procedure listed in 16 CFR 1500.42 or other appropriate techniques.

5. "Sensitizer:" A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

6. "Toxic." A chemical falling within any of the following categories:

(a) A chemical that has a median lethal dose (LD(50)) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

(b) A chemical that has a median lethal dose (LD(50)) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC(50)) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one

hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

7. "Target organ effects."

The following is a target organ categorization of effects which may occur, including examples of signs and symptoms and chemicals which have been found to cause such effects. These examples are presented to illustrate the range and diversity of effects and hazards found in the workplace, and the broad scope employers must consider in this area, but are not intended to be all - inclusive.

8.3 industrial noise: Industrial noise is often a term used in relation to environmental health and safety, rather than nuisance, as sustained exposure can cause permanent hearing damage. Traditionally, **occupational noise** has been a hazard linked to heavy industries such as ship-building and associated only with noise-induced hearing loss(NIHL). Modern thinking in occupational safety and health identifies noise as hazardous to worker safety and health in many places of employment and by a variety of means.

Noise can not only cause hearing impairment (at long-term exposures of over 85 decibels (dB), known as an exposure action value), but it also acts as a causal factor for stress and raises systolic blood pressure.

Additionally, it can be a causal factor in work accidents, both by masking hazards and warning signals, and by impeding concentration.

Noise also acts synergistically with other hazards to increase the risk of harm to workers. In particular, noise and dangerous substances (e.g. some solvents) that have some tendencies towards ototoxicity may give rise to rapid ear damage.

A-weighted measurements are commonly used to determine noise levels that can cause harm to the human ear, and special exposure meters are available that integrate noise over a period of time to give an L_{eq} value (equivalent sound pressure level), defined by standards