Industrial Hygiene & Occupational Health

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Content

1. Industrial Hygiene & Occupational Health – An Overview

Industrial hygienists analyze, identify, and measure workplace hazards or stresses that can cause sickness, impaired health, or significant discomfort in workers through chemical, physical, ergonomic, or biological exposures. Two roles of the industrial hygienist are to spot those conditions and help eliminate or control them through appropriate measures.

ANTICIPATION – this involves identifying potential hazards in the workplace before they are introduced.

RECOGNITION - this involves identifying the potential hazard that a chemical, physical or biological agent - or an adverse ergonomic situation - poses to health.

EVALUATION of the extent of exposure to the chemical hazards, physical or biological agents (or adverse ergonomic situation) in the workplace. This often involves measurement of the personal exposure of a worker to the hazard/agent in the workplace, particularly at the relevant interface between the environment and the body, e.g. breathing zone, hearing zone, and assessment of the data in terms of recommended occupational exposure limits (OELs), where such criteria exist

CONTROL of the chemical, physical or biological agent - or adverse ergonomic situation, by procedural, engineering or other means where the evaluation indicates that this is necessary.

Occupational health deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards. The health of the workers has several determinants, including risk factors at the workplace leading to cancers, accidents, musculoskeletal diseases, respiratory diseases, hearing loss, circulatory diseases, stress related disorders and communicable diseases and others. Employment and working conditions in the formal or informal economy embrace other important determinants, including, working hours, salary, workplace policies concerning maternity leave, health promotion and protection provisions, etc

Historical Highlights

370 BC	Hippocrates identified lead poisoning in miners and metallurgists
1700 AD	Ramazzini, “father of occupational medicine”, published “Diseases of Workers” and introduced the question, “Of what trade are you?”
1900 AD	Dr. Alice Hamilton investigated dangerous occupations, first woman faculty member at Harvad University, wrote “Exploring the Dangerous
1914 AD	IPSHS organized Division of Industrial Hygiene and Sanitation. Americal Public Health Association organized industrial hygiene section
1922 AD	Harvard University established industrial hygiene degree programme
1939 AD	AIHA organized. ACGIH prepared first list of maximum allowable concentrations for chemical exposures in industry.
1960 AD	American Board of Industrial Hygiene Organized by AIHA & ACGIH
1970 AD	I.S. Occupational Safety and Health Act adopted
1981 AD	Professional Code of Ethics adopted by U. S. industrial hygiene associations

Job Hazards : To be effective in recognizing and evaluating on-the-job hazards and recommending controls, industrial hygienists must be familiar with the hazards' characteristics. Potential hazards can include air contaminants, and chemical, biological, physical, and ergonomic hazards.

I) Air Contaminants : These are commonly classified as either particulate or gas and vapor contaminants.

The most common particulate contaminants include dusts, fumes, mists, aerosols, and fibers. Dusts are solid particles generated by handling, crushing, grinding, colliding, exploding, and heating organic or inorganic materials such as rock, ore, metal, coal, wood, and grain.
Fumes are formed when material from a volatilized solid condenses in cool air. In most cases, the solid particles resulting from the condensation react with air to form an oxide.

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

Aerosols are also a form of a mist characterized by highly respirable, minute liquid particles. Fibers are solid particles whose length is several times greater than their diameter, such as asbestos. Gases are formless fluids that expand to occupy the space or enclosure in which they

are confined. They are atomic, diatomic, or molecular in nature as opposed to droplets or particles which are made up of millions of atoms or molecules. Through evaporation, liquids change into vapors and mix with the surrounding atmosphere. Vapors are the volatile form of substances that are normally in a solid or liquid state at room temperature and pressure. Vapors are gases in that true vapors are atomic or molecular in nature.
The chemicals used or produced in an industrial operation generally disseminate into the air depending on the process. These can be classified according to their physical states.

A.	Gases and Vapours	Common examples are : Sulphur dioxide, carbon monoxide and hydrogen cyanide gases, and the vapours of tri-benzene, xylene etc.
B.	Particulate matter	
	i) Dust	These are solid particles produced by grinding, crushing, drilling and blasting operations and are suspended in the air. The size of the particles are predominantly higher than 0.2 micron.
	i) Fumes	These are solid particles generated by condensation, generally after volatilization from melted substances and often accompanied by oxidation. The particles size varies from 0.2 to 1 microns. Common examples are lead and zinc fumes.
	ii) Mists	Dispersion of liquid particles in air. These are generally formed by the condensation of water vapour on sub-microscopic particles or by the atomization of liquids. Mist of sulphuric acid is an example of this dispersion.
	iv) Smokes	Small gas borne particles (diameter is less than 0.3 micron) resulting from incomplete combustion and consisting predominantly of carbonaceous material are grouped in this category.
		Apart from these, the air contaminants may be present in forms of smog and fog which are not usually encountered in an industrial environment.

Chemical Hazards : Harmful chemical compounds in the form of solids, liquids, gases, mists, dusts, fumes, and vapors exert toxic effects by inhalation (breathing), absorption (through direct contact with the skin), or ingestion (eating or drinking). Airborne chemical hazards exist as concentrations of mists, vapors, gases, fumes, or solids. Some are toxic through inhalation and some of them irritate the skin on contact; some can be toxic by absorption through the skin or through ingestion, and some are corrosive to living tissue. The degree of worker risk from exposure to any given substance depends on the nature and potency of the toxic effects and the magnitude and duration of exposure. Information on the risk to workers from chemical hazards can be obtained from the Material Safety Data Sheet (MSDS) and requires be supplied by the manufacturer or importer to the purchaser of all hazardous materials. The MSDS is a summary of the important health, safety, and toxicological information on the chemical or the mixture's ingredients. Other provisions of the Hazard Communication Standard require that all containers of hazardous substances in the workplace have appropriate warning and identification labels.

The chemicals may be classified into the following groups according to their effect on human body:

i) Irritant
ii) Asphyxiant
iii) Chemicals causing lung damage
iv) Systematic
v) Central nervous system toxicant
iv) Carcinogen, mutagens

Irritants

There are number of chemicals which are very frequently used in industries many cause irritation to the eyes, nose, throat and mucus membrane. These are commonly referred to as upper respiratory tract irritant. Examples are ammonia, sulphur-di-oxide, formaldehyde etc.

There are certain chemicals which may also cause lower respiratory tract irritation and many lead to pulmonary oedema. Common examples are chlorine, phosgene, sulphur-tri-oxide etc. These gases should be handled very carefully and any leakage of gas should be effectively controlled. Canister gas mask or self-contained breathing apparatus should be used wherever necessary. Emergency first aid should be given immediately if any body falls victim to any of these gases.

Asphyxiates

Gases like nitrogen, carbon-di-oxide, methane, propane, butane etc. may cause simple asphyxiation by limiting the availability of oxygen. Normal air contain 20% oxygen. If the oxygen concentration in the air comes down to below 16%, it may lead to death.

In industries there may be number of confined space or partially confined space where the atmosphere may be deficient in oxygen or may contain highly toxic chemicals contaminants. Also the confined space may contain some gases like nitrogen, carbon-di-oxide etc. in sufficiently high concentration which can limit the availability of oxygen. Under such circumstances, the workers often fall victim to these gases. Hence it is always recommended that before entering into a confined space the oxygen percentage in the space should be determined.

There are certain chemicals like carbon-monoxide gas and hydrogen cyanide gas which act chemically inside the body and lead to chemical asphyxiation. Death may result immediately after exposure to high concentration of these gases. Carbon monoxide reacts with haemoglobin forming a complex car boxy haemoglobin and thereby interferes in the oxygen transport mechanism. The victim of co-poisoning die due to deficiency of oxygen inside the body. Cyanide also cause chemical asphyxiation. Carbon monoxide is a common poison in iron and steel industry particularly, in coke oven and blast furnace gases, in industrial gas plant, in automobile exhaust, in public garages etc.

Cyanide salts are used in heat treatment, electroplating and in many other chemical reactions. Extreme care should be taken while handling these chemicals. Good ventilation, safe and suitable personal protective equipment, are recommended while handling these chemicals. Periodical environmental monitoring should be conducted to ensure that the levels of these gases are maintained within the recommended permissible exposure limits. Cyanide anti-dote kit should be made available in the factory.

Occupational Lung Disorders

Occupational lung diseases are mostly by exposure to dust and fibre. Sometimes, it is caused by exposure to toxic gases also. Respirable dust (5-10 μ dia) when inhaled, it goes to the lung and remains there for a long time. Repeated and prolonged exposure to dust leads to ‘fibrosis’ or ‘scar’ tissue formulation in the lung. Once the lungs are affected, the functions of the lungs reduced considerably. The persons afflicted with this disease suffer from breathlessness, tightness in the chest, chest pain, dyspnoea etc. The lung function capacity becomes very much limited and the persons become tired and exhausted with the little work. There is no effective treatment for any dust disease. However, if the disease is diagnosed at an early stage like may be prolonged, otherwise the conditions become worse. Once the lung is damaged, the person becomes very much susceptible to any of the infections.

Systemic Poisons

Certain chemicals after being absorbed in the blood stream are carried to different organs of the body. These chemicals cause systemic poisoning in the body depending on their chemical nature and dose. Example are lead, mercury, manganese, chromium, cadmium etc.

Lead

Lead is being used in various industries for a long time as a metal, oxides and other combined forms. In India, the use of lead is mainly in industries like accumulator battery manufacture, printing press, type casting boundaries and soldering. Exposure to lead most commonly occurs where reclamation of lead painted metal scraps and other lead containing scrap is done and also when metallic lead is heated beyond its melting point. Various other operation like molten lead baths, burning of lead points and plumbing with lead joints can evolve much fume in confined spaces. Tetra ethyl lead which is mixed with petrol in refineries may enter the body through skin contact apart from inhalation of the vapour.

Repeated and prolonged exposure to high concentration of lead may lead to an occupational disease known as “Lead Poisoning”. Lead interferes in the blood forming system, gastro-intestinal system, central and peripheral nervous system, reproductive system. Stippled cells (immature red calls) appear in blood in lead poisoning cases. Abortion and still birth have been reported among women employed in lead industries.

Control of lead exposure can be done by providing local exhaust ventilation, controlling the temperature of lead bath and use of suitable personal protective equipment.

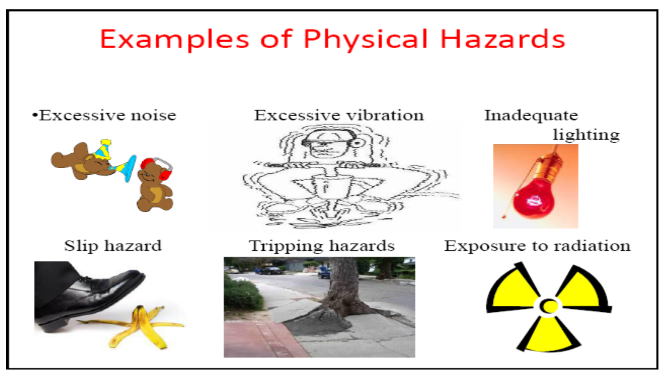
CNS Toxicants

Most of the poisonous gases and vapours affecting central nervous system produced acute narcotic symptoms in similar ways. Chemicals which affects the central nervous systems are :

- Alcohols
- Petroleum Hydro-carbons
- Halogenated Hydrocarbons
- Carbon-di-sulphide
- Hydrogen Sulphide etc.

Biological Hazards : These include bacteria, viruses, fungi, and other living organisms that can cause acute and chronic infections by entering the body either directly or through breaks in the skin. Occupations that deal with plants or animals or their products or with food and food processing may expose workers to biological hazards. Laboratory and medical personnel also can be exposed to biological hazards. Any occupations that result in contact with bodily fluids pose a risk to workers from biological hazards. In occupations where animals are involved, biological hazards are dealt with by preventing and controlling diseases in the animal population as well as properly caring for and handling infected animals. Also, effective personal hygiene, particularly proper attention to minor cuts and scratches especially on the hands and forearms, helps keep worker risks to a minimum. In occupations where there is potential exposure to biological hazards, workers should practice proper personal hygiene, particularly hand washing. Hospitals should provide proper ventilation, proper personal protective equipment such as gloves and respirators, adequate infectious waste disposal systems, and appropriate controls including isolation in instances of particularly contagious diseases such as tuberculosis.

Physical Hazards : These include excessive levels of ionizing and non-ionizing electromagnetic radiation, noise, vibration, illumination, and heat stress. In occupations where there is exposure to ionizing radiation, time, distance, and shielding are important tools in ensuring worker safety.



Danger from radiation increases with the amount of time one is exposed to it; hence, the shorter the time of exposure the smaller the radiation danger. Distance also is a valuable tool in controlling exposure to both ionizing and non-ionizing radiation. Radiation levels from some sources can be estimated by comparing the squares of the distances between the worker and the source. For example, at a reference point of 10 feet from a source, the radiation is 1/100 of the intensity at 1 foot from the source. Shielding also is a way to protect against radiation. **The greater the protective mass between a radioactive source and the worker, the lower the radiation exposure**. In some instances, however, limiting exposure to or increasing distance from certain forms of non-ionizing radiation, such as lasers, is not effective. For example, an exposure to laser radiation that is faster than the blinking of an eye can be hazardous and would require workers to be miles from the laser source before being adequately protected. Shielding workers from this source can be an effective control method.

Noise, another significant physical hazard, can be controlled by various measures. Noise can be reduced by installing equipment and systems that have been engineered, designed, and built to operate quietly; by enclosing or shielding noisy equipment; by making certain that equipment is in good repair and properly maintained with all worn or unbalanced parts replaced; by mounting noisy equipment on special mounts to reduce vibration; and by installing silencers, mufflers, or baffles. Substituting quiet work methods for noisy ones is another significant way to reduce noise-for example, welding parts rather than riveting them. Also, treating floors, ceilings, and walls with acoustical material can reduce reflected or reverberant noise. In addition, erecting sound barriers at adjacent work stations around noisy operations will reduce worker exposure to noise generated at adjacent work stations. It is also possible to reduce noise exposure by increasing the distance between the source and the receiver, by isolating workers in acoustical booths, limiting workers' exposure time to noise, and by providing hearing protection.

Noise has been described as undesired sound. Normal permissible limit for 8 hours continuous exposure has been recommended to be maximum of 90 dBA. In situations where the noise level is high workers get ill effects.

Auditory ill effects

- Temporary hearing loss
- Permanent hearing loss

Non auditory ill effects

- Speech interference
- Variation in blood pressure
- Dilatation of pupils
- Diseases like peripheral vascular disturbance, I.D.H., vascular neuropathy, sympathy, etc.

Noise Control Measures

- Solid foundation of machines and use of rubber padding.
- Proper maintenance of machine
- Installation of suitable sound absorbers
- Lining of walls and ceiling by a-caustic boards
- Use of personal protective equipment
- Introduction of hearing conservation programme.

Heat Stress

Effects of heat stress

On physiological system, increased heat stress leads to several well documented reactions in the human system.

a) The stress on the cardio-vascular system increases with the ambient temperature. The greatest stress was observed when the work was performed in an environment combining high temperature and high humidity.
b) Heart rate during work and recovery varies according to work load and ambient temperature.

c) Blood pressure does not affect by increased ambient temperature. d) Pulmonary ventilation, oxygen consumption and oxygen debt are affected little by ambient temperature. e) Warm-dry surroundings are more favorable to aerobic work than warm humid conditions and reduce the anaerobic processes. f) Sweat loss is greatest under warm-dry environment; under warm - humid conditions evaporative cooling is impaired and body temperature rises appreciably.	

Failure of body to adjust the heat stress produces disorders by (a) Depletion of salt due to profuse sweating and (b) rise in body temperature due to the failure of the normal thermo-regulatory mechanism.

Disorder are –

(1) Systematic
- heat stroke
- heat exhaustion
- heat syncope
- heat cramp
- dehydration

(2) Skin
- prickly heat –
- cancer – Rodent ulcer

(3) Psychoneurotic :
- heat fatigue
- loss of emotional control

On Performance

The effects of high ambient temperature and humidity on the different aspects of performance are many. The remarkable ones may be summarized as follows :

a) Visual and auditory vigilance tasks are affected by temperatures as high as 30 to 50^{o}C.
b) Factual sensitivity decreases at both the high and low temperature extreme.
c) Grip strength decreases at extreme high and low temperatures.
d) Physical performance decreases with increased temperature.
e) Number of errors increased with high ambient temperature and relative humidity.
f) Mental performance showed no decrement in increased temperature.

Heat Control Measures

In order to reduce the thermal load and prevent the workers from the over exposure of increased heat stress, it is required to control the environment and/or to prevent the workers from such exposure by applying appropriate control measure technique.

These Basic Principles are involved :

i) Insulation
ii) Ventilation
iii) Shielding of source co-operator
iv) Substitution of cool for hot processes
v) Job modification
vi) Work rotation
vii) Reduction of humidity and exposure time
viii) Protective clothing

Where there is a need to wear protective clothing, it should be kept in mind that such clothing may interference with freedom of movement and affect co-ordination, particularly in emergency situation. Factors which should be considered at the design stage are :

i) Heat output from the plant and process
ii) Type of work pattern and
iii) Local weather conditions

The following methods have been adopted to control the personnel exposed to heat.

i) Provide ample supplies of cool water.
ii) Provide extra salt where required.
iii) Ensure lightweight loose fitting clothing.
iv) Ensure quickest development of acclimatization.
v) Where possible, do not employ men in hot conditions if they are (a) obese, (b) suffering from any cardiovascular disease (c) over 45 years of age (d) physically unfit (e) Suffering from any skin disease.
vi) If necessary modify the work and rest routine.
vii) Rest period should be taken in cool surrounding.
viii) In extreme conditions :
    (a) Wear ventilated suit.
    (b) Be pre-cooled by immersion in cool water.
    (c) Be cooled down by spraying them with cool water.
ix) While there is a case of heat stroke or heat hyperpyrexia :
    (a) Place the stripped and unconscious patient in a tub or bath filled with ice chips and water, the rectal temperature is checked every three minutes or so and transfer the patient to bet in cool room when it has falled to $38.9^{o}C$. Throughout cooling, the body surface and particularly the limbs are massaged vigorously to promote good circulation of blood.

Illumination :

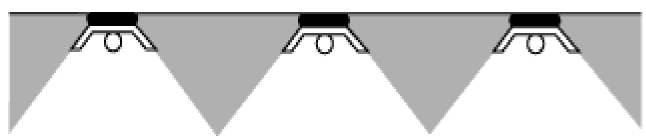
Clear Walkway

Optimum lighting of the workplace provides not only a comfortable and safe visual working environment but also which permits maximum potential and quality of work. To determine whether the visual environment is adequate for safety, comfort, on the performance of particular tasks, an examination of the lighting requirements for each work area is required. This process would invoke.

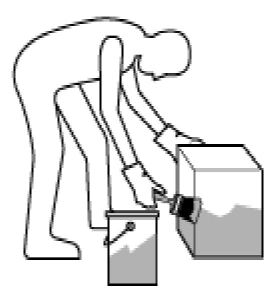
(i) details of the particular job - such as size, in contrast with the background, time required to see the task, and the need for direct on diffused illumination;
(ii) details such as dimensions of the area, reflectance of the surface, source of light (both daylight and artificial), sources of glare, uniformity of illumination, colors of walls, ceiling, floors and equipment, presence of excess contrasts, brightness;.
(iii) Details of luminaries - such as tube, placement and condition,
(iv) The suitability of light fixture in hazardous locations where flammable gases, solvent vapors and explosive dust may be present, and
(v) Details of maintenance and service procedures for lights and ceilings, walls and work bench surfaces.

The luminance is measured with the light-meter or lux meter. The cell type instruments should be used which are cosine and colour-corrected. Before taking the readings, the cells should be exposed to the approximate illuminance to be measured until they become stabilized.

Control :



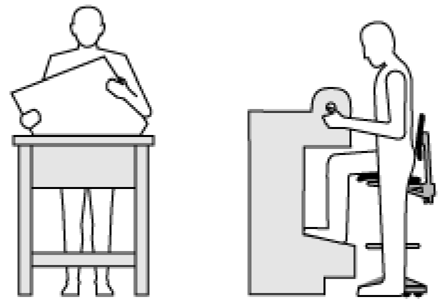
General Lighting



Lighting conditions which are unsuitable for a particular task can be improved by appropriate methods. There include the optional use of artificial light, daylight and colour in both in evasive workplaces and in the design of new premises. In addition to providing suitable lighting conditions, the workplace should be maintained with respect to the following :

(i) regular cleaning of lamps and luminaires to remove dirt and dust which reduce output.
(ii) Cleaning of workplace surfaces - such as bench tops , floors and walls - to remove dirt which devours their reflectance;
(iii) Regular cleaning of windows to remove dirt which might reduce the amount of daylight entering the workplace, and
(iv) Replacement of lamps as soon as

they reach the end of their useful life. The light output of a fluorescent or discharge lamp may devours a great deal before if burns out.



Regular lighting maintenance ensure not only employee safety and comfort but also the most economical use of lighting equipment.

Recommended values of Illumination in lux

Canteen	150
Aircraft	300-450
Engine assembly	300
Radio telephone assembly	700
Foundries	150-300
Iron & steel works	100-300
Steel metal works	200

Defective Colour Schemes

No lighting scheme can be fully effective without the proper colour application. In industries colour are used for improving (a) Quality of workmanship (b) to reduce rejection (c) to reduce accidents (d) to rise house keeping (e) to reduce absenteeism, and (f) to improve morale of the workers. Adverse effects of colour on health of the people are mainly through its psychological effects. Each colour gives a special psychological appreciation on the human and moderates the behaviour accordingly. If this is not in the proper shape ill effects increase.

Temperature
Red & Yellow Warm feeling, Blue & Green Cool Feeling.
These points have to be kept in mind while planning the workplace so that the ill effects due to colour does not occur.

Vibration

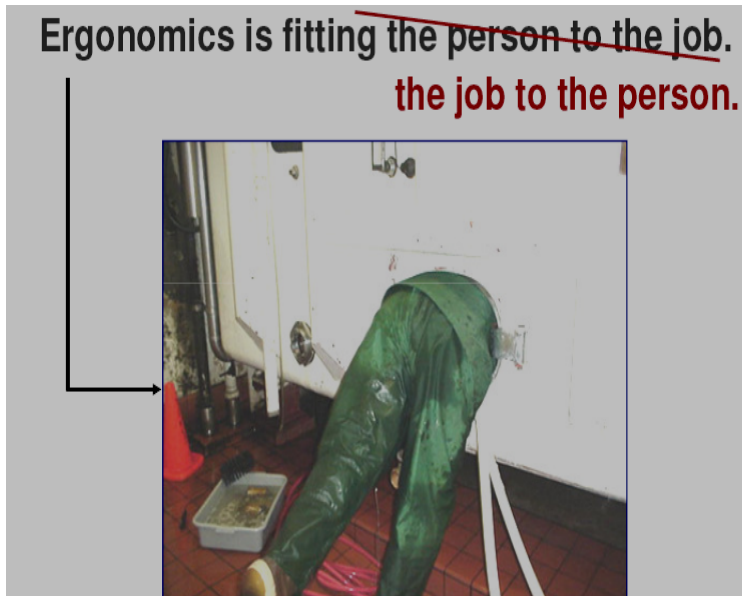
Vibration are causing ill effects in the range of 30 -400 Hz. Under 3 Hz the whole vibrates and ill effect is mainly motion sickness. In industrial situations the ill effects are usually due to continuous handling of vibrating tools. The disorders appears due to local irritant and damaging action on the tissue and on the receptors embedded in them. Effect depends on the physical characteristics of the oscillating process and the duration of conduct.

Vibration Disease

Prolonged exposure to vibration leads to this disease which manifest in “White Finger” due to vascular insufficiency when the factor is affecting locally. If the whole body vibrates changes like polyneuritis appears.

To prevent this disease and related ill effect automation and remote control system should be introduced. The environmental permissible value of vibration should be maintained and medical control like pre-employment and periodic examination should be carried out.

Ergonomic Hazards :



The science of ergonomics studies and evaluates a full range of tasks including, but not limited to, lifting, holding, pushing, walking, and reaching. Many ergonomic problems result from technological changes such as increased assembly line speeds, adding specialized tasks, and increased repetition; some problems arise from poorly designed job tasks. Any of those conditions can cause ergonomic hazards such as excessive vibration and noise, eye strain, repetitive motion, and heavy lifting problems. Improperly designed tools or work areas also can be ergonomic hazards.
Repetitive motions or repeated shocks over prolonged periods of time as in jobs involving sorting, assembling, and data entry can often cause irritation and inflammation of the tendon sheath of the hands and arms, a condition known as carpal tunnel syndrome. Ergonomic hazards are avoided primarily by the effective design of a job or jobsite and by better designed tools or equipment that meet workers' needs in terms of physical environment and job tasks. Through thorough worksite analyses, employers can set up procedures to correct or control ergonomic hazards by using the appropriate engineering controls (e.g., designing or redesigning work stations, lighting, tools, and equipment); teaching correct work practices (e.g., proper lifting methods); employing proper administrative controls (e.g., shifting workers among several different tasks, reducing production demand, and increasing rest breaks); and, if necessary, providing and mandating personal protective equipment. Evaluating working conditions from an ergonomics standpoint involves looking at the total physiological and psychological demands of the job on the worker. Overall, industrial hygienists point out that the benefits of a well-designed, ergonomic work environment can include increased efficiency, fewer accidents, lower operating costs, and more effective use of personnel.

2. Occupational Exposure Limits

The main task of Occupational Hygiene is to protect the health of working population. Among the first practical measures is determination of any dangerous, harmful, i.e. toxic substances in the atmosphere of work environment. After determination of the present concentration at given working place, the nest, natural step, must be evaluation of the obtained results against a national or international exposure limits standards.

Permissible level of chemical substances in work environment.

The exposure limits related to the pollution of work place environment should safeguard the health as it was defined in the constitution of World Organization as a "State of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.

The usefulness of the concept of exposure limits of toxic agents in the working environment has been adequately demonstrated in many practical situations, in which there have been a significant reduction or disappearance of occupational diseases after adequate application of these limits.

"Permissible Level or Limit" has been defined in previous ILO and WHO documents as a quantitative hygienic standard for a level considered to be safe, expressed as a concentration with a defined average time. The term "Permissible Level for Occupational Exposure" can also be taken to mean "Maximum Allowable Concentration (MAC)", or "Threshold Limit Value (TLV)', on " Maximum Permissible Limit or Dose". At present a term "Exposure Limits" is recommended by ILO for chemical substances in the work environment. All mentioned values or standards represent a working place environment limit - the time average concentration of toxic substance in the air under which nearly all workers may be exposed repeatedly for normal work day over a working life time without adverse effect. These value are based on the best available information from industrial experience and experimental studies.

It is necessary to add that a small percentage of workers may experience discomfort from some chemicals and a smaller percentage may be affected more serious by aggravation of a pre-existing condition or by development of an occupational illness at concentrations at or below the limits.

In general, exposure limit (TWA) may be exceeded for short periods without injury to the health of the exposed persons, but there are limitations to this, depending on the following factors :

(a) whether or not the contaminant is a highly toxic, or highly irritating agent,
(b) whether or not its effects are cumulative,
(c) frequency with which high concentration occur,
(d) duration of such periods of high concentrations,
(e) likelihood of acute poisoning resulting from high concentrations.

2.1 Threshold Limits Value

The TLVs are guidelines to be used by professional industrial hygienists. The values presented are intended for use only as guidelines or recommendations to assist in the evaluation and control of potential workplace health hazards and for no other use (e.g., neither for evaluating or controlling community air pollution; nor for estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods; nor for proving or disproving an existing disease or physical condition in an individual). Further, these values are not fine lines between safe and dangerous conditions and should not be used by anyone who is not trained in the discipline of industrial hygiene. TLVs are not regulatory or consensus standards.

Definition of the TLVs

Threshold Limit Values (TLVs) refer to airborne concentrations of chemical substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, over a working lifetimes, without adverse health effects.

Chemical substances with equivalent TLVs (i.e. same numerical values) cannot be assumed to have similar toxicological effects or similar biologic potency. TLVs for each chemical substance (that is, airborne concentrations in parts per million [ppm] or milligrams per cubic meter [mg/m3] and critical effects produced by the chemical substance. These critical effects form the basis of the TLV.

Although TLVs refer to airborne levels of chemical exposure, dermal exposures may possibly occur the workplace.

Three categories of TLVs are specified: time-weighted average (**TWA**);short-term exposure limit (**STEL**); and a ceiling ©. For most substances, a TWA alone or with a STEL is relevant. For some substances (e.g., irritant gases), only the TLV-C is applicable. If any of these TLV types are exceeded a potential hazard from that substance is presumed to exist.

Threshold Limit Value-Time-Weighted Average (TLV-TWA): The TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect. Although calculating the average concentration for a workweek, rather than a workday, may be appropriate in some instances, ACGIH does not offer guidance regarding such exposures.

Threshold Limit Value-Short-Term Exposure Limit (TLV-STEL): A 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the 8 hour TWA is within the TLV-TWA. The TLV-STEL is the concentration to which it is believed that workers can be exposed continuously for short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, 3) dose-rate-dependent toxic effects, or 4) narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue, or materially reduced work efficiency. The TLV-STEL will not necessarily protect against these effects if the daily TLV-TWA is exceeded. The TLV-STEL usually supplement the TLV-TWA where there are recognized acute effects from substance whose toxic effects are primarily of a chronic nature; however, the TLV-STEL may be a separate, independent exposure guideline. Exposures above the TLV-TWA where there are recognize acute effects from a substance whose toxic effects are primarily of a chronic nature; however, the TLV-STEL may be separate, independent exposure guideline. Exposures above the TLV-TWA upto the TLV-STEL should be less than 15 minutes, should occur no more than four times per day, and there should be at least 60 minutes between successive exposures in this range. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

Threshold Limit Value-Ceiling (TLV-C): The concentration that should not be exceeded during any part of the working exposure. If instantaneous measurements are not available, sampling should be conducted for the minimum period of time sufficient to detect exposures at or above the ceiling value. ACGIH (American Conference of Governmental Industrial Hygienists) believes that TLVs based on physical irritation should be considered no less binding than those based on physical impairment. There is increasing evidence that physical irritation may initiate, promote, or accelerate adverse health effects through interaction with other chemical or biologic agents or through other mechanisms.

2.2 Emergency Response Planning Guidelines

ERPGs are intended to be used by persons trained in emergency response planning as planning tools for assessing the adequacy of incident prevention and containment measures undertaken for chemical releases, for transportation emergency planning, and for developing facility site and community emergency response plans. The levels are not to be used to determine safe limits for routine operations, as definitive delineators between safe and unsafe exposure conditions, or as a basis for quantitative risk assessment.

ERPG levels:

ERPG-1: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experience more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.

ERPG-2: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

ERPG-3: The maximum airborne concentration below which it is believed early all individuals could exposed for up to 1 hour without experiencing or developing life-threatening health effects.

USE AND APPLICATION

Emergency response planning programs generally include accidental release scenarios in which air dispersion models determine concentration isopleths. Programs designed to protect the public from transportation incidents involving chemical materials also use the ERPG™ values. ERPG™ also are important for compliance with the U.S. Environmental Protection Agency's (EPA) Emergency Planning and Community Right-to-know Act (EPCRA.)

Those who use ERPG values include :

- Community emergency planers
- Emergency responders
- Air dispersion modelers
- Industrial process safety engineers
- Community Action Emergency Response (CAER) participants
- Local Emergency Planning Coordinators (LEPCs)
- State Emergency Response Commissions (SERCs)
- Industrial hygienists
- Toxicologists
- Transportation safety engineers

- Fire protection specialists
- Government agencies
- Risk assessors and risk managers
- Resource Conservation and Recovery Act (RCRA) managers

ERPG can be used with dispersion models, together with other information such as inventory storage volumes and atmospheric conditions, to provide computerized estimates of the potential spread and airborne concentration in case of a release. From these estimates action plans can be developed. The plans may vary for any given emergency depending on such things as population density, type of population (e.g. schools, elderly), terrain, weather conditions, and the nature of the release. Using estimated release rates, the physical and chemical properties of the products released, and meterological data, the dispersion modeling methods generate estimated distances and time of arrival for ERPG concentrations.

3. Toxicology

Toxicology is the study of the adverse effects of substances on living organisms. Industrial toxicology is concerned with the adverse effects on workers of substances handled in the workplace, although interest usually extends to adverse effects of products on consumers and of workplace effluents on the general public. Historically toxicology was the art and science of poisoning. It is today a discipline which makes use of information developed by a wide range of chemical, physical, biological and medical sciences in order to predict the likely adverse effects on man of an ever-increasing range of substances to which he is exposed.

Terms

Toxicity is the innate ability of substances to injure living things.

Hazard assessment is the prediction of the toxic effects that will be evident under defined conditions of exposure.

Risk assessment is the prediction of the probability that defined toxic effects will occur under defined conditions of exposure in a single person or a defined population.

Substance covers a wide range of materials including single chemical compounds or mixtures of these, simple or complex naturally occurring or synthetically produced substances and micro-organisms. Substances may be chemically pure or contain additives or impurities and may be in the form of solids, liquids, gases, dusts, fibres, fumes or aerosols. Some (e.g. fumes, dusts and aerosols) may be difficult to identify. Substances to which man might be exposed in the workplace include materials used, packed, collected, stored, handled, disposed of or otherwise encountered. They may be final products, formulations, intermediates, components, 'off spec' products, by-products, wastes and residues. They may be materials used or which arise during maintenance or repair of plants or buildings or they may be formed or used during research, development or testing.

Different individuals may react differently to substances: Some people who smoke develop lung cancers; others do not. Penicillin is harmless to most people but produces severe allergic reactions in others. The toxic effects of a substance depend upon:

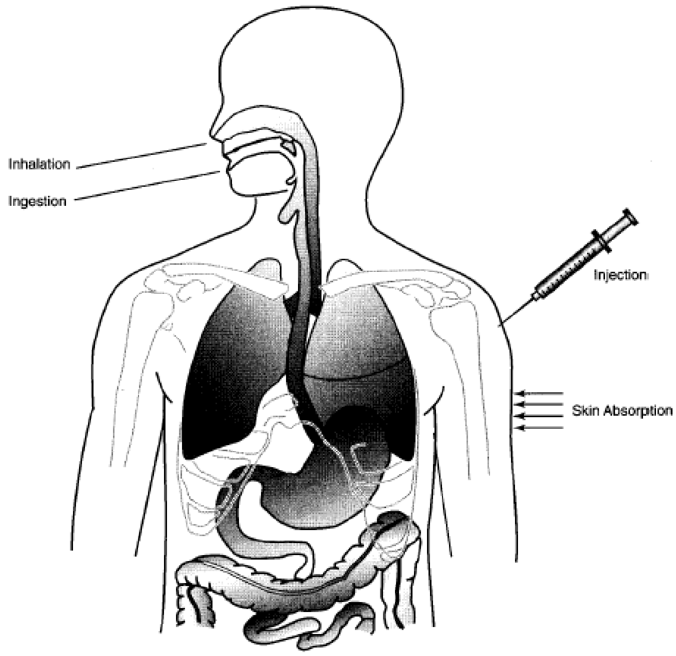
1. Its physical form.
2. The dose.
3. The route of entry.
4. Its absorption, distribution, metabolism and excretion.

Physical Form :

1.Solids - When ground or crushed, dusts result and can be inhaled, ingested or contaminate the skin. Liquids Can be swallowed or contaminate the skin .Gases, Vapours, Fumes ,Mists & Aerosols Can be inhaled or contaminate the skin.

2. Dose is the product of concentration of the substance and duration of exposure to it. In simple terms it may be described as: Dose = Exposure x Time

3. **Route of entry / absorption** : The four main routes of entry of toxins into the body are via inhalation, the skin , ingestion and injection



Ingestion: Ingestion is the least significant route of entry in industry while in environmental toxicology it is the most. During evolution, mechanisms have developed in the gut to regulate the uptake of essential elements. Toxic elements may have to compete so that generally only a fraction of any ingested dose is absorbed into the body (often 10% or less). Possible causes of ingestion in industry are mouth pipetting in laboratories, swallowing dust which has been inhaled and cleared by the mucociliary escalator, smoking and eating at the workstation or simply having dirty hands where the hand later comes in contact with the mouth.

Inhalation: In the lung there are no similar mechanisms for selective uptake. Particles less than 10 micron in diameter may reach the alveoli. If soluble, approximately 40% are then absorbed. Insoluble chemicals are relatively safer, for example lead sulphide, whereas lead carbonate is highly soluble and causes poisoning quickly. Larger inhaled particles are less of a risk as absorption higher up the respiratory tract is less efficient. It is important to remember that not only is the lung responsible for the uptake of substances into the body it is also acted on as a target organ. Materials which are not absorbed into the body can remain in the lungs and cause physical and/or chemical damage to them. Inhalation accounts for 90% or so of industrial poisoning.

The Skin: In the skin there is again no selective uptake. Fat-soluble compounds are absorbed readily as are organic solvents. Absorption through healthy intact skin occurs with nitrobenzene, phenol, mercury, and aniline. Absorption of phenol through just a few square inches of intact skin can be lethal. Impervious protective clothing like gloves will increase the rate of absorption if accidental contamination occurs on the inside. Damaged skin also facilitates absorption of toxins.

Response to toxins

The body's response to toxins depends on several variables:

Age :- The elderly and very young tend not to cope well as their metabolic pathways are less efficient than average.

Underlying Illness:- Some conditions, for example diarrhoea or reduced lung function will limit toxic effects by reducing absorption. Others, for example anaemia, would compromise even further the body's response to lead or carbon monoxide.

Medication:- Drugs can affect enzyme systems, increasing or decreasing the effects of toxic substances.

Alcohol :-May compromise liver function and thus detoxification processes.

Smoking:- Smoking potentiates the action of some substances like asbestos.

Individual:- People vary enormously in their responses to external agents, from noise to coal dust, and allergens to chemicals. This is probably a genetic effect.

Type of response :

♣Local effects at the point of entry e.g. irritation, burns.
♣ Allergic reactions e.g. dermatitis, asthma.
♣ Effects on target organs.
♣ Cancer.
♣ Reproductive effects e.g. sterility, abortions.
♣ Teratogenesis - congenital birth defects.
♣ Childhood tumours in offspring of those exposed.

ASSESSMENT OF HEALTH RISKS

Introduction : The primary reason for conducting a workplace assessment is to assess the risk(s) to the health of employees. Where a less than satisfactory situation is indicated there will be an additional requirement:

1. To specify steps to achieve adequate control.
2. To identify any other action that is required.

Hazard and Risk : When undertaking risk assessments, it is important to have a clear understanding of the differences between hazard and risk.

♣A hazard is something that can cause harm if not controlled.
♣ The outcome is the harm that results from an uncontrolled hazard.
♣ A risk is a combination of the probability that a particular outcome will occur and the severity of the harm involved.

Assessment of Health Risks : The process of assessing risks to health can be broadly described by the steps below.

Step 1 : Define the extent of the assessment
Step 2 :Gather Information

Step 3 : Assess Exposure
Step 4 : Identify Actions
Step 5 : Record the Assessment
Step 6 : Carry Out Actions
Step 7 : Review the Assessment (Go to Step 1)

Define the extent of the assessment

At first it is necessary to define the process or activity which is being assessed. This may involve one or more activities as well as one or more workers at a time. It may also be necessary to assess different hazards as part of different assessments, e.g. noise assessments are usually conducted separately from chemical risk assessments as they involve very different approaches. However, when assessing hazards from chemicals such as solvents it is often possible to group any chemicals under one assessment, as they possess similar properties and require similar controls.

Gather Information

An assessment of the health risks in the workplace necessitates an appreciation of a number of factors in the decision making process, including some or all of the following, as appropriate - and therefore as a first step information pertaining to these factors has to be gathered if a meaningful assessment is to be undertaken:

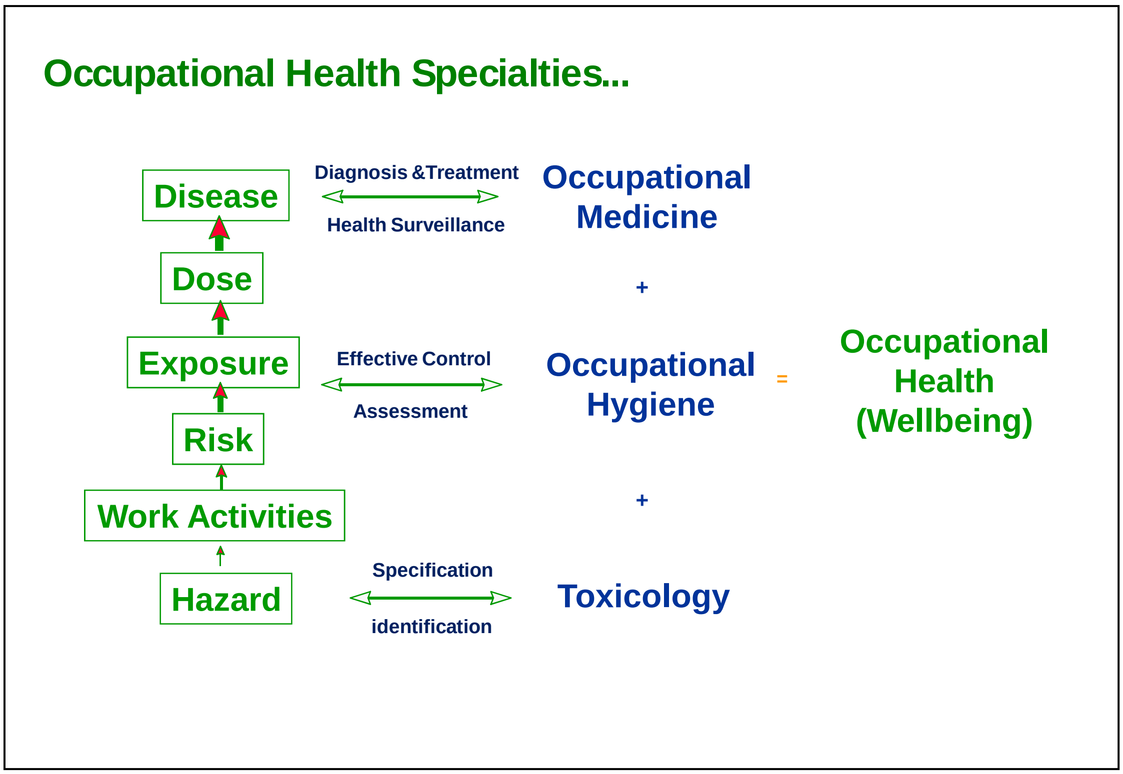
- ♣ The nature of the process or operation, e.g. continuous or batch, indoor or outdoor.
- ♣ The substances used and produced (chemical, biological) plus other agents (noise, radiation) and factors (ergonomic) present. For the substances, some may be expressed as trade names and their chemical composition will need to be understood.
- ♣ It is also important to remember that most industrial exposures to chemicals (inhalation, skin contact) are to mixtures, not to single substances. In these cases, information about the mixture composition will need to be known.
- ♣ The form of the substances (gases, vapours etc.) and other agents plus a knowledge of where these are present in the workplace location/task undergoing assessment.
- ♣ Work/shift pattern.
- ♣ The recommended operating practices and precautionary measures (incl. engineering control).
- ♣ Worker health experiences, e.g. check whether there are/have been any cases of occupational ill-health, incidents, complaints or compensation claims.

Any other relevant information there is a need, for example, to put observations, data etc., in perspective and to ascertain how typical they are as compared to 'normal' practices and procedures. The existence of inventories/registers of substances, non-chemical agents (e.g. noise and radiation sources) and the types of job undertaken can be extremely useful in progressing an assessment.

The availability of relevant sources of information can also be of considerable advantage, e.g. Material safety data sheets (MSDS).

- ♣ Manufacturers' labeling.
- ♣ TLV documentation.

Assess the Health Risk(s) Having gathered all the relevant information, the actual assessment is now carried out. This involves keen inquiry and observation, for example, in relation to the operating practices and precautionary measures actually adopted in a specific task, and, where necessary, environmental measurement (e.g. personal exposure monitoring). Remember to ask about the existence and application of a work permit system and to check the scope and effectiveness of its application from a health protection viewpoint. An assessment should be 'suitable and sufficient'. Clearly, therefore, it should be conducted by a 'competent person' and the type of individual that constitutes such a person will vary from one workplace to another. In some cases the assistance of a fully qualified occupational hygienist will be necessary because of the more complex nature of the risk(s) being investigated. A critical point to be appreciated is that the term 'assessment' is not synonymous with the 'measurement' or 'monitoring' of occupational exposures. On the other hand, the findings from measurements of occupational exposures to chemical, physical or biological agents in the workplace may form an important element of the overall assessment.



Recognizing and Controlling Hazards : Industrial hygiene recognize that engineering, work practice, and administrative controls are the primary means of reducing employee exposure to occupational hazards.

Engineering controls minimize employee exposure by either reducing or removing the hazard at the source or isolating the worker from the hazard. Engineering controls include eliminating toxic chemicals and substituting non-toxic chemicals, enclosing work processes or confining work operations, and the installation of general and local ventilation systems.

Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice controls include :

1. Changing existing work practices to follow proper procedure that minimize exposures while operating production and control equipment.
2. inspecting and maintaining process and control equipment on a regular basis;
3. implementing good housekeeping procedures;
4. providing good supervision; and
5. mandating that eating, drinking, smoking, chewing tobacco or gum, and applying cosmetics in regulated areas be prohibited

Administrative controls include controlling employees' exposure by scheduling production and tasks, or both, in ways that minimize exposure levels. For example, the employer might schedule operations with the highest exposure potential during periods when the fewest employees are present. When effective work practices or engineering controls are not feasible or while such controls are being instituted, appropriate personal protective equipment must be used. Examples of personal protective equipment are gloves, safety goggles, helmets, safety shoes, protective clothing, and respirators. To be effective, personal protective equipment must be individually selected, properly fitted and periodically refitted; conscientiously and properly worn; regularly maintained; and replaced, as necessary.

4. Workplace Monitoring

It may be necessary to obtain some monitoring data, particularly regarding exposure levels, as part of the overall assessment of health risks. Where workplace monitoring is required, the aim is to assist in ensuring the health protection of employees and the sampling strategy adopted should be appropriate to the basic reason for the type of survey to be conducted. The latter ranges from initial monitoring of a plant or operation, in order to establish a 'baseline' situation, to the periodic monitoring of a plant or operation in order to check, at regular intervals, that acceptable conditions are being maintained.

The following are the types of factor that should trigger such a further assessment of the health risks:

1.The substances/agents involved and/or their sources.
2. The plant e.g. modified engineering control.
3.The process or method of work.
4. The volume or rate of production.

♣ Adverse results from: Personal exposure monitoring.
♣ Health surveillance monitoring (e.g. audiometry, biological monitoring).
♣ Monitoring of process control (e.g. fugitive emissions)

Worksite Analysis : A worksite analysis is an essential first step that helps an industrial hygienist determine what jobs and work stations are the sources of potential problems. During the worksite analysis, the industrial hygienist measures and identifies exposures, problem tasks, and risks. The most-effective worksite analyses include all jobs, operations, and work activities. The industrial hygienist inspects, researches, or analyzes how the particular chemicals or physical hazards at that worksite affect worker health. If a situation hazardous to health is discovered, the industrial hygienist recommends the appropriate corrective actions.

4.1 Occupational Hygiene Survey for Chemical Substances

The purpose of occupational hygiene survey is to ensure healthy working condition and safe work place for employees. It includes recognition, evaluation, and control occupational health hazards associated with manufacturing process at a work place. Such studies are scientific investigations, conducted within the premises of industrial establishments to determine the nature and magnitude of health hazards that may adversely affect the well being of the persons employed. The basic components of occupational hygiene survey incorporate the following steps.

1. Collection of essential information with regard to industrial operations, process of manufacture, types of raw materials used and products, etc.
2. A thorough inspection and critical observation of workplace, nature of work, method of operations, system safety, safety practices, and unsafe condition and acts.
3. Sampling & evaluation of air borne contaminants.
4. Inspection & evaluation of reliability & effectiveness of existing control measures to minimize hazards.
5. On the basis of observations made and findings obtained, recommendations to improve the workroom environment and minimize health hazards.

Types of Survey :

The occupational hygiene survey may be broadly divided into two categories.

(a) Unidisciplinary Study :

Unidisciplinary studies are undertaken to monitor the level of stresses and magnitude of exposure to various health hazards by direct method of monitoring the work room environment using only Industrial Hygiene Techniques.

(b) Multidisciplinary Studies :

Multidisciplinary studies should aim at to evaluate the level of exposure, and the extent of harmful effects on exposed persons by air and biological monitoring and medical investigations..

Preliminary Investigation :

Before an occupational hygiene survey is undertaken to monitor the work room environment, basic information is collected by making a personal visit to the concerned industrial establishment for detailed planning of the technical investigations.

(a) Plant building and lay out : A blueprint of the factory lay out should be seen at the time of visit to the plant. Any modification or expansion in the industrial operations and processes should be checked, compared & discussed with the management.

(b) Data Collection : The preliminary investigation should include general information the plant such as year of establishment, total number of workmen, number of shifts, timing and duration of shifts, number of workmen in various categories and sections or units, size of the plant and its sections, organizational structure, first aid facilities, fire fighting devices, safety set up, plant medical services, personal protective equipment issued by the management to different categories of workmen and the existing engineering control measures for minimizing the harmful exposures (Pl. see Annexure - I)

(c) Manufacturing Process and Industrial Operations : A flow diagram of manufacturing process should be obtained from the management and at the shop floor, the actual operations should be observed and noted. The names of various raw materials, by-products and products should be collected including their monthly or yearly consumption or production. Examples of by-products of certain industrial operations are given in Annex. -I.

(d) Visual Observations : The Industrial hygienist who make a preliminary visit in the plant should spend (a) considerable time in making a thorough on sight observations of various activities carried out in the plant. Such as material handling transportation of various chemicals from one place to another industrial operations (crushing, grinding, milling, mixing autoclaving etc.) storage system of raw materials and final products, activities of workmen and their normal practices of work, ventilation system, exhaust and scrubbing devices, housekeeping and hygiene conditions. Such observations help in the selection of sampling locations, duration and type of sampling needed personal monitoring and for deciding the recommendations.

Annexure - I

Example of By- Product of Certain Industrial Operation

Operation or process	Example of possible chemical hazard
Welding	Nitrogen Oxides, ozone, metal fumes (metal and flux)
Welding if metal port has been cleaned With chlorinated hydrocarbon	Nitrogen oxides, ozone, fumes, phosgene, HCl.
Contact of nitric acid with organic matter	Nitrogen oxide
Degreasers	Vapours used in the fail, phosgene and HCl If heat or ultravoilet sources are present and Chlorinated hydrocarbon solvents are used.
Contact of acid with metal containing Arsenic as impurity	Arsene
Operations that enable the reaction of Formaldehyde and HCL	BIS- Chloromethyl other.
Hyrolysis of wood, load, fuel oil and And natural etc.	CO, hydrocarbon, sulphur oxides, methanol, acetic acid, nitrogen oxides.
Pyrolysis of plastics	CO, HCN. HCL, Isocyanates, styrene oxides
Spinning operations of viscose rayon	Hydrogen sulphide .

(e) Industrial Waste Treatment and Disposal : It is essential to examine the system of treatment and disposal of industrial waste (solid, liquid or gas) of the concerned plant. Information should be collected regarding the type of waste production per day, methods of treatment, dumping of waste and its disposal or discharge to outside work place. The waste treatment plant, scrubbing devices, and dust collectors etc. should be physically seen and checked for their effective performance.

The above information collected during the preliminary visit to the plant helps industrial hygienist in planning a detailed occupational hygiene survey.

Planning of Survey :

The detailed study on Industrial Hygiene is dependent up on objectives of survey. It may have one or more than one objectives as given below :

i) To assess level of exposure to stress factors and to find whether the exposure is safe or unsafe on the basis of recommended permissible or threshold limit values.
ii) To examine the efficiency of control measures already provided to minimize the level of exposure.
iii) As part of research project on assessing the industrial health hazards and their effects on exposed personnel in a particular type of industrial establishment.

On the basis of the preliminary investigation made in the plant and objectives of the studies the following activities should be decided.

i) Location of Sampling
ii) Number of samples to be collected
iii) Duration of sampling
iv) Method of sampling
v) Selection of sampling equipment
vi) Selection of analytical method
vii) Type of personal monitoring
viii) Type of biological monitoring
ix) Type of medical investigation if required

i) Selection of Sampling Locations :

The location for environmental sampling are selected considering the industrial operation. The location should be nearest to the operator or the work man who is engaged in various jobs in the plant. The sampling locations should be selected at many places under the same work room. In case of airborne contaminant, sample should be collected in the breathing zone of the work man. Noise and heat stress measurement should be taken at the chest height (4 ft. approximately in Indian work situation.)

It is appropriate to select more locations at a particular work place to understand the distribution of contaminants and their pathways in the work room environment. The location should be well defined and distinctly identified to enable the management to understand the level of contaminant at the sampling spot. While mentioning the location, it should also be pointed out that how many operations and which operations were carried out during the air sampling or measurement of physical factors.

ii) Number of Samples :

The number of samples to be collected depends upon the purpose of sampling to a great extent. To calculate the time weighted average exposure of various group of workman , a sufficiently large number of samples need to be collected. In case only the efficiency of a particular control device is to be examined, a less number of samples (3 to 5 numbers) will be sufficient. It is appropriate to collect a minimum of 3 to 5 samples at each sampling spot but more number of samples will definitely provide data on the extent of variation level of air borne contaminants.

iii) Duration of Sampling :

Permissible limit values for chemical and physical agents are based on eight hours daily exposure, therefore, the duration of sampling should continuously maintained for 8 hrs. in every shift . Because of limitations of monitoring equipment and the various operations, the duration may be reduced. It would be more distinct and clear if the sampling heads are changed in every 15 minutes and process of sampling continues for eight hours. It will not only help to understand the eight hours exposure but also depict the short term exposures. In addition, short duration sampling are essential to understand the pattern of increase or decrease in the level of contaminants in workroom environment and also to compare with its ceiling values. Some time the processes or the operations in industry are of intermittent in nature and may be only for a few minutes. To cover such operations, it is essential to keep duration of air sampling limited to the timing of industrial operations.

In few industrial processes running maintenance and preventive maintenance are carried out when the normal production process is in progress. On such occasions, a series of samples should be collected to understand the deviations from normal work situation.

iv) Method of Sampling :

Collection of air samples to evaluate air borne concentration of contaminants, is a specialized field and only trained people should undertake such Job. Various types of sampling methodology are adopted such as instantaneous or grab sampling. Consecutive sampling for partial period and long term sampling by using different types of suction devices. While collecting the samples, precautions should be taken to watch any alteration in suction rate, leakage in the sampling tube or sampling head. Samples should be numbered well and respective locations should be clearly mentioned. Collected samples should be safely stored and transported to laboratory for analysis.

v) Selection of Sampling Equipment :

Selection of equipment is dependent upon the type of sampling required for the study i.e. grab sampling or long term sampling. It is also dependent upon the limitations and availability of equipments in the industrial Hygiene Laboratory. A variety of sampling equipment including direct reading equipment and conventional type of sampling equipment are available. Each sampling equipment for collection of air sample consists of three parts (I) a source of suction (ii) means for measurement of air flow (iii) a sample collector or a trapping device.

Some equipment are also used not only to determine the concentration of air contaminants, but also to detect the presence of comfortable atmosphere and to ascertain sufficient or insufficient Oxygen. In presence of combustible atmosphere, only flame proof equipment should be used for sampling. The equipment taken for field investigation should be strong, light in weight, easy in handling and movement.

vi) Selection of Analytical Methods :

The selection of method for analysis of air sample is dependent upon following factors.

i) Type of contaminant.
ii) Probable concentration of contaminant in collected air sample.
iii) Threshold limit values recommended for the contaminants
iv) Limitation of sampling equipments and duration of sampling.
v) Sensitivity of the analytical method.
vi) Presence of interfering agents in the work-room environment.
vii) Stability of the collected air sample.
viii) Limitation of resources available in the laboratory.

The method of analysis should be easy and rapid with minimum chances of interference and minimum efficiency and sensitivity.

vii) Personnel Monitoring :

The environmental monitoring at various locations in the plant does not always reflect quantitative exposure to the contaminants by various persons engaged on different job in the plant, because of their normal movement from place to place including tea and lunch break. Time Weighted-Average exposure for 8 hrs. duration by an individual person during his shift can only be ascertained by personal monitoring using personal sampler. Personal monitoring is important for various categories of workman including shift incharge, supervisors, skilled, semiskilled and unskilled worker.

Normally a personal sampler consist of a battery operated suction pump hooked on the waist belt of a workman connected to a sampling head fitted on the body of the worker near his breathing zone. Personal samplers are light in weight and to lightly fitted to the body which does not produce any interference in normal work performance.

The personal sampler should be fitted to the exposed person before he starts his job in a particular shift and should be collected back at the end of the shift.

A close observation should always be kept on Sampling head, and it should be replaced if there is any high deposit which can prevent the desired suction rate of the pump and also decrease the absorption or filtration process.

viii) <u>Biological Monitoring</u> :

Biological monitoring is an indirect method for the measurement of exposure to chemicals. Regular Biological monitoring is useful for validation of the environmental findings.

Environmental monitoring gives a picture of present working condition when the survey has been conducted, but it can not indicate the quality of workroom environment which the workmen had been exposed earlier. In this context biological monitoring is a better method of ascertaining the extent of exposure that the worker had in the past especially in the case of metals and their compounds. However, biological monitoring also offer opportunities for error due to the following reasons.

i) Individual Susceptibility
ii) Dietary habits & climatic conditions.
iii) Individual work habits and physical activity
iv) Personal Hygienist condition
v) Age and sex of the workers
vi) Physical ailments and health status
vii) Socio-economic condition.
viii) Use of drug and medicines
ix) Smoking and alcoholic drinks.

The samples in biological monitoring are mostly human excretions or derivatives such as urine, stool, blood, sputum, nails, hair, exhaled air etc. These samples are mostly unstable and as such precautions should be taken in collection, storing, preservation and transportation. Suitable type of sample bottles are selected for storing them and transportation's.

Various types of clinical, pathological and radiological examinations are conducted depending upon the stress factors in the work-environment. Most of the harmful effects of stress factors are known and accordingly details of clinical investigation can be decided. The investigation should be more subjective and objective.

Field Investigation :

The field Survey should be made without any delay after the preliminary visit was made in the plant and necessary information was collected. The field investigation may involve collection of air samples, biological samples, and measurement of efficiency of existing control system. The occupational hygiene survey should be carried out with the co-operation of shop-floor personnel, safety officer, or other officials concerned with the particular work place. It is also desirable that the workman may be made aware about the type of the survey being carried out at their workplace, its importance and benefits for the working group. Their co-operation and involvement will certainly lead to a better and representative sample collection. Foremen or the shop-floor supervisor is a key man who can assist in maintaining the normal conditions as well as simulating abnormal conditions, if such we are required for a true evaluation.

Air samples may be taken at pre-selected locations to determine individual exposure, general room work environment and source of contaminant. The collection of samples should be repeated at the same locations for as many times as possible considering the time factor and industrial operations. The sampling time may also be suitably designed during the night shift, if required, because certain operation in the factory in carried out only during night to overcome the problems of production and other reasons.

The man power required for an occupational hygiene survey depends upon the type of study i.e. unidisciplinary and multidisciplinary study, varying from two persons to as many as a group of eight or ten persons involving industrial hygienist, biochemist, occupational health experts and safety engineers. However, minimum number of survey personnel prevents from over crowding at shop-floor and distraction of attention of workmen and interference in normal work situation.

The survey team should always keep a note book or diary to note down various observation that he finds during samples collection. Such as, method of work of the workman, addition or discharge of raw materials or products, "shut" or "start on" any operation that he may and finds at the workplace.

The existing control measure to reduce the dispersions of contaminant in work environment and to protect the workman from harmful exposure should be well examined for its efficiency and quality. It may include general ventilation, and local exhaust at the source of contaminant, dust collectors, gas and vapour scrubbers, and respiratories.

Air samples collected from various locations and operations including biological sample should be well stopped, preserved and safety stored in samples kit. It should be sent to the laboratory as early as possible to get a better and reliable result.

Before the survey team complete the field investigation, it is preferable to have discussion with the plant manager, production manager, maintenance manager and safety officer regarding brief of the findings and observations along with recommendations and suggestions for control. The discussions may bring out practical and feasible solutions of the control measures being recommended by the survey team.

5. Statutory Provision Related to Industrial Hygiene

The Factories Act-1948

- **Section 13. Ventilation and temperature**

(1) Effective and suitable provision shall be made in every factory for securing and maintaining in every workroom--
   (a) adequate ventilation by the circulation of fresh air, and
   (b) such a temperature as will secure to workers therein reasonable conditions of comfort and prevent injury to health;-
   and in particular,-
   (i) walls and roofs shall be of such material and so designed that such temperature shall not be exceeded but kept as low as practicable;
   (ii) where the nature of the work carried on in the factory involves, or is likely to involve, the production of excessively high temperatures, such adequate measures as are practicable shall be taken to protect the workers.

(2) The State Government may prescribe a standard of adequate ventilation and reasonable temperature for any factory or class or description of factories or parts thereof and direct that 1*[proper measuring instruments, at such places and in such position as may be specified, shall be provided and such records, as may be prescribed, shall be maintained.]

- **Section (14) – Dust & fumes**

(1) In every factory in which, by reason of the manufacturing process carried on, there is given off any dust or fume or other impurity of such a nature and to such an extent as is likely to be injurious or offensive to the workers employed therein, or any dust in substantial quantities, effective measures shall be taken to prevent its inhalation and accumulation in any workroom, and if any exhaust appliance is necessary for this purpose, it shall be applied as near as possible to the point of origin of the dust, fume or other impurity, and such point shall be enclosed so far as possible.

(2) In any factory no stationary internal combustion engine shall be operated unless the exhaust is conducted into the open air, and no other internal combustion engine shall be operated in any room unless effective measures have been taken to prevent such accumulation of fumes there from as are likely to be injurious to workers employed in the room.

- **Section 15 Artificial humidification**

(1) In respect of all factories in which the humidity of the air is artificially increased, the State Government may make rules,-
   (a) prescribing standards of humidification;
   (b) regulating the methods used for artificially increasing the humidity of the air;
   (c) directing prescribed tests for determining the humidity of the air to be correctly carried out and recorded;
   (d) prescribing methods to be adopted for securing adequate ventilation and cooling of the air in the workrooms

(2) In any factory in which the humidity of the air is artificially increased, the water used for the purpose shall be taken from a public supply, or other source of drinking water, or shall be effectively purified before it is so used.
(3) If it appears to an Inspector that the water used in a factory for increasing humidity is required to be effectively purified under sub-section (2) is not effectively purified he may serve on the manager of the factory an order in writing, specifying the measures which in his opinion should be adopted, and requiring them to be carried out before specified date.

- **Section 17 – Lighting**

(1) In every part of a factory where workers are working or passing there shall be provided and maintained sufficient and suitable lighting, natural or artificial, or both.
(2) In every factory all glazed windows and skylights used for the lighting of the workrooms shall be kept clean on both the inner an outer surfaces and, so far as compliance with the provisions of any rules made under sub-section (3) of section 13 will allow, free from obstruction.
(3) In every factory effective provision shall, so far as is practicable, be made for the prevention of-
(a) glare, either directly from a source of light or by reflection from a smooth or polished surface;
(b) The formation of shadows to such an extent as to cause eye-strain or the risk of accident to any worker.
(4) The State Government may prescribe standards of sufficient and suitable lighting for factories or for any class of description of factories or for any manufacturing process.

SCHEDULE "A"
(As per Maharashtra State Rule – 1963)

Sr. No.	Area and Work-room	Minimum intensity of illumination in Lux
1.	Stock-yards, main entrance and exit roads, cat-walks of outdoor plants, coal unloading and storage areas.	20
2.	Passage-ways and corridors and stairways, warehouses, stock-rooms for large and bulky materials, platforms of outdoor plants, basements.	50
3.	Engine and boiler rooms, passengers and freight elevators, conveyer crating and boxing departments, store-rooms and stock-rooms for medium and fine materials, lockers rooms, toilet and wash rooms.	100

SCHEDULE "B"
(As per Maharashtra State Rule – 1963)

Sr. No.	Nature of Work	Examples	Minimum intensity of illumination in Lux
1.	Where discrimination of detail is not essential.	Handling of material of coarse nature, rough sorting, grinding of clay products, handling coal or ashes.	50

2.	Where slight discrimination of detail is essential.	Production of semi-finished iron and steel products, rough assembling, milling of grains, opening, carding, drawing, slubbing, roving, spinning (ordinary) counts of cotton.	100
3.	Where moderate discrimination of detail is essential.	Medium assembling, rough bench work and machine work, inspection and testing of products, canning, sawing, venering planning of lumber, sewing of light coloured textiles and leather products, weaving light thread, warping, slashing doubling (fancy) spinning fine counts.	200
4.	Where close discrimination of detail is essential.	Medium bench and machine work 300 fine testing, flour grading, leather finishing, weaving cotton goods, or light coloured woolen goods, welding sub-assembly, drilling, riveting, book-binding and folding.	300
5.	Where discrimination of fine detail is involved under a fair degree of contract for long period of time.	Fine assembling, fine bench and machine work, fine inspection, fine polishing and beveling of glass, fine wood working, weaving dark coloured woolen goods.	500
6.	Where discrimination of extremely fine detail is involved under conditions of extremely poor contrast for long periods of time.	Extra fine assembling, extra fine inspection, testing of extra fine instruments, jewellery and watch manufacturing, grading and working of tobacco products, dark cloth hand tailoring, final perching in dye works, make-up and proof reading in printing plants.	

- **Section 36 – Precautions against dangerous fumes, gases etc.**

(1) No person shall be required or allowed to enter any chamber, tank, vat, pit, pipe, flue or other confined space in any factory in which any gas, fume, vapour or dust is likely to be present to such an extent as to involve risk to persons being overcome thereby, unless it is provided with a manhole of adequate size or other effective means of egress

(2) No person shall be required or allowed to enter any confined space as is referred to in sub-section (1), until all practicable measures have been taken to remove any gas, fume, vapour or dust, which may be present so as to bring its level within the permissible limits and to prevent any ingress of such gas, fume, vapour or dust and unless-

(a) a certificate in writing has been given by a competent person, based on a test carried out by himself that the space is reasonably free from dangerous gas, fume, vapour or dust; or

(b) such person is wearing suitable breathing apparatus and a belt securely attached to a rope the free end of which is held by a person outside the confined space."

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- **36A. Precautions regarding the use of portable electric light.**

In any factory--

(a) no portable electric light or any other electric appliance of voltage exceeding twenty-four volts shall be permitted for use inside any chamber, tank, vat, pit, pipe, flue or other confined space; 2*[unless adequate safety devices are provided] and

(b) if any inflammable gas, fume or dust is likely to be present in such chamber, tank, vat, pit, pipe, flue or other confined space, no lamp or light other than that of flame-proof construction shall be permitted to be used therein.]

- **Section 37 – Explosive or inflammable dust, gas, etc.**

(1) Where in any factory any manufacturing process produces dust, gas, fume or vapour of such character and to such extent as to be likely to explode on ignition, all practicable measures shall be taken to prevent any such explosion by--

(a) effective enclosure of the plant or machinery used in the process;
(b) removal or prevention of the accumulation of such dust, gas, fume or vapour;
(c) exclusion or effective enclosure of all possible sources of ignition.

(2) Where in any factory the plant or machinery used in a process such as is referred to in sub-section (1) is not so constructed as to withstand the probable pressure which such an explosion as aforesaid would produce, all practicable measures shall be taken to restrict the spread and effects of the explosion by the provision in the plant or machinery of chokes, baffles, vents or other effective appliances.

(3) Where any part of the plant or machinery in a factory contains any explosive or inflammable gas or vapour under pressure greater than atmospheric pressure, that part shall not be opened except in accordance with the following provisions, namely:--

(a) before the fastening of any joint of any pipe connected with the part or the fastening of the cover of any opening into the part is the cover of any opening into the part is loosened, any flow of the gas or vapour into the part of any such pipe shall be effectively stopped by a stop-valve or other means;
(b) before any such fastening as aforesaid is removed, all practicable measures shall be taken to reduce the pressure of the gas or vapour in the part of pipe to atmospheric pressure;
(c) where any such fastening as aforesaid has been loosened or removed effective measures shall be taken to prevent any explosive or inflammable gas or vapour from entering the part or pipe until the fastening has been secured, or, as the case may be, securely replaced:

2.1 Provisions related to Occupational Health in The Factories Act, 1948

Chapter III - Health
Section 11 - Cleanliness
Section 12 - Disposal of wastes and effluents
Section 13 - Ventilation and Temperature
Section 14 - Dust and Fumes
Section 15 - Artificial Humidification
Section 16 - Overcrowding
Section 17 - Lighting
Section 18 - Drinking water
Section 19 - Latrines and Urinals
Section 20 - Spittoons

Chapter IV – A Provisions Relating to Hazardous Processes

.**41C. Specific responsibility of the occupier in relation to hazardous processes**.

Every occupier of a factory involving any hazardous process shall—

(a) maintain accurate and up-to-date health records or, as the case may be, medical records, of the workers in the factory who are exposed to any chemical, toxic or any other harmful substances which are manufactured, stored, handled or transported and such records shall be accessible to the workers subject to such conditions as may be prescribed;

(b) appoint persons who possess qualifications and experience in handling hazardous substances and are competent to supervise such handling within the factory and to provide at the working place all the necessary facilities for protecting the workers in the manner prescribed Provided that where any question arises as to the qualifications and experience of a person so appointed, the decision of the Chief Inspector shall be final;

(c) provide for medical examination of every worker--

   (a) before such worker is assigned to a job involving the handling of, or working with, a hazardous substance, and

   (b) while continuing in such job, and after he has ceased to work in such job, at intervals not exceeding twelve months, in such manner as may be prescribed.

41E. Emergency standards.

(1) Where the Central Government is satisfied that no standards of safety have been prescribed in respect of a hazardous process or class of hazardous processes, or where the standards so prescribed are inadequate, it may direct the Director General of Factory Advice Service and Labour Institutes or any institution specialised in matters relating to standards of safety in hazardous processes, to lay down emergency standards for enforcement of suitable standards in respect of such hazardous processes

(2) The emergency standards laid down under sub-section shall, until they are incorporated in the rules made under this be enforceable and have the same effect as if they had been incorporated in the rules made under this Act

41F. Permissible limits of exposure of chemical and toxic sub-stances.

(1) The maximum permissible threshold limits of exposure of chemical and toxic substances in manufacturing processes (whether hazardous or otherwise) in any factory shall be of the value indicated in the Second Schedule

(2) The Central Government may, at any time, for the purpose of giving effect to any scientific proof obtained from specialised institutions or experts in the field, by notification in the Official Gazette, make suitable changes in the said Schedule.]

41G. Workers' participation in safety management

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.(1) The occupier shall, in every factory where a hazardous process takes place, or where hazardous substances are used or handled, set up a Safety Committee consisting of equal number of representatives of workers and management to promote cooperation between the workers and the management in maintaining proper safety and health at work and to review periodically the measures taken in that behalf Provided that the State Government may, by order in writing and for reasons to be recorded, exempt the occupier of any factory or class of factories from setting up such Committee

(2) The composition of the Safety Committee, the tenure of office of its members and their rights and duties shall be such as may be prescribed

41H. Right of workers to warn about imminent danger

(1) Where the workers employed in any factory engaged in a hazardous process have reasonable apprehension that there is a likelihood of imminent danger to their lives or health due to any accident, they may bring the same to the notice of the occupier, agent, manager or any other person who is in charge of the factory or the process concerned directly or through their representatives in the Safety Committee and simultaneously bring the same to the notice of the Inspector

(2) It shall be the duty of such occupier, agent, manager or the person incharge of the factory or process to take immediate remedial action if he is satisfied about the existence of such imminent danger and send a report forthwith of the action taken to the nearest Inspector

(3) If the occupier, agent, manager or the person incharge referred to in sub-section (2) is not satisfied about the existence of any imminent danger as apprehended by the workers, he shall nevertheless, refer the matter forthwith to the nearest Inspector whose decision on the question of the existence of such imminent danger shall be final."]

Section 45 - First aid appliances

- First aid boxes with prescribed contents
- Nothing else to be kept in first-aid box
- First-aid box in charge of responsible person trained in first aid
- If more than 500 workers, provision of ambulance room

The First Schedule [Section 2(cb)]

List if Industries Involving Hazardous Processes

- 29 Processes

The Second Schedule [Section 41-F]

Permissible Levels of Certain Chemical Substances in Work Environment

- 116 chemicals
- 4 types of Dusts – Silica, Asbestos, Portland Cement, Coal Dust
- The Second Schedule [Section 41-F]
- Time-weighted Average Concentration (TWA) 8 hours
- Short-term Exposure Limits (15 minutes)

The Third Schedule [Section 89 and 90]

List if Notifiable Diseases

- 29 Diseases

2.2 The Maharashtra Factories Rules, 1963

Rule 66 - Excessive Weights

Maximum weight of Material article, tool or appliance (Kilograms) Lift, put down, carry or move Medical examination before and after employment

Sr.	Person	Maximum weight in Kg
A	Adult male	55
B	Adult Female	30
C	Young person (Male 15-16 years)	30
D	Young person (Female 15-16 years)	20
E	Young person (Male 14-15 years)	16
F	Young person (Female 14-15 years)	14

Rule 73-L - Health and Safety Policy

Rule 73-M - Material Safety Data Sheet (MSDS)

- Identity
- Routes of entry
- Physical & Chemical Hazards – Acute & Chronic
- Permissible limits of exposure
- First-aid
- Details of manufacturer

Rule 73-V - Medical Examination of Workers

For whom	• Workers employed in hazardous processes
Periodicity	• Once before employment • Once in a period of 6 months
How to record	• Form 6 – Certificate of Fitness – Before employment • Form 7 – Health Register • Form 23 – Special certificate of fitness
Who will do it	Factory Medical Officer

Rule 73-W - Occupational Health Centre

Qualification of Factory Medical Officer

- M.B.B.S. degree
- Diploma in Industrial health or equivalent PG certificate course

- Diploma as in (2) exempted if sufficient experience subject to satisfaction of DGFASLI
- Syllabus and organization approved by State Government or DGFASLI
- Complete particulars of FMO intimated to inspector having jurisdiction

Duties of Factory Medical Officer

- Medical examination of workers
- First-aid care and emergency treatment
- Notification of occupational diseases
- Immunization services
- Medical records
- Referral services

Infrastructure

- Required if work involving hazardous processes if more than 50 workers
- Services and facilities as per scale in Schedule

No. of Workers	Provisions
upto 50 workers	• Services of FMO on retainership basis • A minimum of 5 persons trained in First-aid in each shift • A fully equipped first-aid box
upto 51 to 200 workers	• Services of FMO on part-time basis (visit- at least twice a week) • One qualified and trained dresser-cum-compounder in each shift • A fully equipped first-aid box in each department
Above 200 workers	• Services of one full-tome FMO upto 500 workers and one more FMO for every 100 workers or part thereof • One nurse, one dresser-cum-compounder and one sweeper-cum-ward boy in each shift • OHC fully equipped to manage medical emergencies

Rule 73-X – Ambulance Vans

- Availability of Ambulance van if more than 200 workers
- If Less than 200 workers, suitable arrangements
- Manned by driver-cum mechanic and helper trained in first-aid
- Maintained in good conditions
- Equipped with articles as specified in sub-rule (2)

Rule 73-Y – Decontamination facilities

- Drenching showers
- Eye wash facilities

Rule 73-Z

- Making health record available to workers and specified authorities

Rule 76 – First-aid Appliances

- Sufficient no. of first-aid boxes
- Distinctly marked " First-Aid "
- Equipped with articles specified in rules depending on number of workers
- Only for first-aid material
- Protected form dust or moisture
- In charge of person trained in first-aid
- Always readily available

Rule 77– Notice regarding first-aid

- Notice containing names of persons
- Trained in first-aid and in-charge of first-aid boxes
- Location
- Name of nearest hospital and telephone number

Rule 78 – Ambulance Room

For more than 500 workers

- Ambulance room separate from factory
- Ambulance room in charge of qualified medical practitioner

- At least one qualified nurse
- Display of emergency numbers
- Facilities as specified in sub-rule (3)

Rule 114 – Dangerous operations

- Schedule I to XXVI
- Relevant occupational health measures pertaining to the operation specified in the schedule