International Diploma in Safety Engineering

IDSE

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ACCREDITED STUDY CENTRE

Endorsed Qualification

Level 6 Diploma in OH&S

Unit 2

Principles and Application of Science and Technology in Safety

BCSP
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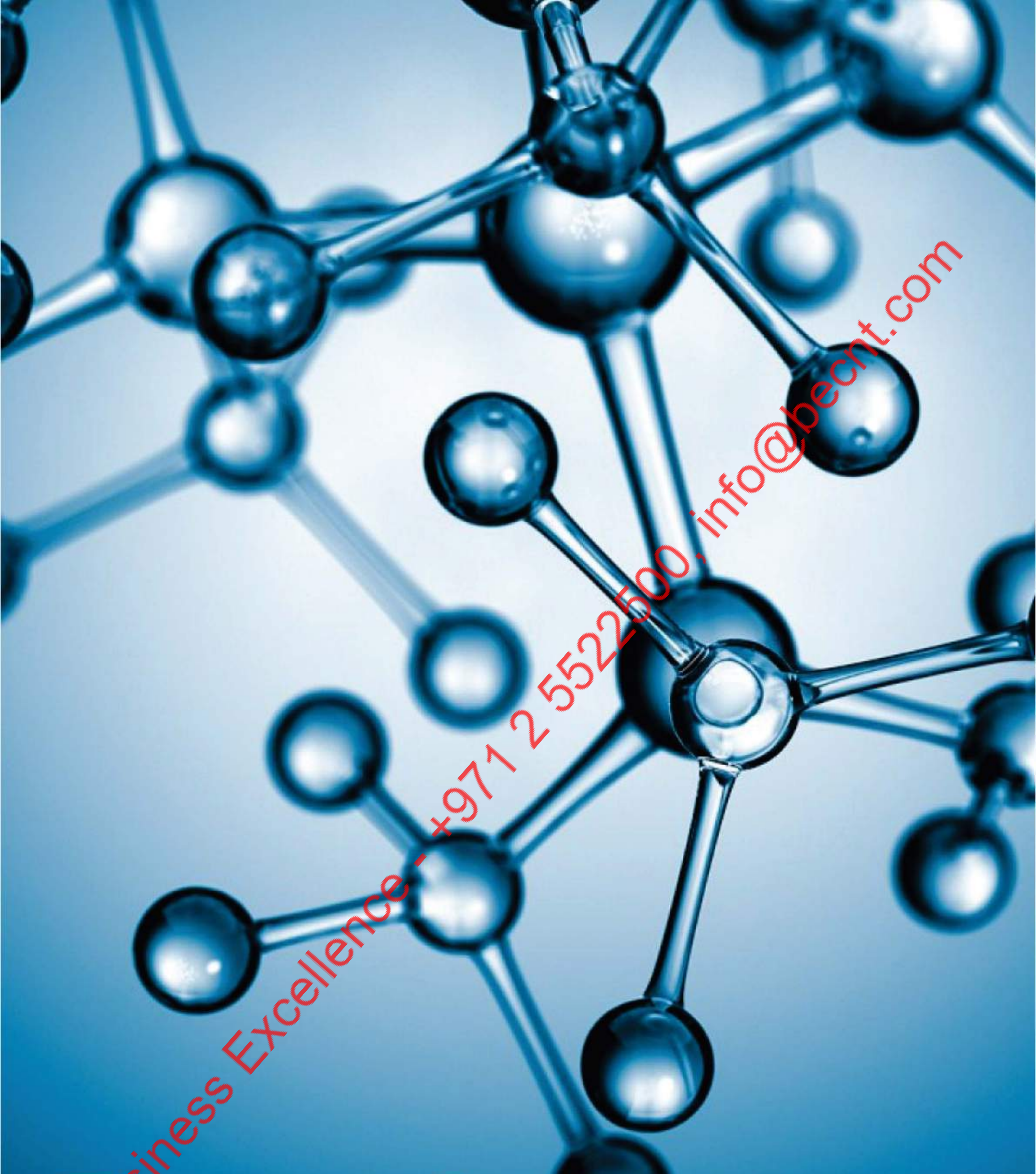
Element 1

Assess and apply basic principles of Chemistry at the workplace for occupational health and safety



Element 1

Assess and apply basic principles of Chemistry at the workplace for occupational health and safety

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Learning outcomes

1.1 Evaluate the hazards due to the nature and form of chemical agents and suggest control measures from hierarchy of control perspective. This should include the transportation hazards associated with the chemical agents.

1.2 Explain the current developments in identification, measuring and monitoring and control of chemical agents at the workplace

1.3 Identify and interpret the legal requirements for use, storage and transportation of chemical agents

1.4 Explain the human physiology with natural immunity and defense mechanism against chemical agents

1.5 Identify the requirements and application of personal protective equipments in a chemical environment for sufficiency and adequacy including future design requirements of PPEs

1.6 Explain the features of an emergency preparedness and response procedure for accidents related to chemical agents

1.7 Identify the requirement of operational controls with clear direction to what and how should the human involvement be eliminated/ reduced

1.8 Outline the physio chemical hazards of inflammables at the workplaces

1.9 Present a case for the possibility for use of clean energy with cost benefit analysis and implications on occupational health and safety

1.1 Forms of Chemical Agents

The humans are often exposed to the chemicals for the execution of the tasks. It is important to understand the physical nature of the chemical so that we may know the possibility of exposure through a specific entry route in the human body. Following known forms of chemical agents are present:-

Solids

The chemical may be present in the solid form e.g. sodium (NA)

Liquids

The chemical in the form of liquids are also present e.g. Gasoline or diesel

Gas

Gases are materials that exist as individual molecules in the air at room temperature; gases are measured as a percent volume of air, or parts per million (ppm). Examples include Welding gases (e.g., acetylene, nitrogen),CO, H2S, CH4 etc

Dust

The airborne solid particles of very small sizes are present in the natural atmosphere. The dust is abundantly present on construction sites due to various operations like girding, polishing, cutting etc.

Vapors

Vapors are the gaseous form produced from the solid or liquid chemicals. They are invisible to a naked human eye e.g. vapors of Gasoline etc.

Fumes

Solid particles present in gaseous form e.g. smoke or metallic powder in plasma spray units, Lead or cadmium particles.

Mist

The suspended liquid particles present in air and normally can be seen with a naked eye. For example water mist or paint spray etc. Mists are measured in milligrams or micrograms per cubic meter of air (mg/m^3) or (µg/m^3).

1.1 a Toxicology

The study of the negative effects of chemicals on living things

- chemical is considered toxic depending on
- How much of it is necessary to cause harm
- How easily it can enter the body

LD50 and LC50

These terms derive from laboratory tests on animals
LD50 is the dose which when swallowed, injected, or applied directly, kills half the test subjects. This is defined as the dose required to kill half the members of a specific animal population when entering the animal's body by a particular route. LD50 is a general indicator of a substance's toxicity within a short space of time. It is a measure of acute toxicity.
LC50 is the concentration of a chemical in a test atmosphere that kills half the test subjects within one hour when inhaled. LC stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air but in environmental studies it can also mean the concentration of a chemical in water.

Why LD50 and LC50 are values a measure of acute toxicity?

Acute toxicity is the ability of a chemical to cause ill effects relatively soon after one oral administration or a 4-hour exposure to a chemical in air. "Relatively soon" is usually defined as a period of minutes, hours (up to 24) or days (up to about 2 weeks) but rarely longer.

How are LD/LC50 tests done?

In nearly all cases, LD50 tests are performed using a pure form of the chemical. Mixtures are rarely studied.
The chemical may be given to the animals by mouth (oral); by applying on the skin (dermal); by injection at sites such as the blood veins, muscles or into the abdominal cavity.

The LD50 value obtained at the end of the experiment is identified as the LD50 (oral), LD50 (skin), LD50 (i.v.), etc., as appropriate. Researchers can do the test with any animal species but they use rats or mice most often. Other species include dogs, hamsters, cats, guinea-pigs, rabbits, and monkeys. In each case, the LD50 value is expressed as the weight of chemical administered per kilogram body weight of the animal and it states the test animal used and route of exposure or administration; e.g., LD50 (oral, rat) - 5 mg/kg, LD50 (skin, rabbit) - 5 g/kg. So, the example "LD50 (oral, rat) 5 mg/kg" means that 5 milligrams of that chemical for every 1 kilogram body weight of the rat, when administered in one dose by mouth, causes the death of 50% of the test group.

If the lethal effects from breathing a compound are to be tested, the chemical (usually a gas or vapor) is first mixed in a known concentration in a special air chamber where the test animals will be placed. This concentration is usually quoted as parts per million (ppm) or milligrams per cubic meter (mg/m3). In these experiments, the concentration that kills 50% of the animals is called an LC50 (Lethal Concentration 50) rather than an LD50. When an LC50value is reported, it should also state the kind of test animal studied and the duration of the exposure, e.g., LC50 (rat) - 1000 ppm/ 4 hr or LC50 (mouse) - 5mg/m3/ 2hr.

How should an LD50 value be used?

The LD50 can be used:

- As an aid in developing emergency procedures in case of a major spill or accident.
- To help develop guidelines for the use of appropriate safety clothing and equipment. For example, if the dermal LD50 value for a chemical is rated as extremely toxic, it is important to protect the skin with clothing, gloves (etc.) made of the right chemical-resistant material before handling. Alternatively, if a chemical has an inhalation LC50 value which indicates that it is relatively harmless, respiratory protective equipment may not be necessary (as long as the oxygen concentration in the air is in the normal range - around 18%).
- For the development of transportation regulations.
- As an aid in establishing occupational exposure limits.
- As a part of the information in Safety Data Sheets. Remember, the LD50 is only a ball park figure so that lethal toxicity can be compared. It says nothing about levels at which other acute toxic but non-lethal, effects might occur.

The LD50 is only one source of toxicity information. For a more thorough picture of the immediate or acute toxicity of a chemical, additional information should be considered such as the lowest dose that causes a toxic effect (TDLO), the rate of recovery from a toxic effect, and the possibility that exposure to some mixtures may result in increasing the toxic effect of an individual chemical

1.2 What is Epidemiology?

The word epidemiology comes from the Greek words epi, meaning on or upon, demos, meaning people, and logos, meaning the study of. In other words, the word epidemiology has its roots in the study of what befalls a population. Many definitions have been proposed, but the following definition captures the underlying principles and public health spirit of epidemiology:

Epidemiology is the **study** of the **distribution** and **determinants** of **health-related states or events** in **specified populations**, and the **application** of this study to the control of health problems

Occupational epidemiology involves the application of epidemiologic methods to populations of workers. Occupational epidemiologic studies may involve looking at workers exposed to a variety of chemical, biological or physical (e.g., noise, heat, radiation) agents to determine if the exposures result in the risk of adverse health outcomes. Alternatively, epidemiologic studies may involve the evaluation of workers with a common adverse health outcome to determine if an agent or set of agents may explain their disease..

Epidemiology Surveillance

Disease surveillance is the systematic collection, analysis, and interpretation of health data in order to detect, control, and prevent health problems. Epidemiologic surveillance is the macroscopic surveillance perspective, carried out primarily by public health agencies on a statewide or nationwide basis. These efforts seek to identify and quantify illness, injury or excessive exposure, and monitor trends in their occurrence across different industry types, over time, and between geographic areas. Medical surveillance, by contradistinction, focuses its surveillance components on the hazards and potential hazards of a particular workplace, company or group of workers.

Example: Studies of Mortality

During the late 1970s and early 1980s, a confluence of interests led NIOSH to conduct a cohort mortality study of workers exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), one of many dioxin congeners. Studies from Scandinavia were pointing to an association among chemical production workers between TCDD exposure and excess risk for soft tissue sarcoma and lymphoma.Concern existed for veterans and others exposed during the Vietnam War to TCDD, an inadvertent contaminant of the widely used defoliant Agent Orange.Toxicological studies were also pointing to an increased risk and a physiologic mechanism for toxicity, the aryl-hydrocarbon receptor. Risk for soft tissue sarcoma and lymphoma.Concern existed for veterans and others exposed during the Vietnam War to TCDD, an inadvertent contaminant of the widely used defoliant Agent Orange.Toxicological studies were also pointing to an increased risk and a physiologic mechanism for toxicity, the aryl-hydrocarbon receptor.In 1980, the U.S. Department of Defense requested assistance from NIOSH in conducting an epidemiologic study of soldiers who had served in Vietnam. A recent EIS Officer (W.H.) and the Director of NIOSH, Tony Robbins, visited the Pentagon, where they learned of the limited available records that could be used to accurately characterize the location of soldiers in Vietnam and their exposure to defoliants. They concluded that a study in civilian exposed workers was more likely to be useful than a study among soldiers. The civilian study could then be applied to Vietnam War veterans.

In 1981, NIOSH began efforts to identify plants in the United States that produced chemicals contaminated with TCDD (11). In all, 5,172 workers at 12 plants were included in a cohort mortality study. An extensive effort was made to characterize workers' potential exposure to TCDD at these plants from job assignment records. TCDD was measured in serum from a subset of 253 workers. Cause of death on a death certificate was used as the outcome of interest. Vital status was ascertained as of the last day of 1987. The duration of exposure of the cohort members varied: 54% had <1 year of exposure; 29% had 1--5 years; 13% had 5--15 years; and 4% had ≥15 years. The latency from first exposure was substantial: >20 years for 61%. The analysis of all workers did not substantiate an excess risk for lymphoma but found a non-significant increase in soft tissue sarcomas. The analysis of workers with >1 year of exposure and 20 years of latency indicated a significant increase in death from lung cancer and soft tissue sarcoma, and an analysis of all cancers combined also showed a significant increase. In an updated analysis that extended determination of vital status and cause of death through 1993 (12), excess mortality from all cancers was still in excess---a 60% increase for workers in the highest exposure group. Estimated exposure for this group was 100--1,000 times higher than for the general population and similar to doses used in experimental animal studies that showed cancer excess. The original study (11) has been cited >400 times and the later study (12) 175 times. Both studies have been used in risk assessments of national and international importance, in decisions on compensation of veterans, and for other reasons.

1.3 Classification of Chemicals based on their health, Safety & Environmental Risk

The chemical agents present a variety of Risk to human safety & health, environmental damage. They can broadly be classified into following 3 categories

1- Health Risk

Toxic

Very small doses of these types of chemicals can cause death or severe health effects. For example potassium cyanide (KCN) or H2S gas

Toxic for Reproduction

Some chemical agents affect the fertility & may affect the health of an unborn child. Acetone is an example.

Harmful

These chemical agents can cause death or severe health issues if exposed with large quantities.

Corrosive

This chemical destroys the living tissues e.g. skin concentrated sulfuric Acid (H2SO4) is an example.

Irritant

These chemicals causes inflammation on the contact area e.g. prolonged exposure to cement on hands. Similarly ozone gas causes inflammation to lungs if exposed for prolonged time

Carcinogenic

These chemical agents cause cancer in the body. Asbestos dust cause lung cancer

2- Environmental Effects

Some chemicals agents effect the environment & can be detrimental for aquatic life and plants.

3- Physio- Chemical Effect

Some chemicals due to their physical & chemical properties present the risk of fire and/or explosion e.g. highly flammable liquids etc.

1.4 Routes of entry into human body (At workplaces)

Humans are exposed to hundreds & thousands of chemical & biological agents on daily basis. These agents may enter the human body through any of the following routes.

Inhalation

Inhalation is the main source of causing ill health issues. The substance is inhaled through nose or mouth & reaches the lungs. Here the substance enters the blood which carries it to each part of the body. Hydrogen sulfide (H_2S) is a toxic gas & its main route of entry is inhalation.

Ingestion

Ingestion is a process of swallowing a substance & it reaches the stomach. The toxic chemicals then move through the body from digestive system. It is less likely that a human will swallow a toxic or harmful chemical but there are chances when un-intentional contaminations of hands lead to swallowing it along with normal food or a kid with no risk perception swallows a detergent etc.

Injection

Injection is cutting/puncture of skin such as the blood is exposed. The substance may enter the blood through injection. Biological agents normally enter the human body through injection e.g. Tetanus Virus.

Absorption through Skin

The human skin affects a natural resistance against the substances but some chemical agents may enter the human body through skin. This is very rare possibility of ill-health issues originated from substance absorption through skin.

1.5 Human Immunity against chemical agents

Understanding the potential adverse human health effects of environmental chemical exposure has coincided with an increased understanding of the immune system and an appreciation of its complex regulatory network. This has spawned a broad interest in the area of immune-toxicology within the scientific community as well as certain concerns in the public sector regarding chemical-induced hypersensitivity and immune-suppression. The incidence of alleged human sensitization to chemicals has increased, in part, due to the fact that chemical companies are moving to larger and/or different markets. It has been estimated that 35 million Americans suffer from allergic disease, of which 2-5% are from occupational exposure. Although there is not yet a clear understanding of dose-response relationships or disease predisposition, there are many well-defined examples (isocyanates, anhydrides) of chemical sensitizers in humans and experimental animals. Evidence that chemicals suppress immune responses in humans is considerably less well established, although there is a public perception that chemicals generally cause immune-suppression. This perception has been fueled by highly publicized legal cases and scientific controversies within the academic and industrial communities. As a consequence of these public and scientific concerns, many of the regulatory agencies are developing immune-toxicity testing guidelines. At the present, however, there are limitations on adequate human methodology and data that allow the extrapolation of animal data to assess human risk. The potential for human immune-suppression remains of concern, however, because of a large database generated from animal studies that demonstrates immune-suppression as well as reports of immune-suppression in humans inadvertently.

Local Immunity in the Skin

The skin is not merely an inert barrier that physically prevents entry of foreign materials, but possesses biologically active systems and products, including immunological systems, that function as an effective defense system. The immune system of the skin, called "skin-associated lymphoid tissue" (SALT) by Streilein, contains multiple cell types that participate in immune-mediated processes. These include Langerhans cells, which possess antigen-presenting capabilities, and dendritic Tcells, which retain helper and suppressor, function. Additionally, immune cells and active components (e.g., antibody-antigen complexes) are readily recruited to the skin from the circulatory system in response to stimuli initiated at the skin surface. Abundant in the dermis are fibroblasts and capillary endothelial cells that bear cytokine receptors and can be induced to secrete cytokines. Keratinocytes, which differentiate as they ascend through the epidermis, are also reservoirs of cytokines, which are secreted in response to various stimuli. Because the skin is a common site of exposure to environmental agents, it is not surprising that SALT is a common target. Depending on the chemical agent and the dose, toxicity can be manifested as contact hypersensitivity, inflammation, or immune-suppression.Contact hypersensitivity reactions in the skin are common, affecting literally millions of Americans. The incidence associated with environmental or occupational exposure is unknown, but has been estimated to be approximately 5-10% of all cases.The events associated with induction and elicitation of chemical induced hypersensitivity reaction have been intensely investigated. It is thought that Langerhans cells initially interact with antigen in the skin and transport it to the draining lymph nodes where the antigen is presented to immune-competent in context with class II antigens. This initiates an immune response whereby subsequent exposure to the antigen can evoke elicitation in sensitized individuals. This involves the interaction of processed antigen with sensitized lymphocytes. The sensitized lymphocytes are transformed into lymphoblasts, which proliferate and secrete various biologically active products including antibodies and lymphokines. These products, either directly or indirectly, are responsible for the generation of inflammatory mediators such as chemo-attractants, adhesion molecules, and pharmacological mediators. A number of chemical agents have the capacity to produce contact hypersensitivity, a widely recognized environmental and occupational problem. The characteristic that sets allergic responses apart from immune mechanisms involved in host defense is that the reaction is excessive and often leads to tissue damage. Chemical-induced hypersensitivities fall into two categories distinguished not only mechanistically but temporally: delayed type hypersensitivity, a cell-mediated response that occurs within 24-48 hr after challenge, and immediate hypersensitivity, which is mediated by immune-globin, and manifests within minutes after exposure to an allergen. The type of immediate hypersensitivity response elicited depends on the interaction of the sensitizing antigen or structurally related compound with antibody. In contrast, delayed-type hypersensitivity responses are characterized by T-lymphocytes, bearing antigen-specific receptors, which, on contact with cell-associated antigen, respond by secreting cytokines. Metals such as beryllium, mercury, cobalt, nickel, platinum, chromium, and gold can induce a spectrum of hypersensitivity responses, from delayed-onset to immediate. Nickel is considered a medium-to- strong contact sensitizer in humans and has been used as a "gold standard" in development of new assays for assessing hypersensitivity. In addition to contact hypersensitivity responses, some chemicals and environmental agents can alter the normal processes associated with SALT and in certain instances suppress systemic immunity in laboratory animals. In the former, for example, the disappearance or functional loss of Langerhans cells is associated with dermal exposure to ultraviolet light, particularly UV-B radiation or certain chemical agents such as dimethyl benzanthracene, lanthanides (32), pentamidine (33), or phorbol esters (34). Subsequently, the ability to elicit contact hypersensitivity with known sensitizers is lost when the skin is pretreated with these agents. On the other hand, some compounds, such as those with antioxidant activity, exacerbate contact hypersensitivity in mice after dermal exposure. This is associated with an increase in Langerhans cell function as evidenced by increases in Ia antigen density on the cell surface (35). Systemic immunosuppression may occur in experimental animals at doses of UV-B higher than that which suppresses local immunity (36). This is characterized by an inability to respond to sensitizers when applied to unirradiated as well as irradiated sites and a decrease in delayed hypersensitivity responses. The mechanism(s) responsible for these effects are unclear, but may depend on the induction of antigen-specific suppressor Tlymphocytes and bioactive products released from UV-damaged keratinocytes. An association between skin cancers and immunosuppression by UV-B has been established in laboratory animals where UV-induced immunosuppression affects the rejection of UV-induced skin tumors (37). UV-B radiation may also affect SALT in humans, as suggested by the observation that UV exposure inhibited the subsequent ability to induce contact hypersensitivity at the irradiated site in 40% of normal subjects and in 90% of patients with sunlight-induced skin cancer (38). Chemical agents may also produce local inflammatory responses in the skin through nonspecific mechanisms. The keratinocyte, which represents the vast majority of cells that compose the epidermis (> 95%), is the primary source of immuno-active cytokines. It has been postulated that the release of these mediators in response to various stimuli orchestrate many of the immunological and inflammatory responses that occur in the skin after exposure to dermatotoxins (39). In this respect, the pathogenesis of psoriasis, a chronic skin disease characterized by excessive keratinocyte proliferation and inflammatory cell infiltrates in psoriatic plaques, is closely associated with altered regulation of keratinocyte-produced cytokines (40) and may serve to characterize chemical-induced dermatotoxicity. The mechanisms and events by which these processes occur are currently major areas of research. Cytokines known or presumed to be products of keratinocytes include IL-lca and (3, 1L-3, IL-6, IL-8, granulocytic macrophage colony-stimulating factor, tumor growth factor-ca and (3, and TNF-a. Based upon several lines of in vitro and in vivo evidence, a cytokine network theory has been proposed (39). In this theory, environmental stimuli, which includes contact allergens, ultraviolet light, or certain dermatotoxic chemicals, can act directly on keratinocytes, resulting in the release of IL-1 and TNF-ca, as well as the expression of ICAM-1, an adhesion ligand for lymphocytes. The secretion ofIL-1 and TNFa leads to the expression ofsurface leukocyte adhesion molecules (e.g., VCAM-1) as well asthe releaseofkeratinocyte-derived IL-8, a potent attractant for T-lymphocytes and polymorphonuclear leukocytes. Tumor necrosis factor-ax and/or IL-1 may also stimulate keratinocytes in an autocrine fashion. When the initial environmental stimulant is antigenic, such as in the case with NIS04, the response involves increased apposition ofmononuclear cells with subsequent involvement of sensitized T-cells, which increases the intensity and perpetuation of the response.

Local Immunity in the Lung

The average person who is moderately active during the daytime breathes about 20,000 liters (more than 5,000 gallons) of air every 24 hours. Inevitably, this air (which would weigh more than 20 kilograms [44 pounds]) contains potentially harmful particles and gases. Particles, such as dust and soot, mold, fungi, bacteria, and viruses deposit on airway and alveolar surfaces. Fortunately, the respiratory system has defense mechanisms to clean and protect itself. Only extremely small particles, less than 3 to 5 microns in diameter, penetrate to the deep lung.

One of the respiratory system's defense mechanisms involves tiny, muscular, hair-like projections (cilia) on the cells that line the airways. The airways are covered by a liquid layer of mucus that is propelled by the cilia. These tiny muscles beat more than 1,000 times a minute, moving the mucus that lines the trachea upwards about 0.5 to 1 centimeter per minute. Particles and pathogens that are trapped on this mucus layer are coughed out or moved to the mouth and swallowed.

Because of the requirements of gas exchange, alveoli are not protected by mucus and cilia—mucus is too thick and would slow movement of oxygen and carbon dioxide. Instead, the body has another defense system. Mobile cells on the alveolar surface called phagocytes seek out deposited particles, bind to them, ingest them, kill any that are living, and digest them. The phagocytes in alveoli of the lungs are called alveolar macrophages. When the lungs are exposed to serious threats, additional white blood cells in the circulation, especially neutrophils, can be recruited to help ingest and kill pathogens (foreign particles). For example, when the person inhales a great deal of dust or is fighting a respiratory infection, more macrophages are produced and neutrophils are recruited.

Conclusions and Future Direction

The immune system is composed of several cell populations whose maturation is subject to orderly control by endogenous hormones and/or exogenous bacterial products. These mediators possess activation, growth promotion, or differentiation properties and are under the influence of potent and well-defined regulators. From studies in rodents and limited observations in humans, it is apparent that a number of environmental and chemical agents can adversely affect the immune systems, resulting in either immune-suppression, hypersensitivity, or autoimmune disease. These examples and our current knowledge about the pathogenesis of disease support the possibility that chemical-induced damage to the immune system may be associated with a wide spectrum of diverse pathological conditions, some of which may become detectable only after a long latency. Likewise, exposure to chemical agents might represent an additional risk to individuals with already fragile immune systems (e.g., malnutrition, infancy, old age). The value of incorporating immunological experimental data for the toxicological assessment of drugs, chemicals, and biological for human risk assessment has been increasingly accepted. For example, in addition to previously established test guidelines proposed by the Environmental Protection Agency (EPA) for hypersensitivity testing, the EPA (48) and the Food and Drug Administration (49) have recently discussed the benefits of testing the immunosuppressive potential of biochemical pest control agents and antiviral drugs, respectively. Furthermore, EPA has established reference doses (Rf or NOAEL/SF) using immunotoxicity data for several compounds including 1,1,2- trichloroethane, 2,4-dichlorophenol, and dibutyltinoxide, and the Agency for Substances and Disease Registry has derived, "minimum risk levels" for arsenic, dieldrin, nickel, 1,2-dichloroethane, and 2,4-dichlorophenol from immune endpoints (M. Selgrade, personal communication). The preceding decade of research has provided a database of immunotoxic and nonimmunotoxic compounds, a better understanding of the mechanisms responsible for hypersensitivity disease, studies correlating immune dysfunction and altered host resistance, and more predictive methods for detecting immunomodulatory chemicals. Future research is needed to a) further refine and validate immune function tests and host resistance assays, particularly in the rat as well as tests for autoimmunity; b) establish better test methods to evaluate the effects of chemical exposure on lung and skin immunity; c) develop and evaluate in vitro methodology for detecting chemical-induced immunotoxicity; d) develop and implement a testing battery to examine immune changes in humans occupationally or environmentally exposed to chemicals shown to be immune-toxic in laboratory animals; and e) establish appropriate mathematical models to allow for extrapolating experimental studies.

Ref: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1519592/pdf/envhper00370-0221.pdf

1.6 Control of Chemicals as a regulatory compliance

Different countries have developed their own regulations regarding control of chemicals which are hazardous for humans. The control includes; the control of exposure to chemicals and the transportation of such chemicals. ILO has developed convention i.e. C170 and recommendation R177 regarding the control of chemicals.

ILO C170

Classifications and Related Measures

Classification Systems

- Systems and specific criteria appropriate for the classification of all chemicals according to the type and degree of

- their intrinsic health and physical hazards and for assessing the relevance of the information required to determine whether a chemical is hazardous shall be established by the competent authority, or by a body approved or recognised by the competent authority, in accordance with national or international standards.
- The hazardous properties of mixtures composed of two or more chemicals may be determined by assessments based on the intrinsic hazards of their component chemicals.
- In the case of transport, such systems and criteria shall take into account the United Nations Recommendations on the transport of dangerous goods.
- The classification systems and their application shall be progressively extended.

Labelling and Marking

- All chemicals shall be marked so as to indicate their identity.
- Hazardous chemicals shall in addition be labeled, in a way easily understandable to the workers, so as to provide essential information regarding their classification, the hazards they present and the safety precautions to be observed.
- Requirements for marking or labeling chemicals pursuant to paragraphs 1 and 2 of this Article shall be established by the competent authority, or by a body approved or recognized by the competent authority, in accordance with national or international standards.
- In the case of transport, such requirements shall take into account the United Nations Recommendations on the transport of dangerous goods.

Chemical Safety Data Sheets

- For hazardous chemicals, chemical safety data sheets containing detailed essential information regarding their identity, supplier, classification, hazards, safety precautions and emergency procedures shall be provided to employers.
- Criteria for the preparation of chemical safety data sheets shall be established by the competent authority, or by a body approved or recognised by the competent authority, in accordance with national or international standards.
- The chemical or common name used to identify the chemical on the chemical safety data sheet shall be the same as that used on the label.

Responsibilities Of Suppliers

- Suppliers of chemicals, whether manufacturers, importers or distributors, shall ensure that:
  - Such chemicals have been classified in accordance with Article 6 on the basis of knowledge of their properties and a search of available information or assessed in accordance with paragraph 3 below;
  - Such chemicals are marked so as to indicate their identity in accordance with Article 7, paragraph 1;
  - Hazardous chemicals they supply are labeled in accordance with Article 7, paragraph 2;
  - Chemical safety data sheets are prepared for such hazardous chemicals in accordance with Article 8, paragraph 1, and provided to employers.
- Suppliers of hazardous chemicals shall ensure that revised labels and chemical safety data sheets are prepared and provided to employers, by a method which accords with national law and practice, whenever new relevant safety and health information becomes available.
- Suppliers of chemicals which have not yet been classified in accordance with Article 6 shall identify the chemicals they supply and assess the properties of these chemicals on the basis of a search of available information in order to determine whether they are hazardous chemicals.

Responsibilities of employers

IDENTIFICATION

- Employers shall ensure that all chemicals used at work are labeled or marked as required by Article 7 and that chemical safety data sheets have been provided as required by Article 8 and are made available to workers and their representatives.
- Employers receiving chemicals that have not been labeled or marked as required under Article 7, or for which chemical safety data sheets have not been provided as required under Article 8, shall obtain the relevant information from the supplier or from other reasonably available sources, and shall not use the chemicals until such information is obtained.
- Employers shall ensure that only chemicals which are classified in accordance with Article 6 or identified and assessed in accordance with Article 9, paragraph 3, and labeled or marked in accordance with Article 7 are used and that any necessary precautions are taken when they are used.
- Employers shall maintain a record of hazardous chemicals used at the workplace, cross-referenced to the appropriate chemical safety data sheets. This record shall be accessible to all workers concerned and their representatives.

TRANSFER OF CHEMICALS

Employers shall ensure that when chemicals are transferred into other containers or equipment, the contents are indicated in a manner which will make known to workers their identity, any hazards associated with their use and any safety precautions to be observed.

Employers shall:

- Ensure that workers are not exposed to chemicals to an extent which exceeds exposure limits or other exposure criteria for the evaluation and control of the working environment established by the competent authority, or by a body approved or recognized by the competent authority, in accordance with national or international standards;
- Assess the exposure of workers to hazardous chemicals;
- Monitor and record the exposure of workers to hazardous chemicals when this is necessary to safeguard their safety and health or as may be prescribed by the competent authority;
- Ensure that the records of the monitoring of the working environment and of the exposure of workers using hazardous chemicals are kept for a period prescribed by the competent authority and are accessible to the workers and their representatives.

OPERATIONAL CONTROL

- Employers shall make an assessment of the risks arising from the use of chemicals at work, and shall protect workers against such risks by appropriate means, such as:
  - The choice of chemicals that eliminate or minimize the risk;
  - The choice of technology that eliminates or minimizes the risk;
  - The use of adequate engineering control measures;
  - The adoption of working systems and practices that eliminate or minimize the risk;
  - The adoption of adequate occupational hygiene measures;
  - Where recourse to the above measures does not suffice, the provision and proper maintenance of personal protective equipment and clothing at no cost to the worker, and the implementation of measures to ensure their use.
- Employers shall:
  - Limit exposure to hazardous chemicals so as to protect the safety and health of workers;
  - Provide first aid;
  - Make arrangements to deal with emergencies.

Duties of workers

- Workers shall co-operate as closely as possible with their employers in the discharge by the employers of their responsibilities and comply with all procedures and practices relating to safety in the use of chemicals at work.
- Workers shall take all reasonable steps to eliminate or minimize risk to themselves and to others from the use of chemicals at work.

RIGHTS OF WORKERS

- Workers shall have the right to remove themselves from danger resulting from the use of chemicals when they have reasonable justification to believe there is an imminent and serious risk to their safety or health, and shall inform their supervisor immediately.
- Workers who remove themselves from danger in accordance with the provisions of the previous paragraph or who exercise any other rights under this Convention shall be protected against undue consequences.
- Workers concerned and their representatives shall have the right to:
  - Information on the identity of chemicals used at work, the hazardous properties of such chemicals, precautionary
  - measures, education and training;
  - The information contained in labels and markings;
  - Chemical safety data sheets;
  - Any other information required to be kept by this Convention.
- Where disclosure of the specific identity of an ingredient of a chemical mixture to a competitor would be liable to cause harm to the employer's business, the employer may, in providing the information required under paragraph 3 above, protect that identity in a manner approved by the competent authority under Article 1, paragraph 2 (b).

Note: For detailed ILO recommendations R177, please study through following link
http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:55:0:::55:P55_TYPE,P55_LANG,P55_DOCUMENT,P55_NODE:REC,en,R177,/Document

1.7 Type of health effects based on quantity of dose

Acute Health Effect

Acute effects are those ill-health issues which are caused by exposure with high quantity/concentration for a short period of time. For example, exposure with H2S for more than 500PPM can cause death in seconds

Chronic Health effects

Prolonged exposure to a low quantity substance may generate health effects over a period of time. For example, silica dust prolonged exposure causes lung cancer.
It is noteworthy that a substance may present both acute & chronic effects e.g.H2S gas. Prolonged exposure with low PPM (parts per million) H2S may cause headache, corneal blistering, sleep disturbance etc.

What are the Occupational Exposure Limits (OEL)?

The maximum safe dose of an airborne substance, which an employee may be exposed through inhalation for a specific period of time, is OEL.
Exposure limits for different substances will be different e.g. H2S may have low value as compared to CO (Carbon Monoxide)
It is also noteworthy that there is no uniform international standard which lays out the OEL (occupational exposure limits) for the hazardous substances. Every country may have set exposure limits for substances.

Type of OEL Occupational exposure limits)

We have earlier studied the acute & chronic effects of substance on the health of the persons. The OEL may be divided into 02 main type based on the ill-health effect the substances may present

Short Term exposure limits (STEL)

STEL is the maximum safe dose/concentration of an airborne substance that an employee/person may be subject to exposure for maximum 15minutes duration. For example STEL for H2S gas is 15PPM/15min.

Long Term Exposure limits (LTEL)

LTEL is the maximum safe dose of an airborne substance that an employee may be subjected to exposure for an 8hrs (normal duty time per shift) time duration a day for a life time working. LTEL value for H2S gas is 10PPM/8 hrs.
Note: - Some substances may present both acute & chronic health effects & must be dealt accordingly while taking control measures.

Time Weightage Average (TWA)

In the context of LTEL and STEL, it should be understood that exposure to uniform concentration of a substance may not be practical to be monitored as the concentration level may be different throughout the day. This is the reason the concept of TWA is introduced in which the specific hours are multiplied with the concentration value & added together. The sum is then divided by 8 (total shift hours) to get the Average exposure in 8 hrs i.e. TWA.

Example

LTEL for H2S is 10PPM/8hrs. A worker has been exposed as follows:-
2hrs at 5PPM
2hrs at 7 PPM
3hrs at 11PPM
1hr at 13 PPM
Calculate the TWA & decide if he has exceeded LTEL or not
Answer:-
2*5+2*7+3*11+1*13
10+14+33+13
TWA = 10+14+33+13/8 = 70/8= 8.8PPM
LTEL was not exceeded

Advantages of Occupational Exposure Limits

Occupational Exposure Limits i.e. STEL & LTEL are very important in deciding the control measures against the substances ill-health effects on the employees.. The organization may follow the general hierarchy of control measures (as applicable) to safeguard its personnel against the exposure through inhalation.

Limitations of Occupational Exposure Limits

- Exposure Limits have been tested for various substances on different animals (not the human). So it is very difficult to figure out the exact exposure Limits
- Exposure limits may vary from person to person depending on following factors
  - Gender
  - Age
  - Smoker/Non smoker
  - Alcoholic/Non Alcoholic
  - Psychological & physical health condition
- OEL have been designed to tackle ill-health effects due to inhalation only. Whereas, the persons may be subject to exposure through ingestion etc.
- OEL have been designed for isolated substance e.g. H2S or CO etc. OEL may not work well where there is combined exposure to various substances simultaneously
- The environmental factors e.g. temperature humidity etc. may influence the validity of OEL's
- OEL are guidelines only and do not force on employer to adhere to it.
- Measuring & monitoring equipment may get unserviceable leading to false sense of safety against exposure.
- The employees may not wear appropriate personal measuring equipment hence exact value of exposure may not be known
- Employees may not wear suitable RPE's to meet the production deadlines due to the lack of awareness & low risk perception.

1.8 Chemical Processes and Implications on OH&S

Type of Chemical Reactions

The chemical reactions may be Exothermic or endothermic.
Exothermic are those chemical reactions which release heat and energy. The common example of exothermic reaction is combustion in which a flammable substance reacts with oxygen to produce heat and energy.
Endothermic are those chemical reactions which absorb heat and energy. The common example is melting of ice, evaporation of water etc.
The majority of chemical reactions carried out in industry are exothermic. In some cases, an exothermic reaction can lead to a thermal runaway if the rate of heat generated by the reaction exceeds the removal rate. As the surplus heat begins to raise the temperature of the reaction mass, the rate of reaction starts to increase. This in turn accelerates the rate of heat production. Thermal runaway can occur because, as the temperature increases, the rate of heat removal only increases approximately linearly but the rate of heat production increases exponentially. For example, an increase in temperature of 10 K often results in a two- to three-fold increase in the rate of reaction. Once control of the reaction is lost, the temperature can rise rapidly leaving little time for correction. The elevated temperatures may initiate secondary, more hazardous runaways or decompositions.
A runaway exothermic reaction can have a range of results from the boiling over of the reaction mass, to large increases in temperature and pressure that lead to an explosion. Such violence can cause blast and missile damage. Release of flammable materials may result in fire or secondary explosions. Hot liquids and toxic materials may contaminate the workplace or generate a toxic cloud that may spread off-site.
There can be serious risk of injuries to plant operators, other personnel and the general public and damage to the local environment. At best, a runaway causes loss and disruption of production; at worst it has the potential for a major accident, as the incidents at Seveso and Bhopal have shown.
Causes of exothermic runaway and decompositions

- A number of factors can cause imbalance between the rates of heat production and heat removal that can result in exothermic runaway or decomposition. Studies of real runaway incidents show that the main causes are:
- Mischarging of reactants e.g. addition of the wrong material or the wrong amount, addition in the wrong order or at the wrong rate or omission of a reactant;
- thermo-chemistry e.g. poor appreciation of the heat of reaction, unknown thermal instability of reactants, intermediates or products;
- Temperature control e.g. failure to control temperature, misreading of temperature, incorrectly positioned or failed thermocouples or coolant failure;

- Inadequate agitation e.g. omission to start agitation, agitator failure or incorrect specification;
- Maintenance e.g. unauthorized modifications, build-up of residues, blockages, leaks or equipment restarted in an incorrect state;
- Poor control of raw materials e.g. variable raw material specification or contamination; and
- Others e.g. human errors, not following procedures or poorly defined procedures.

The underlying causes of many incidents involving chemical reactions are:

- Inadequate knowledge of the reaction chemistry/thermo-chemistry;
- Inadequate engineering design for heat transfer;
- Inadequate process control; and
- Inadequate procedures and training.

Protective measures

Protective measures mitigate the consequences of a hazard. They are rarely used on their own. Some preventive measures are usually present to reduce the demand on the protective system. Protective measures include:

- Containment within the reactor system;
- Emergency pressure relief or venting, and dumping;
- Crash cooling;
- Reaction inhibition;
- Drown-out and quenching; and
- Secondary containment.

All the protective measures, with the exception of containment and venting, normally rely on a control system to operate them. Therefore, the safety integrity of the protective measure and the integrity of the control system are both important in its selection.

As with all other aspects of safe chemical processes, it is important that the design of any protective measure is adequate. For this to happen you must understand the runaway reaction process in detail. An undersized vent on a reactor will not totally protect the reactor against damage. As the protective measure is the last line of defense, it needs designing to protect against the worst case scenario.

For the majority of businesses carrying out chemical reaction processes, there are four main events that individually, or jointly, have the potential to cause significant harm or damage:

- Fire;
- Explosion;
- Release of a toxic substance; and
- Release of a corrosive substance.

Risk assessment needs to consider how these events could occur. Examples include:-

Fire

- Mixing of incompatible chemicals
- Ignition following a spill or release
- Arson
- Hazardous activities - welding, smoking, etc
- External events - lightning, impact, fire at an adjacent location, etc

Explosion

- Fire
- Ignition following a spill or release
- Exothermic runaway or decomposition
- Pressure build-up by gas generation

Releases

- Containment failure
- Impact
- Human error

Risk assessment of chemical agents

To save the workers from potential ill-health issues, it is necessary to carry out a Risk assessment where employees may be subjected to be exposed to chemical or biological agents. The risk Assessment will be similar 5 step process which we carry out for any other activity at the workplace:-

- Identity the hazardous nature of the substance and the potential ill-health effects it may cause. (we shall also study the sources of information about the hazardous nature of the substance)
- Identity the people who may be exposed. The routes of entry into human body must also be considered
- Evaluate the health risk based on current control measures & suggest suitable control measures (Note:- General principle risk control measures should be followed)
- Record & implement the changes
- Review for suitability

Factors need to be considered in risk assessment for chemical Agents

- Hazardous nature of the chemical substance e.g. Toxic, Harmful etc.
- The number of workers who might be exposed
- The duration of time for which workers might be exposed & frequency of exposure in a day or in a week etc.
- ·The quantity of chemical substance present at the workplace to gauge the physio-chemical effects e.g. flammable liquids
- The concentration of the substance in the air e.g. PPM (Parts per million) for CO or H_2S etc.
- The physical form of the substance e.g. solid, liquid, vapor, mist, fume etc.
- The routes of entry into human body e.g. inhalation, ingestion, injection etc.
- Any reported ill-health issues at the workplace.
- The availability & effectiveness of the existing control measures
- The safety culture & general awareness & risk perception of the workers. This will help suggesting control measures

How to identify the hazardous nature of a substance

We have studied in the health Risk assessment procedure that the hazardous nature of the substance should be identified to evaluate the potential ill-health effects on human body. There are several sources of information but following are considered the authentic

- Product Label
- MSDS (Manufacturer Safety Data Sheet)
- Guidance documents e.g. regulatory body website etc.

Product Label

Product Label bears following information

- The name of the substance & hazardous nature e.g. Toxic
- Guidance for the safe usage
- The possible routes of entry into human body
- Any emergency or first Aid action
- A phrase/symbol indicating the potential Risk e.g. (keep away from children) etc.
- Any restriction of use e.g. not to be used near a naked flame
- The information about the supplier/manufacturer

MSDS

MSDS contains the basic kinds of information, such as

Chemical Identity: Name of the product.

Manufacturer's Information: Name, address, phone number and emergency phone number of the manufacturer.

Hazardous Ingredients/Identity Information: List of hazardous chemicals.

Physical/Chemical Characteristics: Boiling point, vapor pressure and density, melting point, evaporation rate, etc.

Fire and Explosion Hazard Data: Flash point, flammability limits, ways to extinguish, special firefighting procedures, unusual fire and explosion hazards.

Reactivity Data: How certain materials react with others when mixed or stored together.

Health Hazard Data: Health effects (acute= immediate; chronic= long-term), ways the hazard can enter the body (lungs, skin or mouth), symptoms of exposure, emergency and first aid procedures.
Precautions of Safe Handling and Use: What to do in case materials spill or leak, how to dispose of waste safely, how to handle and store materials in a safe manner.
Control Measures: Ventilation (local, general, etc.), type of respirator/filter to use, protective gloves, clothing and equipment, etc.

Guidance Documents

Safety Regulatory bodies in different country publish information about the hazardous products. This information include:-
STEL
LTEL
Flash point
Fire point
Auto ignition point
Physical forms of substance
Health hazards etc.
Health & safety Executive (HSE) is a UK's regulatory body &OSHA (Occupational safety & Health Administration is an American regulatory & enforcement body.

Limitation of Information available about the Hazardous substances

- They take into account the hazardous nature of a substance once studied in isolation about the specific substance & do not consider the synergistic /mixed exposure of various chemicals.
- The exposure limits are generic and do not take into account the personal susceptibility to substances. The risk of H2S gas will be different for smoker & nonsmoker if exposed to same concentration for some period of time.
- The information may not be understood or misinterpret by the user
- The information is based on current human knowledge. There may be some un- known hazardous about the substance which may not be exactly known so far. For example, frequent use of cell phones may affect the human brain but this effect cannot be quantified so far.
- Poor storage of hazardous substances may lead to lack of traceability. An un-labeled drum of H2SO4 may be used instead of saline water drum compromising the control measures based on the information about the hazardous nature of substance.

1.9 Monitoring & Measuring of Hazardous Substances at workplace

Purpose

We have earlier discussed the occupational exposure limits & time weightage Average (TWA) which necessitate the requirement of measuring & monitoring the hazardous substances to ensure:-

- The workers are not being exposed above the occupational exposure limits
- To comply with legal requirements
- To ensure that control measures are effective. LEV, Ventilation etc.
- To alarm the workers of any sudden high release of any hazardous substance so that they may leave the workplace
- To identify the workplace areas where PPE's are mandatory to be worn
- To provide training, information, instructions & awareness to the workers

Methods of Monitoring & Measurement

Electronic detection System

These systems work using Electro-Chemical sensors to detect the presence of a specific type of airborne hazardous substance. They may further be categorized into 02 main types:-

a) Fixed

These systems are fixed to some workplace where possibility of hazardous substance may exist. They may be integrated with an audible alarm& beacon light which operates where the hazardous substance may reach a pre-set value:-

Advantages

- They are highly accurate & Reliable
- They alarm the workers of OEL's are exceeded
- They can be programmed to calculate TWA, peak values & data logging
- Does not require worker competence to interpret the values.

Limitations

- Require calibration otherwise may provide false sense of safety
- Very expensive
- Training for maintenance, use & installations required
- Separate system for each type of hazardous substance. for example H2S or CO. it will not alarm for any mixed

Exposure

- It can be tempered with by the workers intentionally e.g. to avoid frequent Alarm or un-intentionally e.g. during maintenance, calibration or use (Some cables may get damaged)
- These cannot be used as a personal exposure verification

Personal Monitors

Personal monitors work on the same principle as fixed detection system but they are to be worn by the workers

Advantages

- Portable
- Cheap solution
- Workers may use with short training
- They beep/ alarm once a pre-set value of a hazardous substance is reached

Limitations

- Required calibration & bump testing
- May not be used to monitor TWA
- May not store date e.g. peak values
- It can only be used for a specific hazardous airborne material

Note: Bump testing is a method of ascertaining the serviceability of the personal monitor. In this method, the personal monitor is exposed to very large quantity of hazardous substance in a very short time. The reliability & serviceability is thus ensured

Other Detection systems

Passive Samplers

Airborne substance is diffused into the passive sampler. After a set time e.g. 8hrs, they are sent to the lab for analysis.

Advantages

- They are used to measure TWA
- It can identify the exposure of all type of hazardous substances present at the workplace through Lab Analysis
- Accurate

Limitations

- Require competence for Lab Analysis
- It cannot be used for STEL because it only gives the value over a period of time
- Does not alarm the worker of any high exposure
- The value of results cannot be used as personnel exposure

Stain Tube Detectors

Stain tubes are filled with a substance which reacts & changes color which exposed to a specific type of hazardous gas/fumes or vapor. These tubes are calibrated in such a way that with higher concentration the color changes to a specified length of the tube which is marked on the tube. These are available for more than 500 different gases etc.

Advantages

- Cheap & easy method
- Only short training is required to operate
- No Lab analysis required

Limitations

- Each stain tube will work for a specific type of hazardous substance e.g. H2S or CO etc.
- Cannot be used for TWA
- They have a shelf life & expires afterwards
- Once use only
- They have a specific range to measure

Dust Monitoring Equipment

Dust exposure at a workplace may be monitored by passive samplers or personal dust monitoring which is worn by the worker. It consists of a pre- weighted filter fitted into a dust sampler& is attached to the nose. After a set period of time, it is removed& filter is re-weighted. Any change is weight is actually the amount of Dust exposure

Advantages

- Cheap option
- Can be used for personal exposure monitoring

Limitations

- May provide inaccurate results due to absorption of other chemicals/form
- Can only be used as TWA
- Once use filters

Smoke Tubes

The smoke tubes generate smoke through a chemical reaction & the smoke is pumped out of tube through a rubber bulb. These are used to evaluate the effectiveness of ventilation system

General Limitations of Monitoring System

- They require specific training for use & maintenance
- Without proper calibration & maintenance, they may provide wrong results
- They take into account the inhalation hazardous and do not measure or monitor the exposure through other routes of entry
- Most of them operate in a specific range i.e. 0-50PPM etc.
- They may be misused or tampered with to manipulate the data

Monitoring Devices Selection Consideration

Factor to consider

- Environmental condition in which the measuring or monitoring equipment is to be used
- Type of hazardous substance against which the detection system is required e.g. CO, H2S or SO2 gases etc.
- Workplace conditions e.g. requirement of spark proof system to be used in a flammable conditions
- Detection range requirement e.g. 0-50PPMor 0-100PPM or 0-1000PPM etc.
- Any requirement of resolution of the displaying. 10.0or 10.00 or 10.000 etc.
- Response time for sensors to alarm immediately. This will be required where possibility of sudden release of toxic gases is present
- The compatibility with Alarm system
- The competence of the people who are supposed to use, operate & maintenance & any specific training requirement.
- Calibration frequency & any specific equipment training or competency requirement for the calibration
- The Accuracy, reliability & repeatability of the equipment
- Requirement of being tamper-proof & ruggedness

Factors effecting Efficiency of Monitoring & Measuring Devices

- Extreme high or low temperatures
- Extreme humid or dry weather conditions
- Shelf life of the devices
- Lack of competency will lead to inaccurate interpretation of results
- Misuse by the workers
- Noncompliance with manufacturers recommendations for use, maintenance & calibration
- Improper installation

1.10 Risk Control Measures against Hazardous Substances

The organization need to establish, implement & maintain procedures & take action to control the Risk Associated with exposure to hazardous substances. We shall now discuss various options that may be utilized using the General Hierarchy of Risk Control i.e.:-

- Elimination of hazardous substances from the workplace
- Reduction/substitution of hazardous substances will less hazardous substances
- Applying engineering controls
- Applying Administrative controls
- PPE

It should be noted that not all the control measures will be feasible to apply for all type of work places. Therefore the hierarchy of control measures must be kept in mind to ensure lesser reliance on worker competence.

I. Elimination of hazardous substances

It is highly recommended (if feasible) to eliminate the hazardous substances or the processes from the workplace. The example could be outsourcing a process e.g. surface treatment of metal parts.

II. Reduction/substitution of hazardous Substances

In certain situation, elimination of a hazardous substance or process may not be a wise decision but there may be some options available which came reduce the risk. This may be carried out by substituting a hazardous substance with a less hazardous substance. For example; the use of less flammable liquids instead of highly flammable materials and use of natural pesticides (Pyrethrins) instead of pesticides may be carried out.

Note: Carefully examine before substituting the chemical to avoid any unforeseen risks with the new chemicals.

III. Engineering controls

Engineering controls may be applied to reduce the risk as follows:-

- Process control
- Enclosure, isolation or segregation
- Ventilation

We shall discuss each one in detail

a) Process Control

Process control requires the careful examining a process and change the way it's being done e.g.

- Use of wet methods rather than dry e.g. during drilling, cutting, grinding, polishing etc. to damp down the dust
- Use of electric motors instead of diesel motors
- Decreasing the temperature of a process to reduce the evaporation
- Automate the processes to exclude the workers minimum number of workers
- Avoid spray painting & use brush painting or airless painting methods

b) Enclosure & Isolation

These methods aim to eliminate the requirement of workers & chemicals being present simultaneously. It may be used as chemicals inside & workers outside (Robotic Spray painting Booth) or workers inside & hazardous chemicals outside (Diesel Generator to be kept away from building).

- Enclosure is sealing tightly a hazardous so that it may not escape
- Isolation is placing a hazardous substance or process at a geographically distant location from the workplace so that it may not pose a risk of high exposure.

c) Ventilation

- Local Exhaust Ventilation (LEV)
- Dilation Ventilation

Ventilation is a method of controlling Risk from hazardous substances (mainly inhalation) through adding fresh air or removing contaminated air from the workplace. Following methods of ventilation may be used

Local Exhaust Ventilation

Local Exhaust Ventilation (LEV) is an effective means of controlling hazardous exposure.
It comprises following parts

- A hood placed near the source (emitting hazardous substance)
- Dust system to carry the contaminated Air/ Airborne hazardous substance
- A filter to avoid environmental pollution
- A fan (extractor) which forces the Airborne substance to travel through the duct to the outside environment

It is very important that LEV must be designed & manufactured by competent persons keeping in view various factors including:-

- The quantity of hazardous substances present at the workplace
- The concentration of Airborne hazardous substances in the workplace
- The hazardous nature of the substance
- Occupational Exposure Limits for the substance
- Required number of hoods
- The distance through which the airborne hazardous substance will travel through the ducts
- Requirement of filtration before discharging into environment. (As per legal or regulatory guidelines)
- Any expected modification in future
- The presence of any other Risk control measures
- The presence of hazardous substance detection, alarm system & emergency procedures

It should be noted that the efficiency of an LEV may be decreased with the passage of time.
Following may be the reasons which may lead towards an ineffective LEV system:-

- The hood placed wrongly i.e. away from emission sources
- Physical damage to the ducts which may have caused holes in ducts or reduction in inside area of the duct
- Contamination/clogging of material along the inside of duct resulting lesser path for movement of airborne substances
- The faulty/unserviceable fan/motor
- Non approved modification e.g. Increased number of hoods or sharp edges in the ducting system
- Blocked filter causing increased force of fan.

Dilution Ventilation

Dilute ventilation operates by dilating the concentration of hazardous substance in the workplace by pulling the contaminated air from workplace or injecting fresh air into the workplace

Passive Ventilation

Large windows/voids causing the natural flow of air through workplace result the dilution of hazardous substance

Active Ventilation

It is done through exhaust fans/powered extractors

Advantages of Dilation Ventilation

- Cheap option for the workplaces where the OEL for the substances are high and Risk is low with exposure
- It may be used where the concentration of Airborne substances remain very low

Limitations of Dilation ventilation

- It is not reliable for toxic substances
- May not be effective for airborne hazardous substances which are heavier than air
- It is also not suitable for the workplaces where outside air is more hazardous/contaminated than inside air
- It is ineffective for Acute exposure situations
- It does not completely remove the hazardous substances from the workplace

May be ineffective for the workplaces with high concentration of Airborne hazardous substances or where sudden release of hazardous substances may occur

iv- Administrative controls

Administrative control measures are the procedures & rules which ensure that workers are not exposed beyond the OEL's. This may be done through various measures including:-

Reduce the exposure Times

Reducing the time for which a worker may be exposed to hazardous substances will reduce the risk of ill-health for the worker. This may be achieved through frequent job rotations, rest breaks & elimination of un-necessary persons from such workplace.

Education, Information, Awareness & Training

The workers with increased risk perception are less likely to suffer ill-health issues. Therefore it is necessary to impart training to the workers as follows:-

- Hazards and risk
- Control measures
- Use of PPE's
- How to respond in emergency
- Use of measuring and monitoring equipments
- Occupational exposure limits

Good House Keeping

It is important to prevent un-necessary accumulation of hazardous substances at workplace. This may be carried out through an effective housekeeping program.

Personal Hygiene

It should also be considered that inhalation is not the only route of entry but there are absorption through skin, ingestion etc. can also expose an employee to hazardous substances. Eating at workplace should be prohibited and workers should be motivated to wash hands before they eat to avoid hazardous substance ingestion into the body. Similarly frequent washing of working overalls should be made necessary

Health surveillance

It is though not a proactive approach towards the risk control but it may indicate any severe exposure to hazardous substances or the violation of compliance with OEL's.

Health Surveillance may also be used to gauge the effectiveness of existing control measures. The organization must have procedure in place for medical examination at the time of induction & medical examination (weekly/monthly/Quarterly/Yearly) depending on level of risk or past ill health records

v- PPE's

The fifth and the last control measure in the hierarchy of the control are PPE. Although PPE's are assumed to be least effective means of protection against the risks but certain situations e.g. emergency evacuation or temporary works necessitate the use of PPE's. There are various types of PPE's designed to give protection against the inhalation hazardous, ingestion hazardous, injection hazardous & skin absorption hazardous.

High Efficiency Particulate Air (HEPA)

High-efficiency particulate air filtration, or HEPA, is capable of filtering 0.3 micrometer particles with 99.97% efficiency, for use in contaminated environments. Where airborne particles are less than 10 microns (µm= 1/1000000 of a meter) in diameter, a HEPA (100) rated respirator is highly recommended.

Respiratory protection Equipment's (RPE's) are the type of PPE which are used where airborne hazardous substances may enter through inhalation. We shall discuss in detail about the characteristics advantages & limitation of each type in following paragraphs:-

Respiratory Protective Equipment (RPE)

There are mainly 02 types RPE's

Respirators

They only filter the available air before it enters the human respiratory system

Examples: - Face piece respirator, ori-nasal respirator full face respirators etc.

Advantages of Respirators
- Low cost
- Can be re-used after filter replacement.
- Some are available as disposable e.g. face piece respirators.

Limitations of respirators
- These cannot be used in oxygen depleted environments
- These cannot offer protection against toxic gases e.g. CO or H2S etc.
- Difficulty in inhalation due to the presence of filter.
- Negative pressure inside the face mask resulting atmosphere contaminated is to leak through & enter the human respiratory system.
- May not be comfortable for the wearer which will encourage workers not to wear them.

Breathing apparatus
Breathing apparatus provide the fresh air/oxygen from another source. They may further be categorized as:-

Fresh air breathing apparatus
The intake of air is from an outside source through a hose

Limitations
- Supply of air restricted to a specific length of hose
- Damaged hose can cause contaminated air to be inhaled
- Kinked hose can cause difficulty in breathing
- It cannot be utilized in fire evacuation
- Restrict free movement of wearer

Compressed Air Breathing Apparatus
The supplied air is through an external source (compressor). As compared to fresh BA, these do not create breathing difficulty because there is positive pressure inside the face mask.

Limitations
- Hose may get damaged allowing contaminated air to enter inside
- Supply of hose is restricted
- Free movement of wearer is restricted
- Kinked hose can cause suffocation/breathing difficulty
- It cannot be used in fire evacuation emergencies

Self-Contained Breathing Apparatus (SCBA)
Similar to compressed Air Breathing Apparatus i.e. positive pressure inside face mask but the supplied air is through a small cylinder attached to the body of wearer. Because there is no hose attached. SCBA provides complete freedom of movement. It can also be utilized for rescue & evacuation purposes

Limitations
- Supply of Air is time bound
- The wearer may feel uncomfortable to carry the cylinder
- May become ineffective if not properly worn
- Expensive
- Training required for use and maintenance

We have so far discussed various options of PPE's against inhalation hazardous. But certain works require wearing PPE's against hazards which might enter through other routes. Following are some of examples of PPE which are used against hazardous substances:-

Gloves
Protection of hands against chemical or biological agents

Overalls and Aprons

There act as a shield against hazardous substances from coming into direct contact with skin. e.g. grease & liquid chemicals safety

Goggles

Protection against chemical spillage into the eyes

Face Visors

It provides protection against chemical splashes onto the face.

Factors to consider for selection of PPE's

We have studied various PPE's but not all the PPE's will effectively work against all or a specified hazard at the workplace. Therefore selection of PPE's may be made considering following factors:-

- Type of hazard e.g. inhalation, absorption etc.
- The risk level at the workplace
- The level of protection required (OEL)
- The competence & general safety culture of the workers
- The nature of hazardous substance e.g. toxic, carcinogen etc.
- Compatibility with other PPE's
- Required level of degree of freedom in movement
- The presence or absence of oxygen in the workplace
- Required level of training for use & maintenance
- Cost of the PPE's
- Comfort of wearer
- Physical fitness of the workers who are supposed to wear.

1.11 The Future of Personal Protective Equipments

Personal protective equipment is at the bottom of the hierarchy of controls. This has been kept for a reason. It is the least reliable form of protection. It can be uncomfortable for the wearer and may not offer complete protection and workers prefer not wearing them. It also shifts the burden of protection from the employer, who by law must provide a safe workplace, to the worker.

It should instead be a goal to protect workers in such a way that no one needs to wear PPE to be safe? It may sound far-fetched, but zero PPE is not an impossible dream. We shall be discussing the elimination of personal protective equipment in detail in subsequent elements.

Use of Nanomaterials for Personal Protective Equipments

Personal protective equipment (PPE) of the future will be built on a foundation of nanomaterials that will yield a range of new properties to save more lives and prevent more injuries, as well as affording workers enhanced communication, increased comfort and greater durability.

That is the bold new world of PPE envisioned by one of the leading U.S. authorities on nanotechnology science. Richard W. Siegel, Ph.D., founding director of the Rensselaer Nanotechnology Center at Rensselaer Polytechnic Institute, Troy, N.Y., shared his perspectives at "Protection 2033," a symposium on worker health and safety over the next 25 years. Dr. Siegel is a pioneer in the field of nanotechnology, and his research has been recognized around the world. The International Safety Equipment Association (ISEA) sponsored the event in November 2008 to commemorate its 75th anniversary and as a look ahead to its centennial year.

What new technologies did Siegel's crystal ball reveal and how will they translate into better PPE? Workers and those responsible for protecting them will have numerous options from which to choose.

In the area of eye and face protection, the professor predicts tougher, more scratch-resistant plastic face masks and spectacles with transparency and reflectivity that workers can tune to their needs or that will respond automatically to their environment. And this eye/face protection will have built-in, embedded electronic communications devices and instrumentation, along with interactive displays powered by lightweight batteries. They will be equipped with sensors for thermal, chemical and biological monitoring.

Head protection is likely to be transparent to enhance all-around visibility, and made from lighter weight, tougher ceramic/polymer-nanocomposite armor. It also will come equipped with embedded communications devices, as well as sensors to detect and warn of hazardous environments, and to provide thermal management (heating, cooling). Similar advances will provide hearing protection that is more active and responsive, adjusting to fluctuations in workplace noise level.

Hand and foot protection also will benefit from nanomaterials. Expect lighter weight, ceramic-nanocomposite armor embedded in flexible polymer composites to yield more robust footwear and gloves that heal themselves. And these protective devices also will have embedded, responsive thermal management systems for greater comfort, and embedded sensors to detect and warn of environments carrying thermal, chemical or biological threats. Siegel even envisions foot and hand protection having built-in first-aid with therapeutic delivery in the event of an injury, and more work-efficient materials to enhance performance and reduce fatigue.

Siegel predicts that some of the most profound advances will be made in protective and high-visibility apparel. These enhancements will be derived from instrumented, lightweight, responsive textiles that use tougher, wear-resistant polymers that also benefit from embedded, ceramic-composite armor. Like future hand and foot protection, these garments will have embedded warning, thermal-management and first-aid systems.

High- or modulated-visibility (tunable) textiles powered by lightweight, flexible batteries embedded in the fabric will enable manufacturers to produce garments that are visible day or night — at any level of light. And when the need arises, these items will be equipped with electronic communications systems with interactive displays and remote monitoring of worker conditions.

In a real sense, the future of worker protection looks very bright. But how far away are these PPE advances? While some may not be available until ISEA's 100th anniversary, others could be just around the corner. A show of hands at the "Protection 2033" symposium indicated that a number of ISEA member companies already are working to apply some of these miraculous new technologies to their products. Stay tuned.

With Nanotechnology's Promise Also Comes Challenges

While carrying great promise for products that protect workers better, nanotechnology also presents new challenges in protecting workers.

"Nanomaterials present new challenges to understanding, predicting and managing potential health risks to workers. Following staid 20th century historical practices, by the time a material is in commerce, scientific data on the health effects in exposed workers or the public — especially long-term health effects — are largely still unavailable and a government risk management that is specific is still decades away.

"In the case of nanomaterials, the uncertainties are magnified because the characteristics of nanomaterials may be different from those of the larger particles with the same chemical composition. As we forge ahead with these 21st century technologies, we must simultaneously take a hard look at our current risk characterization, risk control and risk communications methods and ask ourselves: 'Are they the ones that will best serve as effective tools to help us achieve global occupational safety and health goals in a changing 21st century world?'"

1.12 Emergency procedures

Initiating emergency procedures at the earliest stage of an incident can significantly reduce the impact of an incident on people and premises. You will need, therefore, a written procedure for dealing with any reasonably foreseeable incident, for example fires, spills or leaks. It should cover:

- Raising the alarm;
- Calling the emergency services;
- Evacuating the area and providing safe havens; and
- Tackling the fire or controlling the spill or leak (when it is safe to do so).

You need to consider the range of possible events to take into account the following:

- The nature and quantities of the materials involved;
- The location of the process and its design; and
- The people and environment, both on-site and off-site that may be affected.

When the fire brigade arrives they will assume responsibility for firefighting and rescue operations. They may, at the discretion of the fire brigade incident commander, undertake any other appropriate emergency operations to prevent and limit any environmental damage the incident might cause. It is therefore important that they are aware of the facilities and capabilities at your site.

Where large numbers of employees on-site or people off-site may be at risk a nominated person should co-ordinate or manage the risk assessments and, in consultation with the emergency services, prepare an emergency action plan.

1.13 Benefits of 'Good Work'

Employing persons for jobs does not mean giving them financial incentives alone against the value of work they do. With the evolvement of health and safety regulations, the employers have been assumed to invest on health, safety and welfare provisions. The concept of acceptable risks however allowed the employers to achieve their production targets while restraining the health and safety risks.

However, over a passage of time, it has been concluded that better work environment and "good work" are not only a key to success of the businesses but betterment of the country's economy. Just 'having a job' - regardless of its quality - is not sufficient. The objective must be to ensure that for as many people as possible, work is a source of well-being, personal growth, fulfillment, autonomy and meaning. In other words, the jobs available in today's labor market should offer 'Good Work'. A significant weight of evidence supports the argument that job quality, employee health, and an employee's ability to perform productively at work, are closely linked

"Good work is engaging, fair, respectful and balances job demands, autonomy and job security. Good work accepts the importance of culture and traditional beliefs. It is characterized by safe and healthy work practices and it strikes a balance between the interests of individuals, employers and society. It requires effective change management, clear and realistic performance indicators, matches the work to the individual and uses transparent productivity metrics."

Characteristics of "Good Work"

Job Satisfaction

The workers spend almost one third of their life at the workplaces. Job satisfaction is a key factor in productivity of individuals. Job satisfaction has many facets mainly the aptitude of the individual for the job.

Job Security

The employees must be provided with job security. The organizations must devise policies for to ensure the job security. Hiring and firing as a routine matter discourages the productive workers. It also results in non productive teams and groups within the organizations.

Appreciation

Requiring appreciation for the work is a human nature. The workers get more satisfied and productive if they are appreciated for the quality & any creative work they do

Autonomy

Autonomy is the degree of freedom for doing a specific job and decision making. The autonomy of the job is a key feature of "Good Work" because it taps creativity and productivity.

Training and Development

What happens if we train them and they leave? A wise and visionary CEO replied that what happens if we don't and they stay? It is very costlier to retain and untrained workforce. A "Good Work" opportunity must focus on personnel training and development.

Challenging

A good work must provide its employees challenging opportunities for their self actualization and personal prestige

Flexibility

A "Good Work" must be result oriented and should provide flexibility in the working hours to suite the employees own personal needs. However, this flexibility should be agreed upon so as not to adversely affect the productivity of organization where the work of some individuals may become bottle neck

Career Development

A "Good Work" must provide a career path to all its employees and provide equal opportunities for career development and growth

Participation and Involvement

Participation and involvement of employees and/or their representatives in strategic business decision making motivates the employees and increases their loyalty and workplace ownership

Health, Safety and Welfare Facilities

Other than regulatory requirements, an organization's visible commitment for OH&S and welfare facilities retains the skilled workforce which also remains happy, motivated and productive for the organizations.

Resources

The employees must be provided with all relevant technical and other resources as required, which should be necessary in performing a task in a faster and better way.

Communication
The organizational policies should be communicated to all employees so that they remain aware of any changes. This way, they feel themselves as part of the organization and feel the ownership
Note: The benefits of "Good Work" will not only result into business profits and growth of the organizations but more labor will be inclined to doing job instead of waiting for good job opportunities and remain jobless for months.

1.14 Clean Energy and OH&S implications

What is clean energy?
Renewable energy generates electricity from sustainable sources like wind, solar, and geothermal power with little or no pollution or global warming emissions.
Clean energy means lesser or no use of coal, flammable substances e.g. Methane, propane, gasoline, diesel, furnace oil etc. The global warming is really hot issue and world is unanimously heading forward for making legislations e.g. many countries like Japan, Netherlands, Germany etc have vowed to ban all natural fuel powered vehicles within next 10 to 15 years. Some countries are even thinking of banning the production of these vehicles. Some futurists have predicted that in next 20 years, there will be more electric charging stations than the petrol/ gas stations in the world. Tesla; a renowned electric car producer has reached almost equal demand than Ford in year 2017 which is a sign of complete paradigm shift from Fuel powered to clean energy.
But how this paradigm shift will affect occupational health and safety is an important consideration.

Health risks in a green economy – mitigation and management
- Occupational hazards and risks associated with "green technologies" are often similar to those in conventional industries. Known measures can be employed to reduce such risks. These include: design and protective gear against falls from height; local exhaust encapsulation and exhaust ventilation for protection from excessive exposure to toxic chemicals and indoor particulates; ergonomic devices (e.g. for lifting and carrying); training of workers and improved employment terms.17 Clear policies and actions are needed to help governments, employers, workers and other social actors address these known problems.
- Some green economic strategies may draw more employment to sectors with known hazards; these need to be managed and mitigated. For instance, retrofitting homes and recycling materials are both "green strategies." But these also have known health risks to workers who may be obliged to work in close proximity sorting or removing materials contaminated by unknown toxics, chemicals or bacteria. Particularly in developing countries, the informal sector also is responsible for much of the materials recycling. And while recycling is of great value in resource conservation, jobs may entail dirty, undesirable and even dangerous and unhealthy work, for which people are often poorly paid. Occupational health measures targeted at the informal sector are thus of particular importance.
- Some green technologies also may generate new or increased exposures to air pollution hazards. For instance, workers may be exposed to nano-particles or hazardous chemicals in certain types of solar panel production which need to be mitigated. Incineration, or "co-processing" of waste materials (tires, plastics, used oils and solvents, sewerage sludge, etc.) to generate energy for steel and cement production and other industries can conserve energy and replace fossil fuels while reducing waste volumes. However, poorly designed and managed technologies may generate toxic emissions that can affect workers and people who live close to industrial facilities. Waste-to-energy schemes thus require oversight and monitoring policies that are currently lacking or inconsistently applied
- Some green technologies require further attention to workers´ ergonomic risks. For example, production of renewable energy can also involve hazards, e.g. falls from wind power installations, exposure to nano-particles or hazardous chemicals in solar panel production, which need to be mitigated. Using waste materials for "co-processing" of energy (tires, plastics, used oils and solvents, sewerage sludge, etc.) in steel and cement/clinker industries promotes recycling and energy conservation (even replacing fossil combustibles) while eliminating toxic residues. However, poorly designed and managed reuse technologies may generate toxic emissions; excessive exposures can increase risks of cancer and reproductive / immune disorders for workers and people who live close to industrial facilities. This requires oversight and monitoring that is often inconsistent or lacking

Some climate mitigation measures and green technologies present new hazards or risks to worker health. When a technology raises threats of harm to human health, precautionary measures should be employed, even before final scientific proof of cause-and-effect relationships. For example, a Precautionary Principle policy adopted by the city of San Francisco (USA) with regards to chemical use notes that "... early warning signs of harm" should trigger an occupational health response that uses the "best available science to identify safer alternatives."

·This policy has encouraged the use of measures such as: financial incentives through procurement contracts; certification and promotion of safer business practices; requirements for information disclosure; and outright bans and restrictions on the sale of products when safer alternatives are readily available

Green technologies are highly varied in scale and job demands, and they are not free of hazards. Workers in these industries will be exposed to risks that may be the same as, less than or elevated compared to conventional technologies. If green technologies are disseminated in ways that present increased risk to worker health, sustainability will be achieved at the cost of inequitably distributed risks and benefits, regardless of the benefit to the global community as a whole. Green technologies that protect or enhance worker health will achieve sustainability not only at the community level but down to the level of families, contributing to sustainability of income security and social equity. This document seeks to anticipate green technologies' consequences for occupational health and safety, including hazards or risks they may present. The goal is to remove impediments to the dissemination and adoption of green technologies and to reduce avoidable risks for workers. This document identifies remediable hazards and manageable risks as well as the strategies to manage them so green technologies can be implemented without compromising worker health.

Identified clean energy technologies

- The following are the clean energy technologies which are and will be replacing the existing fossil based energy.
- Concentrating solar power (CSP) technologies
- Photovoltaic (PV) solar technologies
- Solar hot water and space heating and cooling (installation and use in workplaces)
- Wind energy
- Biofuels: bioethanol from sugarcane
- Biofuels: bioethanol from corn, wheat and other crops
- Biofuels: biodiesel from castor beans, soybeans, palm oil and non-edible plant oils
- "Modern" biomass resources and bio-energy conversion technologies
- Fuel cells
- Replacement and/ or reduction of traditional fossil sources of energy (selected industries and vehicles)
- Materials recycling of both "external" raw materials or materials generated on site of selected industries
- Energy efficiency of buildings
- Transportation: energy consumption and efficiency
- Mitigation measures in agriculture: techniques for reduction of carbon emissions
- Mitigation measures in forestry: techniques for reduction of carbon emissions and for carbon fixation

Note: Further detail regarding health and safety risks and their controls can be studied at http://www.who.int/hia/green_economy/hgebrief_occ.pdf

1.15 Chemical Agents

We shall discuss in detail about the following chemical agents which create a significant health risk at most of the workplaces.

- **Asbestos**
- **Silica dust**
- **Cement**
- **Wood dust**
- **Carbon monoxide (CO)**

Asbestos

What is Asbestos

Asbestos refers to a set of six naturally occurring fibrous minerals. Asbestos has six primary sub-classifications: chrysotile, crocidolite, amosite, anthophyllite, tremolite, and actinolite. Among these, chrysotile and amosite asbestos are the most common.

(Ref: www.mesothelioma.com/asbestos-cancer/what-is-asbestos.htm)

Characteristics of Asbestos

Asbestos has a host of physical properties that make it almost a superstar in the world of industrial chemistry. Its tensile strength surpasses that of steel. It has tremendous thermal stability, thermal and electrical resistance and is non-flammable.

Why is asbestos dangerous?

- Asbestos still kills around 5000 workers each year, this is more than the number of people killed on the road.
- Around 20 tradesman die each week as a result of past exposure
- However, asbestos is not just a problem of the past. It can be present today in any building built or refurbished before the year 2000.

When materials that contain asbestos are disturbed or damaged, fibers are released into the air. When these fibers are inhaled they can cause serious diseases. These diseases will not affect you immediately; they often take a long time to develop, but once diagnosed, it is often too late to do anything. This is why it is important that you protect yourself now.

Health Risks

Mesothelioma

Mesothelioma is a cancer which affects the lining of the lungs (pleura) and the lining surrounding the lower digestive tract. It is almost exclusively related to asbestos exposure and by the time it is diagnosed, it is almost always fatal.

Asbestos-related lung cancer

Asbestos-related lung cancer is the same as (looks the same as) lung cancer caused by smoking and other causes. It is estimated that there is around one lung cancer for every mesothelioma death.

Pleural thickening

Pleural thickening is generally a problem that happens after heavy asbestos exposure. The lining of the lung (pleura) thickens and swells. If this gets worse, the lung itself can be squeezed, and can cause shortness of breath and discomfort in the chest.

Asbestosis

Asbestosis is a serious scarring condition of the lung that normally occurs after heavy exposure to asbestos over many years. This condition can cause progressive shortness of breath, and in severe cases can be fatal

Note: It is also important to remember that people who smoke, and are also exposed to asbestos fibers, are at a much greater risk of developing lung cancer.

Managing and working with asbestos

The importation, supply and use of all forms of asbestos are banned. However, many buildings, and some plant and equipment, still contain asbestos-containing materials (ACMs).

Before you start any work in a building that might contain asbestos (e.g. built or refurbished before the year 2000), you need to do the following:

<u>Identify whether asbestos is present and determine its type and condition</u>

People responsible for maintenance of non-domestic premises have 'duty to manage' the asbestos in them, and should provide you with information on where any asbestos is in the building and what condition it is in.

If no information is available or it is limited and you suspect asbestos may be present you should have the area surveyed and representative samples of the material you are going to work on analyzed.

Alternatively, you can assume that any material you need to disturb does contain asbestos and take the appropriate precautions for the highest risk situation.

<u>Carry out a risk assessment</u>

Decide if it is possible to carry out the building or maintenance work avoiding the risk of asbestos exposure all together.

If that's not possible, identify who might be at risk and the level of possible asbestos exposure from any work.

On this basis, decide what work methods are necessary to provide effective control of the risks.

<u>Decide if the work needs to be carried out by a licensed contractor</u>

Most asbestos removal work will require a contractor holding a license from HSE.

All work with sprayed asbestos coatings and asbestos lagging and most work with asbestos insulation and asbestos insulating board (AIB) require a license.

Identify if your work needs a licensed contractor; Find a licensed contractor, or find out how to apply for a license.

If the work is not licensable, decide if the work needs to be notified

If it doesn't need a license, you can do maintenance work on or around ACMs with the appropriate controls in place.
Some non-licensed work also has additional requirements, i.e. notification of work, medical surveillance and record keeping. This work is known as notify-able non-licensed work (NNLW).

Ensure those carrying out the work are suitably trained

Any worker who is liable to disturb asbestos during their day-to-day work needs to receive appropriate training to enable them to protect themselves and others.

Silica dust

What is silica?

Silica is a natural substance found in most rocks, sand and clay and in products such as bricks and concrete. Silica is also used as filler in some plastics. In the workplace these materials create dust when they are cut, sanded, carved etc. Some of this dust may be fine enough to breathe deeply into your lungs and cause harm to your health. The fine dust is called respirable crystalline silica (RCS) and is too fine to see with normal lighting.

Occupations at Risk with exposure to Silica Dust

Construction and demolition processes , Quarrying; slate mining and slate processing; potteries, ceramics, ceramic glaze manufacture, brick and tile manufacture; foundries; refractory production and cutting; concrete product manufacture; monumental and architectural masonry manufacture, stone fireplace and kitchen worktop manufacture; grit and abrasive blasting, particularly on sandstone.

Health risks

Silicosis

Silicosis makes breathing more difficult and increases the risk of lung infections. Silicosis usually follows exposure to RCS over many years, but extremely high exposures can lead rapidly to ill health.

Chronic obstructive pulmonary disease (COPD):

COPD is a group of lung diseases, including bronchitis and emphysema, resulting in severe breathlessness, prolonged coughing and chronic disability. It may be caused by breathing in any fine dusts, including RCS. It can be very disabling and is a leading cause of death. Cigarette smoking can make it worse.

Lung cancer

Heavy and prolonged exposure to RCS can cause lung cancer. When someone already has silicosis, there is an increased risk of lung cancer. The health risks from RCS are insignificant when exposure to dust is adequately controlled – you do not need to become ill through work activities.

Control Measures

- Carry out Health Risk Assessment
- Change the Process to eliminate/ reduce the silica dust
- Provide Engineering controls e.g. LEV or dilution ventilation
- Provide Administrative Controls e.g. compliance with OEL, reduced exposure time, Job Rotation, Health Surveillance and Training etc.
- Use of PPE e.g. RPE

Cement

Health Effects

- Irritation of Skin, Eyes and Respiratory system
- Corrosive skin burns with prolonged contact

Control Measures

- avoiding exposure to cement powder by using pre-mixed concrete / mortar

using work methods that increases the distance between the worker and the substance such as longer handled tools
- Use PPE e.g. respirators, gloves, aprons etc
- Provide training to the worker about the hazards and risk control

Wood dust

Health Effects
- It can cause asthma

Control Measures
- Carry out Health Risk Assessment
- Provide Engineering controls e.g. LEV or dilution ventilation
- Provide Administrative Controls e.g. compliance with OEL, reduced exposure time, Job Rotation, Health Surveillance and Training etc.
- Use of PPE e.g. RPE etc.

Carbon Monoxide (CO)

What is carbon monoxide?
Carbon monoxide (CO) is a colorless, odorless, tasteless, poisonous gas produced by incomplete burning of carbon-based fuels, including gas, oil, wood and coal. This gas is produced by gas appliances and engines when there is not sufficient air for them to work correctly. Carbon monoxide is highly toxic gas.

How does it affect human body?
When CO enters the body, it prevents the blood from bringing oxygen to cells, tissues, and organs.

Signs which indicate incomplete combustion
- Yellow or orange rather than blue flames
- Soot or yellow/brown staining around or on appliances
- Pilot lights that frequently blow out
- Increased condensation inside windows

Symptoms of carbon monoxide poisoning
Early symptoms of carbon monoxide (CO) poisoning can mimic many common ailments and may easily be confused with food poisoning, viral infections, flu or simple tiredness. Symptoms to look out for include:

- Headaches or dizziness
- Breathlessness
- Nausea
- Loss of consciousness
- Tiredness
- Pains in the chest or stomach
- Erratic (In-consistent) behavior
- Visual problems

Risk control measures for carbon monoxide

Risk Assessment
Identify: Identify those tasks/situations where significant levels of carbon monoxide may occur. This may include:-
- Using equipment involving liquefied petroleum gas (LPG) in enclosed spaces e.g. work equipment or heaters / cookers in welfare facilities
- Using petrol powered equipment in enclosed spaces (including trenches / excavations) e.g. generators and cut-off saws
- Refurbishing existing buildings which disrupts gas flues or ventilation systems;
- Inadequately installing new gas appliances

You are generally at lower risk if you are in an open / well-ventilated space.

Control

Prevent: Think about eliminating or reducing carbon monoxide risks where possible. Consider:

- Using electrical appliances instead of LPG or petrol ones
- Locating generators etc outside / in well ventilated spaces
- The impact of refurbishment work on existing gas-fired systems during the planning stage
- Future maintenance access to duct systems concealed within voids etc

Note: Even if you minimize some of the risk this way, you may still do other work that might create carbon monoxide. Control the risk by:

Ventilation: Make sure any facilities using LPG have adequate ventilation at both high and low level. Check it is not blocked, e.g. fixed grilles covered by newspaper or rags in cold weather to "stop draughts". Petrol and LPG equipment should be properly extracted / exhausted if used in enclosed spaces. Mechanical ventilation may also be needed.

Detectors: Use personal/mounted carbon monoxide detectors where appropriate.

Installation: Ensure a competent person carries out all LPG / gas installation or refurbishment work.

Other risks: Consider other risks of fire and explosion or confined space work.

Training: Workers need to know how to use the controls properly. They also need to be aware of the signs and symptoms of carbon monoxide poisoning.

Supervise: Ensure that controls are effective and used by the workers.

Maintain: Properly maintain all equipment. LPG equipment can be particularly vulnerable. Blocked or partially blocked burners can lead to higher carbon monoxide levels and flame failure. LPG can also leak from damage to hoses etc.

1.16 Requirement for the Work Environment

For effective and safe execution of the duties, the environment where work is being performed should have some basic requirements. These requirements are quite generic in nature and can be quantified with respect to type of workplace. For outdoor workplaces, it may not be possible to ensure all or some of these requirements fully but must be ensured for indoor activities;

Lighting: Adequate lighting must be provided as per the requirement and the nature of job. Lighting requirement will be different for a tailor who is sewing some clothes (Spot Lights) and for a watchman

Ventilation: Suitable ventilation should be provided to avoid any suffocation. This may be done with exhaust fans or supply of fresh purified air into work area

Thermal Comfort: The employees working in cold storage are exposed to quite cold environment whereas bakery/ furnace workers are exposed to extremely hot environment. They must be provided with suitable clothing. Similarly those working indoor/ outdoor must be ensured with thermal comfort.

Space: Adequate space should be provided such as each worker can perform his duties easily. And activities performed by co-workers must not become a hazard due to limited space.

Seating: Appropriate seating (where applicable) must be provided. Where seating cannot be provided due to the nature of job (Mason/ construction worker) then adequate rest brakes/ administrative measures should be taken to ensure health and safety of workers

Noise: Noise level must be controlled. Adequate Engineering/ Administrative controls should be taken

Welfare Requirements

The employer must ensure the provision of following welfare requirements:

Drinking Water: Easy approach to clean drinking water with suitable temperature

Toilet Facilities: Toilet facilities must be provided. The number of toilets and their distance from the workplace must be suitable. Separate toilets for men and women should be provided. Similarly, disabled workers should also have access to the toilets as per their requirements.

Change Rooms: Where the workers need to change to overalls or aprons, there must be provided with changing rooms and also the accommodation of clothes and valuables like watches/ Mobile phones etc.

Parking: Suitable Parking for the conveyances of the employees should be made such as the employees should not travel too far to reach their workplace in extreme weather condition or else

Washing Facilities: Where there is nature of work may involves exposure to hazardous substances/ dirt etc, suitable washing facilities located at the nearest places must be provided

Place for Resting and Eating: Hygienic place located at fairly away from the noise or other hazards of the workplace where the workers may enjoy their tea breaks/ lunch/ dinner etc. or any other rest breaks.

Exposure to Extreme Temperatures

Depending on the nature of job, the workers may be exposed to extremely hot or cold temperatures. These extreme temperatures may be due to the weather or may be due to nature of the job e.g. Steel Mills worker is exposed to extremely hot temperatures and a cold storage worker is exposed to extremely cold temperature

Effects on Health & Safety due to extremely hot Temperatures

Dehydration: Sweating due to high temperature can lead to dehydration

Skin Burns: Exposure to direct sunlight or touching with a hot source can physically damage a worker

Skin Cancer: Exposure to direct Sunlight over a long period of time may lead to skin cancer as well

Heat Stress: Working in a hot temperature may lead to heat stress i.e. fainting, discomfort etc

Heat Stroke: The worker may become unconscious and suffer extreme fever which if not treated timely and correctly may lead to death

Control Measures against the effects of extremely hot Temperatures

- Eliminate or minimize the work under direct sunlight
- Where elimination or minimizing the work under direct sunlight is not possible, the workers should be provided sufficient work breaks
- Plenty of suitable temperature water should be made available
- Where the extreme temperature is due to some equipment or process e.g. steel furnace/Boiler/ Oven etc then the workers should be provided with suitable clothing
- Automate the process to avoid the presence of workers in the hot area (if feasible)
- Area should be well ventilated
- Shielding of the source (which is generating heat) should be carried out to avoid heat radiation
- Unnecessary persons/processes should be relocated to other areas.
- Cold Havens may be constructed if the nature of job allows to avoid prolonged exposure to extremely hot environment
- Job Rotation should be used as an administrative measure

Effects on Health & Safety due to extremely Cold Temperatures

Frost bite: It is a condition in which localized damaged is caused to skin and tissues due to exposure to extreme cold temperature. In extreme cases of frost bite, the affected area is amputated by the doctors.

Freeze Burns: direct contact with extremely cold surface may result freeze burn injuries.

Slippery Surfaces: The surface may become slippery due to ice and can present slip hazards

Poor Reflex Action: Cold temperatures decrease the energy in the human body and movement of body parts may be slower. This may create a hazard once working near moving parts/ machinery etc.

Hypothermia: Shivering of the body and in extreme prolonged situation, this may result into death

Control Measures against the effects of extremely cold Temperatures

Extreme Cold temperature may be categorized into two parts; Cold temperature due to the weather effects e.g. snow fall or cold temperature due to the nature of job e.g. Cold storage workers. Control Measures can be categorized accordingly:-

a) – Control Measures against Extremely Cold Weather

- Eliminate (If feasible) to work in open areas where extreme cold weather conditions can create hazards
- Minimize the work in open areas where complete elimination is not possible.
- Provide suitable clothing to the workers
- Provide warm drinks and plenty of food to maintain the energy level
- Provide suitable information, instructions and training to the workers to deal with any emergency situation due to cold temperatures
- Proper rest breaks and suitable place for thermal comfort
- The organization must have suitable emergency evacuation and rescue procedure to deal with the hazards of cold temperatures
- Job Rotation may be used as an administrative measure
- Clear Slippery surfaces (Wet/ Icy floors) to avoid slip hazards

b)– Control Measures against Extreme Cold temperature due to Job/ Process/ Equipment

- Following additional measures should be taken along with the control measures suggested above
- Where the extreme temperature is due to some equipment or process e.g. Refrigeration etc. then the workers should be provided with suitable clothing
- Automate the process to avoid the presence of workers in the cold area (if feasible)
- Shielding of the source (Which is generating cooling) should be carried out
- Unnecessary persons/processes should be relocated to other areas.
- Provide frequent rest breaks and access to warm refuges during the breaks
- Thermally comfortable haven may be constructed if the nature of job allows to avoid prolonged exposure to extremely cold environment

Element 2

Assess and apply basic principles of Physics at the workplace for occupational health and safety

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