Chapter 1: Principle Concept to Chemical Management

Objectives

- This chapter will cover the basic knowledge on hazard identification, basic terms and definition, basic classification, relevant principle methods of basic classifications.
- It also elaborates how people are exposed by chemicals through several routes of exposure. Relevant basic concepts of dose response relationship, effects of chemicals to human and factors determining the effects and flammability concept shall also be explained at a basic level.
- In general this chapter provides a quick snapshot of basic principle in chemical management.

1. Introduction

1.1 Hazard Identification

Chemicals are commonly and widely used all across various industries (plastic, textile, rubber, paint, detergent) for a number of applications in production of large scale of product items. Basically chemicals contain inherent hazards and can endanger human health and surrounding environment if it is not properly managed with the right understanding. Chemicals can also be in form of single substances, mixtures and preparations, dilute solutions.

In the past time, the hazard of chemicals was mostly recognized under basic term of "toxicity". The first theory of toxicology[1] was introduced by Paracelsus, a German physician and alchemist born in Switzerland (around 1530). His statement lies as a basic theory of toxicology and hazard identification: "All substances are poisons: there is none which is not a poison. The right dose differentiates a poison and a remedy." In short, it is summarized as the concept of "the dose makes the poison". For example, the oxygen we must breathe for survival is toxic. Too little oxygen in air will kill us, as will too much. Pure water is toxic. Drunk in too large a quantity it too will kill us.

Through decades of toxicological development and advancement, the other terms which represent more specific meaning of hazards are commonly used. The basic term "hazardous and dangerous" are interchangeably applied to express the different level of hazards of chemicals and goods.

[1] Toxicology is the study of the effects of substances on living organisms. The term, toxicology, derives from the Greek word *toxos* or poison.

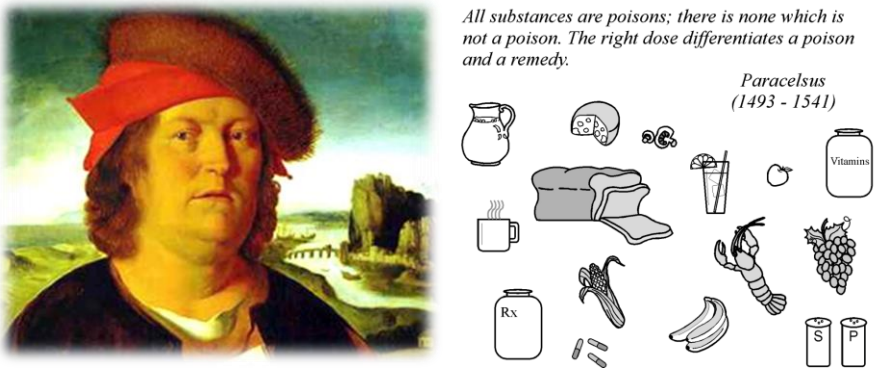

Figure 1-1: Paracelsus and his toxicology theory

1.2 Basic Term and Definition

In the chemical and logistics industries, a number of different terms are widely applied to signify that the cargos (chemicals or goods) are considered "hazardous". Those terms are, for example, dangerous goods, hazardous chemicals and hazardous materials and in some countries it is even called hazardous substances.

The explanatory notes for these terms are as below:-

- Dangerous Goods (most commonly called in short as DG): This term is generally and globally recognized by the United Nations (UN) and it is practically used to classify the dangerous goods under all modes of transportation. According to United Nations, Dangerous Goods are classified into 9 Classes. This shall be discussed in Chapter 2 for more details.
- Hazardous Chemicals: Basically chemicals are considered as a subset of goods. However the term "hazardous" would generally mean "hazardous to human health" when exposed to the chemicals.
- Hazardous Materials (most frequently called in short HazMat): Hazardous materials are common terms used specifically in United States of America. As it can be seen that many of the relevant regulations of United States of America apply the term, Hazardous Materials to represent the meaning of "Dangerous Goods", it in fact intends to convey the same meaning.
- Hazardous Substances: This term tends to have similar meaning as regulated or restricted substances in performing certain activities with chemicals in any specific countries. Normally the competent authorities (CA) are the authorized units in controlling various activities such as import, possession, use or production, transport, storage or even export depending on their appropriate considerations.

1.3 Basic Classification

In order to classify the goods or chemicals with the right understanding, certain basic knowledge concerning classification is provided to give a better insight when handling goods or chemicals especially during transportation.

For the purpose of transportation, goods or chemicals can be in principle easily classified into 2 types: Non-dangerous goods and Dangerous Goods :-

1) Non-Dangerous Goods (or in short commonly called Non-DG)
The term of non-dangerous goods would mean that such goods or chemicals are not classified as dangerous goods when they are either locally or internationally transported. In many circumstances, other terms may also be interchangeably used on label, safety data sheets or even transport documents such as non-hazardous, non-classified, non-restricted, non-regulated goods or chemicals. This can probably be assumed to have the similar meaning as non-dangerous goods.

Normally non-dangerous goods can be handled for transport or storage as general cargo. The only restriction that is not acceptable is to either store in truck or warehouse or load with food products or products for human intakes in any dry container. When handling non-dangerous goods, it cannot be assumed that the cargos are totally non-hazardous. The goods may be classified as non-dangerous but it may contain some of hazardous ingredients in which the result of classification based on the inherent properties and values are not up to the cut-off value/criteria. In case of mixtures, the percentage of hazardous ingredients may not be up to the required concentration limits to be classified as dangerous goods. Therefore some of non-dangerous goods can also possibly be hazardous to human health upon exposure. In this case, the thorough understanding in evaluating the hazardous properties of chemicals or goods is very important.

2) Dangerous Goods (or in short commonly called DG)
Dangerous goods can sometimes be referred by some other terms as hazardous, classified, restricted and regulated goods or chemicals. Therefore when these terms are found in any types of documents, it can be simply presumed that such goods or chemicals may be classified as dangerous goods.

Dangerous Goods can cause adverse impacts during the spillage/leakage out of packaging. Types of dangers can be one of the followings:-

- Flammability or Combustibility (burns easily when gets ignition source)
- Toxicity (hazardous to human health and environment)
- Reactivity (ability to react when exposed to water, heat or even other chemical substances)
- Physical hazards as a state of being compressed

1.4 Principle Methods of Basic Classification
There are various principle methods which are commonly applied in classifying chemicals.

1) Physical State
Physical state refers to the states of matter: solid, liquid, gas. The state of a pure substance depends on its temperature and the pressured exerted on it by the surroundings. At room temperature and normal atmospheric pressure, the states

have the following characteristics. Solid retain their shape and do not flow. They mechanically break into smaller pieces and eventually into fine powders. Liquids are formless fluids that have finite volume. A liquid follows the shape of a container as much as permitted by its volume. Gases and vapors completely fill any container into which they are placed, given sufficient time. A vapor is the gaseous state of a substance that normally is liquid or solid at room temperature.

By learning this thoroughly in the Chapter 2, it can also be seen that certain types of goods or chemicals may be quite difficult or even misleading in determining its exact and correct physical states.

2) Chemistry (Organic and Inorganic Chemicals)
According to the chemistry, chemicals are basically categorized into organic and inorganic chemicals. Organic chemicals are normally obtained from living organisms whereas inorganic chemicals are metal and non-metal chemical compounds. In the transportation of dangerous goods, the way the chemicals are classified as organic or inorganic chemicals is also used in declaring the Proper Shipping Names with regard to UN Numbers.

3) Hazardous Properties in accordance with specific criteria
(Flammability/Toxicity/Reactivity)
This method of classification is based on the 3 major hazardous criteria. Those are flammability – ability of chemicals to get ignited when in contact with ignition source, toxicity – the hazardous properties to human health, reactivity – the chemicals will cause certain reaction when in contact or exposed with any incompatible substances or materials.

This way of classifying based on hazardous properties is the most common method of classification. In the international classification of dangerous goods, the hazardous properties are the most dominant method used as classification criteria in grouping different types of hazard classes and divisions.

1.5 Routes of Exposure
It is important to learn how human beings are normally exposed to the chemical substances. In principle, there are 3 methods that human beings are exposed with chemicals.

1. Inhalation refers to the ability of the chemical to enter the body during breathing activity. Inhalation is the main route of entry of airborne substances.

2. Absorption refers to the ability of the chemicals to pass through the skin or eyes. There are three relevant types of absorption.

- Skin contact: Refers to the initial contact of the chemical with the skin. Several outcomes can result from contact between chemicals and the skin.
- Skin absorption: Refers to the ability of the chemicals to enter the body by permeation across the intact skin.

- Eye contact: refers to the ability of the chemical to enter the body by a path involving the eyes.

3. Ingestion refers to the ability of the chemical to enter the body by mouth during consumption of dandy, food and drink, and cigarette smoking. Ingestion is an important route of entry for some substances. This is especially where the hands and skins of the face become contaminated and the person eats, drinks, smokes, or applies cosmetics on the job.

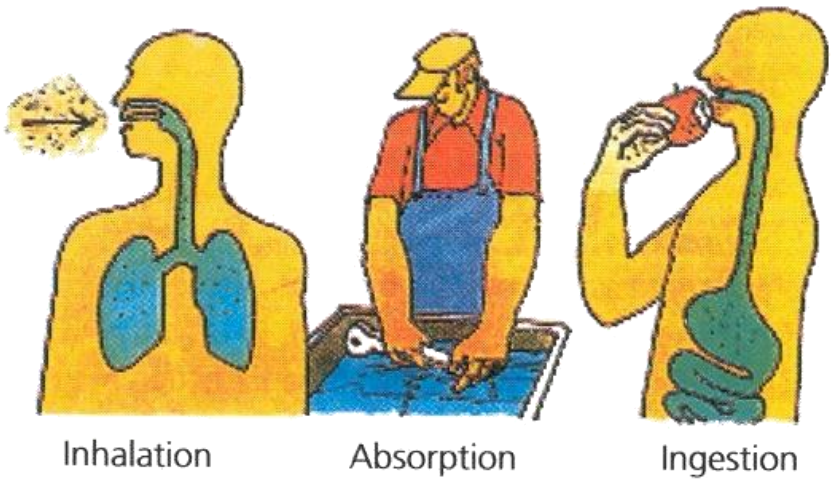

Figure 1-2: Routes of Exposure

1.6 Dose Response Relationship (Causes & Effects)

The important factors in toxicology are the dose rate and the amount or dose. The dose rate is the rate at which a substance enters the body. The dose is the amount of substance that enters. The effect produced by a substance depends upon both the dose rate and the dose. Dose differs from exposure. Exposure is the quantity of substance outside the body available for entry.

Information about the effects of substances is obtained from both human and animal studies. Studies using laboratory animals have provided by far the largest amount of information. Obviously testing using humans is limited due to the ethics involved. Human studies usually result from the following situations:

- Controlled experiments using volunteers
- Accidental or deliberate overdoses
- Use in small-scale situations, such as laboratories and pilot plants
- Industries producing or using the substances

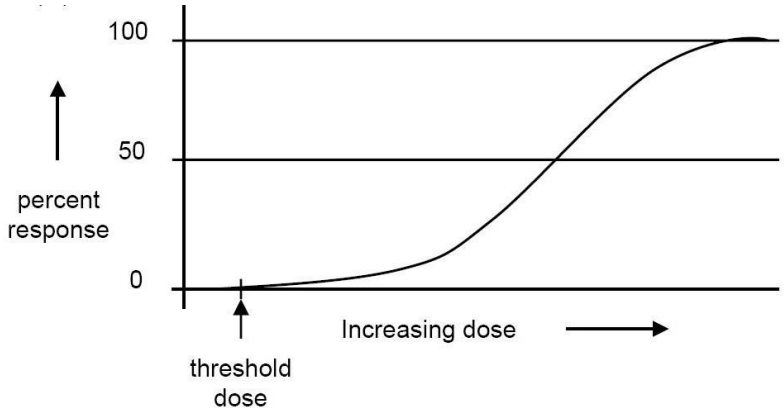

Figure 1-3: Dose Response Curve

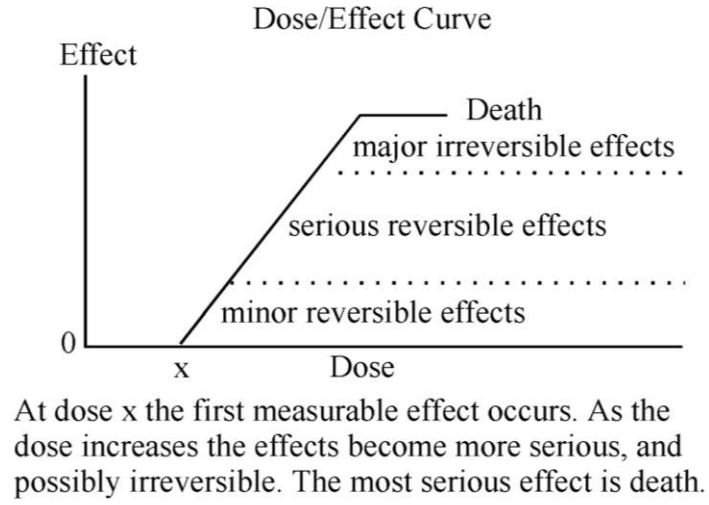

Figure 1-4: Different level of Effects on Dose/Response Curve

1.7 Effects of Chemicals to Human

Effects of chemical hazards depend on level of toxicity and exposure. The magnitude of exposure depends on:-

1) Concentration of Chemical Substances

The higher level of concentration of dangerous chemical substances it is, the higher level of danger it will be for the human being affected.

2) Contact and Exposure Time

The longer contact and exposure time to chemicals it is, the higher level of danger it is for the human being affected.

Some of other effects also include physical effects, radiation, mechanical effects, thermal effects, health effects (hot/cold burns) and reproductive effects. Some of the picture illustrations are given below:-

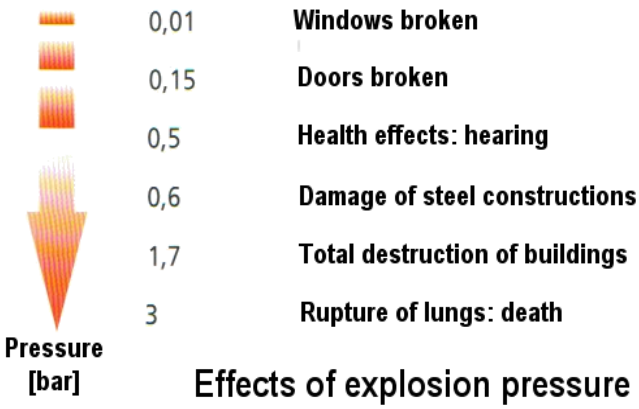

Figure 1-5: Effects of explosion pressure

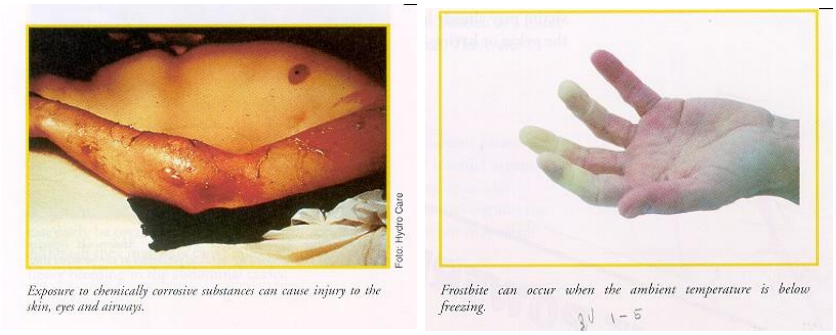

Figure 1-6: Thermal effects of hot burns and cold burns

The role of time in the production of toxic effects is extremely important. Two types of exposure typically occur in the workplace: acute exposures and chronic exposure.

Acute exposures are short-term and often involve a large dose of the chemical. Acute exposures often occur during accident situations, such as escape of compressed gases, or gross contact with solid or liquid materials caused by spillage, splashing, soaking, or dunking. Massive short-term contact with many substances usually produces an acute effect. More typically, workplace exposures are smaller-scale and long-term, or chronic exposures. Compared to acute exposures, chronic exposures may occur for years.

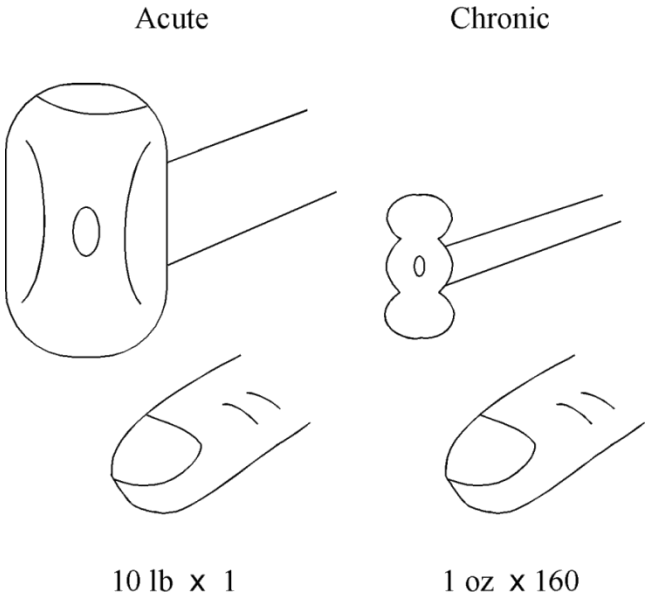

Figure 1-7: Acute and chronic exposure hazards. Which is worse, 1 blow from a 10lb sledge hammer or 160 blows from a 1oz hammer? (160 oz = 10 lb)

1.8 Factors determining the Effects

There are also several other factors which determine the different effects when exposing to the chemical. Those are:-

- Duration and Frequency of Exposure
- Route of Exposure (Inhalation/Absorption/Ingestion)
- Interspecies Variation
- Intra species Variation
    - Age and Maturity
    - Gender and Hormonal Status
    - Genetic Make-ups
    - State of Healths
- Environmental Factors (Surrounding Pollution, Working Environment, Personal Behavior, etc.)
- Chemical Combinations

1.9 Flammability: Fire Triangle

3 components of fire must exist in appropriate proportion in order to generate fire. In contrast, lacking of any component can cause fire to cease. A fire or explosion can occur when a fuel combines with an oxidizer under appropriate conditions of concentration and geometry in the presence of a suitable source of energy. In order for sustained burning, a net release of heat and replenishment of oxygen and fuel must occur.

The accepted model for expressing these requirements is the fire triangle. Deplete or remove any of the elements, or sides in the triangle, and the fire extinguishes. Oxygen is the oxidizer involved in most fires. However, other oxidizers used in

industry also can support combustion. A mixture of gas or vapor and air will burn if the temperature of the bulk mixture is raised to the ignition point. Cooking oil in a pot on the stove that bursts into flame illustrates this principle. The mixture will ignite at lower temperatures when an external source of ignition, such as a flame on a match, is provided. A fire continues to burn only when more heat is produced than is needed to cause burning.

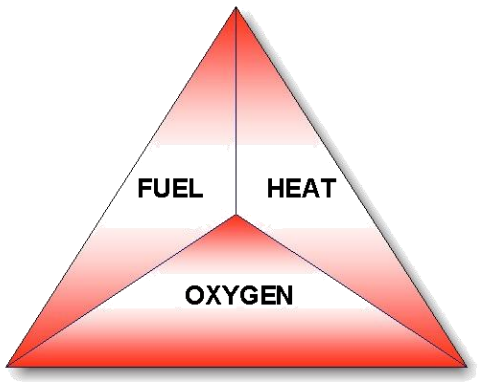

Figure 1-8: Fire Triangle

Components of Fire Triangle	Examples
Fuels – Solids	Wood dust, polymer dust, flour, me particles
Fuels – Liquids	Acetone, isopropyl alcohol, hexa gasoline
Fuels – Gases	Acetylene, propane, butane, hydrogen
Oxidizers	Oxygen, hydrogen peroxide, me peroxide
Ignition sources	Sparks, flames, static electricity, heat

Figure 1-9: Components of Fire Triangle and Examples

1.9 Flammability: Flashpoint

Flash point is the lowest temperature at which vapor emits from the surface of a liquid in sufficient quantity to be ignitable. Flash point is a key indicator of the hazard posed by ignitable vapors.

Flash point is measured by tow main types of equipment: closed cup (Pensky Martens, Tagliabue, or Setaflash methods) or open cup (Cleveland method). Closed cup testers completely enclose the vapor space in the cup except for a small opening at the top. Vapor escaping from the opening passes by the ignition source. Vapor emitted from the entire surface passes through the opening. In open cup testers, the entire top of the cup is open. The surface area of the escape path for the vapor is considerably large. Hence, the vapor is less concentrated. As a result, temperatures obtained using the open cup apparatus usually are several degrees highger than those obtained from closed cup equipment.

Liquid having flash points below ambient (room) temperature are especially hazardous. This mean that ignitable mixtures can develop under conditions of storage, handling, and use in most industrial, commercial, and institutional operations.

Flashpoint is the basis for classifying liquids that produce ignitable vapors. Based on latest classification of Globally Harmonized System of Classification and Labelling of Chemicals (see more details on Chapter 5), liquids whose vapors are ignitable at flash points below 60°C are flammable. Liquids whose vapors are ignitable at flash points of more than 60°C but below 93°C are combustible.

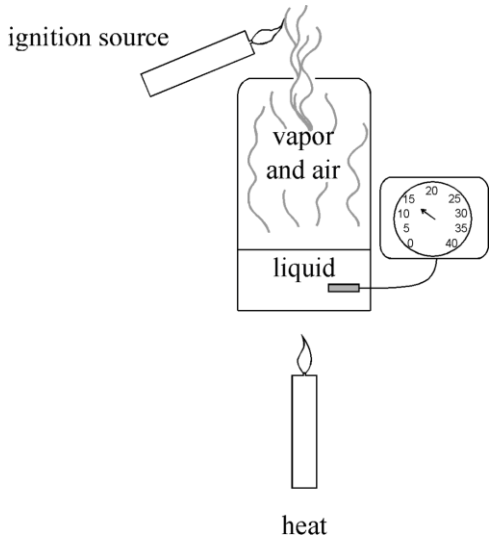

Figure 1-10: The Concept of Flashpoint

2. Conclusion

This chapter provides a large number of basic ideal concepts concerning chemicals and its hazardous properties. By having the right basic understanding to these concepts, it would allow the readers to much easier apply those given concepts not only to their daily activities at the workplace for the best of safe handling and management but also to international classification especially in terms of international transport in the subsequent chapters.

There still remains other additional valuable knowledge which the readers are highly recommended to further read from the given references. Even though the relevant concepts tend to be comprehensively given in this chapter, many more other aspects are not covered and could be additionally referred from external literatures.

References

1. A biography of Paracelsus
http://www.thefamouspeople.com/profiles/paracelsus-142.php
2. McManus, Neil/Green, Gilda (1999) *The HazCom training program*. United States of America: Lewis Publishers/CRC Press LLC.