CHAPTER 2

SAFETY CONSIDERATIONS IN PROCESS INDUSTRIES

Introduction

- Workers in a factory, a manufacturing plant or a chemical plant remain exposed to moving conveyers, machines, dangerous chemicals, heat, pressures, high electric fields, accelerating objects and other sources of hazards.
- If workers are not protected from these hazards, there are chances of incidents to take place, which may result from a simple injury to death of a person.

Introduction

- For Example, On December 26, 1984 at 11:30 pm when people of Bhopal-India:
  - Leak of water into a storage tank containing methyl isocyanate (MIC) at the Union Carbide Plant.
  - About 40 tons of MIC poured from the tank for nearly two hours without any preventive measures being taken.
  - The night winds carried the MIC into the city of Bhopal. Some estimate that 4,000 people were killed, many in their sleep and as many as 400,000 were injured or affected.

Introduction

- On April 26, 1986 at Chernobyl-Ukraine:
  - A nuclear reaction resulted in the explosion of one of the reactors in a nuclear power plant.
  - These reactors were constructed without containment shells.
  - The release of radioactive material covered hundreds of thousands of square kilometers.
  - More than 3-million people of the surrounding suburb suffered from this disaster. While 36 people died in the accident itself, the overall death total has been estimated to be 10,000 persons.

Introduction

- On January 29, 2003, an explosion and fire destroyed the West Pharmaceutical Services plant in Kinston, North Carolina-USA:
  - Six deaths, dozens of injuries, and hundreds of job losses.
  - The investigators have found that the fuel for the explosion was a fine plastic powder used in producing rubber goods.
  - Combustible polyethylene dust accumulated above a suspended ceiling over a manufacturing area at the plant.

Introduction

Introduction

- The significance of safety measures is indicated:
  - in the proper operation of the plant, its regular checkups, overhauling, repair and maintenance, regular inspection of moving objects, electrical appliances, switches, motors, activators, valves, pipelines, storage tanks, reactors, boilers and pressure gauges.
  - The proper training of workers for running the operations and dealing with emergencies, spills, leaks, fire breakouts, chemical handling and electrical shock avoidance should not be ignored.

Types of Hazards in Industry

- **Heat and Temperature**
  - Sources of heat: boilers, kilns, incinerators, evaporators and cryogenic facilities.
  - High and lower temperatures, heat and cold can directly lead to sources of injuries to personnel and also may damage the equipment.
  - The immediate means by which the temperature and heat can injure the personnel is through burns, which can injure the skin and muscles as well as other tissues below the skin.

Types of Hazards in Industry

- **Heat and Temperature**
  - The same degrees of exposure may produce different effects, depending on the susceptibility of the person exposed.
  - High and low temperatures affect the personnel's performance.
  - Long exposure to high temperatures does affect the human performance.
  - The effects of heat and temperature do not only affect the workers but also the equipments and the process. For example, certain chemicals have a low boiling point and increased temperature can cause an explosion.

Types of Hazards in Industry

- **Pressure Hazards**
  - Work at lower pressure can avoid serious injuries and damage.
  - It is also commonly and mistakenly believed that injury and damage will result only from high pressures.
  - Example: the damage caused by a slow moving hurricane or wind blowing at 70 miles per hour is enormous. Nevertheless, the expansive pressure exerted is in the range of 0.1-0.25 psi. Therefore, high pressure is a relative term.

Types of Hazards in Industry

- **Electrical Hazards**
  - Electrical power is beneficial and at the same time it is hazardous if not properly used. The hazards involved are mainly:
    - Shock to personnel
    - Short circuiting and overheating
    - Ignition of combustible materials
    - Electrical explosions
    - Inadvertent activation of equipment
    - Electromagnetic effects on equipments and personnel.

Types of Hazards in Industry

- **Mechanical Hazards**
  - Most of the injuries in industrial plants are originally from mechanical causes.
  - These industrial plants have belt-driven rotating equipment, open geared power-presses, power hammers, cutter conveyers, kilns and incinerators.
  - These different kinds of mechanical equipment are used in industrial plants and each has its own mechanical hazards including cutting, tearing and breaking.

Types of Hazards in Industry

- **Toxic Materials**
  - Highly reactive chemicals are being used more frequently in industries, agriculture, research and defense.
  - Many of these chemicals are found to be carcinogenic, teratogenic and a cause of long lasting injuries.
  - There is a need to understand the ways by which these chemicals enter the human body and their physiological effects to the tissues. The preventive measures should be exercised to avoid this absorption.

Types of Hazards in Industry

- **Toxic Materials**
  - A material is considered toxic when a small quantity will cause injuries to the body of an organism. Almost all materials are injurious to health but at different levels.
  - The oxygen we breathe can be dangerous if taken at 100% without dilution.
  - The nitrogen and carbon dioxide can be dangerous although they are present in the air and lungs at high concentrations.

Types of Hazards in Industry

- **Toxic Materials**
  - The concentration or the toxicity level of the substance is not the only factor of a toxic chemical. The susceptibility of the human body to toxic chemicals and their concentrations varies.
  - The other factors, which affect the severity of the injury, are the concentration, duration of exposure, the route, and the temperature.

Types of Hazards in Industry

- **Toxic Materials**
  - The toxic materials may be solid, liquid or gas. The solid toxic materials are radioactive substances and metals such as Pd, Cd, As, Cr, Al and others in various forms.
  - The chemicals are mostly in liquid and gaseous forms. For example, diethyl bromide, chlorofluoro carbons (CFCs), trichlorethane or trichloromethane are liquids while phosgene, chlorine, carbon monoxide, hydrogen cyanide and isocyanate are gases.

Types of Hazards in Industry

- **Toxic Materials**
  - What happens in an industrial plant when a leak of some toxic gases like isocyanate, ethane or others occurs?
    - The concentration of these gases in air increases while the concentration of oxygen decreases.
    - The worker feels suffocation or asphyxia.
    - The concentration of carbon dioxide increases as a result blood carbonic level increases, which lowers further the concentration of oxygen.

Types of Hazards in Industry

- **Toxic Materials**
  - What happens in an industrial plant when a leak of some toxic gases like isocyanate, ethane or others occurs?
    - The worker undergoes a condition of hypoxia (hypo: below; oxia: oxygen).
    - The effect of hypoxia includes loss in perception, decrease in the brain activity, unconsciousness, and deep breathing.
    - It may lead to irreversible damage to brain, paralysis and ultimately death. Some gases alter the oxygen carrying cells in the blood (hemoglobin).

Types of Hazards in Industry

- **Toxic Materials**
  - What happens in an industrial plant when a leak of some toxic gases like isocyanate, ethane or others occurs?
    - For example, the exposure to carbon monoxide (1-1.5%) decreases the oxygen carrying capacity of blood, which results in hypoxia.
    - Some chemicals like nitrates, nitrites or other oxidizing agents are also harmful to the human body.

Types of Hazards in Industry

- **Toxic Materials**
  - It may also cause the inflammation of skin, eyes, and respiratory tracts. Even a small amount of irritant can cause physiological injury to an extensive area of tissue.
  - Ammonia, acrolein, hydrazine and hydrofluoric acid, fluorosilicic acid, and asbestos can cause injuries to the upper respiratory tract, while chlorine, fluorine, ozone, nitric acid and nitrogen tetroxide affect the lower portion and the alveoli.

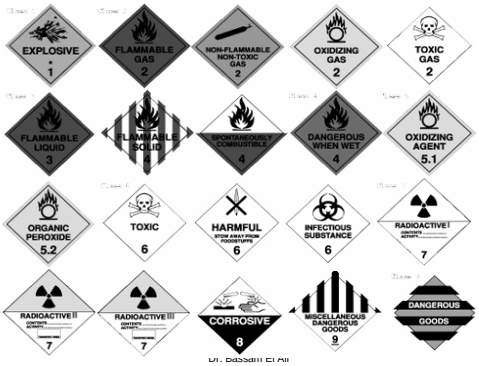
Types of Hazards in Industry

- **Toxic Materials**
  - Some chemicals are carcinogenic (cancer producing).
  - They are eliminated or replaced by non-carcinogenic chemicals.
  - Asbestos is a particulate matter that causes asbestosis and cancer of lungs, colon, rectum and stomach.
  - OSHA has imposed a ban on zero fiber or particulate matter in the working environment.

Types of Hazards in Industry

- **Toxic Materials**
  - All industrial plants are obligated to observe criteria stipulated in OSHA standards, which include the exposure to different chemicals and their threshold limit for industrial workers.
  - Personnel Protective Equipment (PPE) must be used for protection from toxic gases and vapors.
  - Safety respiratory protective equipment is required for normal hazardous operations like working in a spray painting plant, production and utilization of toxic chemicals, and fumigant utilization.

Types of Hazards in Industry



Types of Hazards in Industry

- **Fire and Explosion**
  - Fire and explosion are the common incidents in many chemical industries.
  - A fuel, an oxidizer and a source of ignition are required to start a fire. However, fire and explosion take place only when there are appropriate conditions for it.
  - Many types of fuel and oxidizers are available in any industry. There are three types of fuel. They are mainly solids, liquids or gases.

Types of Hazards in Industry

- **Fire and Explosion**
  - The chemicals that are used as cleaning agents or solvents act as fuels. Lubricants, coatings, paints, industrial chemicals, refrigerants, hydraulic fluids, polymer plastics, and paper wood cartons are potential fuels.
  - The next element for fire is an oxidizer. The most common oxidizer is the oxygen in air, which helps in oxidizing the fuel. Sometimes a chemical can be self ignited in the presence of an oxidizer.

Types of Hazards in Industry

- **Fire and Explosion**
  - For example, white phosphorus catches fires as soon as it comes into contact with air. Pure oxygen is a strong oxidizer. When a slight leak is present in an oxygen cylinder a dangerous fire hazard may exist.
  - Fluorine is another strong oxidizer. It can react with moisture in air and catch fire. It is normally used diluted with nitrogen.

Types of Hazards in Industry

- **Fire and Explosion**
  - These oxidizers should be handled with care and their contact with fuel should be avoided.
  - The source of ignition consists of materials that may initiate a fire on friction. The igniter may be sunlight, an arc or an electrical spark.
  - The common sources of electrical ignition in an industrial plant are the sparks of the electric motors, generators or electrical short circuits, arcing between contacts of electrical switches or relays, …..

Types of Hazards in Industry

- **Fire and Explosion**
  - The fires can have tremendous effects on human live and the immediate surroundings and even on the environment.
  - Fire produces carbon monoxide, carbon dioxide, solid carbon particles, and smoke. Death may occur as the concentration of the oxygen in air decreases in case of fire.
  - In any industrial plant, there are devices installed to detect any kind of fire, smoke, or heat.

Types of Hazards in Industry

- **Fire and Explosion**
  - The suppression of the increasing fire can be carried out by various methods.
  - The very first method is the isolation of the fire which means to cut the supply of fuel to the fire.
  - Fire suppression can also be achieved by blanketing a fire or by covering it with inert solid, foam, thickened water or cover it with nonflammable gas such as CO_2.

Types of Hazards in Industry

- **Fire and Explosion**
  - The other available method is the dilution of the fuel, if it is a liquid fuel, by adding noncombustible liquid into it and, if it is a gas, by adding nonflammable gas.
  - Fire is a chain process. It can be stopped by breaking this chain. Scavengers are used to stop the free radical chain reactions and subsequently the fire is extinguished. Halogenated compounds are usually good chain reaction inhibitors.

Types of Hazards in Industry

- **Fire and Explosion**
  - When fire is ignited due to fuel and there is ***no electrical hazard*** nearby, water is used as a fire suppressant.
  - Water is not recommended for sodium or magnesium metals.
  - Water can also be used as diluents and stop chain reactions.

Types of Hazards in Industry

- **Fire and Explosion**
  - Sometimes thickening agents are added to the water to increase the residence time of water and its effectiveness. The thickening agents such as clays, gums, and sodium and calcium borates are used in forest fires.
  - The chloride of calcium and lithium depress the freezing point to -40°C. The salts of potassium carbonate deposited on burning materials or the gas produced act as fire inhibitors.

Types of Hazards in Industry

- **Fire and Explosion**
  - Gas extinguishers may be used for enclosed spaces. Carbon dioxide (CO_2) is widely used as a fire extinguisher. When carbon dioxide is sprayed on fire it emerges as snow and lowers the temperature.
  - Halogenated hydrocarbons act solely by inhibiting chain reactions. The nature of the halogen is very important. The less reactive would be the best fire extinguisher. However, the problem with these halogenated compounds is their toxicity which limits their use.

Types of Hazards in Industry

- **Fire and Explosion**
  - Foams are also used as fire suppressants.
  - They suppress fire by cooling, blanketing, and sealing the burning fuel from the surrounding atmosphere. They are not suitable for gaseous fuel and fuel which reacts with water.
  - Solid extinguishers such as sand or clay are also used to cover the oil or greases under fire.
  - Sodium and potassium bicarbonate are also used as solid extinguishers for liquid fuel.
  - They act as chain reaction inhibitors. At high temperatures, they decompose to give carbon dioxide which itself is an extinguisher that suppresses fire.

Types of Hazards in Industry

- **Fire and Explosion**
  - Fire extinguishers are available which work automatically. They sense temperature, gas or fumes and start sprinkling the extinguishing materials (CO_2 or others).
  - There are other portable units available which are marked, A, B, C depending upon the class of fires to be extinguished.

Other Types of Hazards in Industry

- **Accelerator and Falling Objects**
- **Confined Space**
- **Radiation**
- **Noise and Vibrations**
- **Ergonomics (Human Factors)**

Risk Management Plan

- **The Role of the Safety Personnel**
  - The hazardneous and the toxicity of chemicals, high temperatures, and pressures are tackled initially by chemists and engineers.
  - Prepare trained personnel to take care of the hazards related to a particular process and the precautionary steps that should be taken to avoid them.

Risk Management Plan

- **The Role of the Safety Personnel**
  - The job of safety personnel is much diversified and is of high skill. He must be a knowledgeable in a wide range of technical, legal and administrative activities.
  - A safety professional should be knowledgeable in depth in all areas of accident prevention and capable of solving problems that may arise.
  - The safety personnel should be qualified by passing certain examinations and should be a certified safety professional.

Risk Management Plan

- **The Role of the Safety Personnel**
  - A group of consultants may be needed to review the plants and determine their compliances with OSHA and others prevailing standards of the country.
  - A second group may be knowledgeable in specific areas, such as flammable gases, toxic chemicals, explosives or mines.
  - The protection of personnel safety comes first followed by the protection of the environment.

Risk Management Plan

- **The Role of the Safety Personnel**
  - This protection includes the prevention of leakage or release of liquids, oil, chemicals, detergents, or noxious gases, metals, complexes deleterious substance and even genetically modified organisms (GMO) in the environment.
  - Protection against damage to the environment comes right after protection of personnel and animal before prevention of damage to equipment. Priority for rescue of equipment is last.

Risk Management Plan

- **The Role of the Safety Personnel**
  - Lack of a simple feature, protective device, pressure regulator, auto-trip systems, are increasingly being addressed.
  - Failure of a component of a process might cause failure in the assembled product.
  - The expertise of a safety engineer can be beneficially applied to product safety.